

Science and Mathematics Education Centre

**THE DEVELOPMENT, VALIDATION AND APPLICATION OF A
PRIMARY SCHOOL SCIENCE CURRICULUM
IMPLEMENTATION QUESTIONNAIRE**

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ABSTRACT

This study focuses on the identification of the broad and complex factors influencing primary science program delivery within the New Zealand context. The study is divided into two phases. In the first phase, the factors influencing science program delivery are identified through (1) a questionnaire survey of 122 teachers in the Central Districts of New Zealand; (2) a questionnaire survey of 155 pre-service teachers at a New Zealand College of Education; (3) a case study of a large intermediate school in the Central Districts; and (4) a review of the research literature pertaining to curriculum, in particular primary science, delivery. Factors influencing science program delivery are identified as being both personal (intrinsic) and environmental (extrinsic). Intrinsic factors identified include teacher professional self-efficacy; interest and motivation; and multidimensional aspects of knowledge. Extrinsic factors influencing science program delivery include multidimensional aspects of time availability and resource adequacy; the availability and adequacy of professional support and leadership; and the priority placed on science as a curriculum area by the school, especially by the administration. The second phase of the study built on this initial phase by focusing on the development of an instrument, the *Science Curriculum Implementation Questionnaire*, which assists schools in identifying factors influencing science program delivery. The development of the SCIQ initially involved the use of a Focus Group to identify and prioritise items to include in the instrument. Statistical validation involved trialling of the SCIQ amongst 293 teachers representing 43 schools in the Central Districts of New Zealand. Using statistical procedures involving ANOVA, alpha reliability and discriminant validity, a seven-scale, 49-item instrument was developed. On the basis of the strong overlap amongst the intrinsic factors influencing science delivery, a further, shorter five scale, 35-item instrument was developed. The seven-scale SCIQ was further applied at the case study school. Quantitative data collected from the application of the instrument confirmed that several psychosocial and physical aspects of Intermediate School identified in the case study are influencing science program delivery. Implications of this study and the practical applications of the Science Curriculum Implementation Questionnaire are also presented in the context of primary science delivery both within New Zealand and internationally.

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Chapter 1 Introduction to the Thesis

1.1 Introduction

The study described in this thesis examines factors influencing science curriculum delivery at the primary school level, particularly within the New Zealand context. Further, it describes the processes involved in the development, validation, and application of an instrument used to identify factors influencing science program delivery. As a teacher educator at one of New Zealand's major teacher training institutions I have ample opportunity to frequent primary schools in a variety of educational jurisdictions. I have become critically aware of the varying degree to which science programs have been successfully implemented, in particular at the primary and intermediate level. Our students-in-training and recent graduates constantly testify to the apparent malaise towards the delivery of science programs that exists in schools. At the same time, I am encouraged when I experience those exceptional schools where the intended curriculum has been implemented and is the achieved curriculum. In such situations, it is readily evident that several aspects of the professional attributes of teachers and the school environment have played a critical role in the implementation of the science curriculum and the provision of meaningful learning experiences for children. The overall aim of this study was to gain a further understanding of how features of the school environment and teachers' professional attributes influence curriculum delivery and how the development of a measurement instrument in this area could assist New Zealand schools and schools internationally in moving ahead successfully in science curriculum implementation.

1.2 Background to the Study

The recent findings from New Zealand's participation in the *Third International Mathematics and Science Study* (TIMSS) and the *Third International Mathematics and Science Study-Revisited* (TIMSS-R) have revealed not only the disturbing level of science achievement by Year 7 (Form 2) and Year 8 (Form 3) students, but also associated concerns with science program delivery in general (Garden, 1996; Ministry of Education, 2000). An evaluation of the teachers participating in TIMSS suggested that several factors were inhibiting the implementation and quality of science

programs in New Zealand primary and intermediate schools. Indicators suggested that the intended curriculum, *Science in the New Zealand Curriculum* (Ministry of Education, 1993), was far from being the actual curriculum in most New Zealand schools (Garden, 1996).

Data from the participating TIMSS New Zealand students, teachers, and principals indicated that on average five percent of the total instructional time, ranging from as low as one percent up to nineteen percent of the total instructional time, is devoted to science instruction (Garden, 1996). At the Year 8 level, indications were that many New Zealand children were receiving no formal science education experience. Thus, although the intended curriculum, *Science in the New Zealand Curriculum*, was clearly defined, the actual or implemented curriculum varied widely in its classroom manifestation. The TIMSS data identified a broad variety of complex factors potentially inhibiting effective science classroom instruction in New Zealand schools. Although these factors included a variety of system elements, the inference was made that the major factors considered to be influencing implementation were primarily the confidence, knowledge, and skill of the teacher in enacting the curriculum at the classroom level.

The release of the TIMSS results brought an immediate call from the Ministry of Education for the primary education community to collectively address the poor science and mathematics performance of New Zealand children. An initial ministerial response to establish a Ministerial Taskforce for Science and Mathematics Education resulted in the production of a report that identified teacher confidence and competence as major factors inhibiting current science implementation and potentially, as a result of this, major contributors to student poor performance in mathematics and science. The TIMSS review asserted that effective teaching in science depends on teachers having the subject-matter knowledge and the professional training to maximise students' learning of the subject (Garden, 1996). The TIMSS and Taskforce assertions that many primary teachers were not confident in their ability to teach science parallel those of many other countries (Harlen, Holroyd, & Byrne, 1995; Tilgner, 1990; Weiss, Matti, & Smith, 1994). Although no single factor is seen to be the source of success or failure of student performance and curriculum

implementation, particular attention has focused both nationally and internationally on improving science teaching competence in primary educators

In response to the concerns and suggestions expressed by the Ministerial Taskforce, the Ministry of Education has embarked on some of the most ambitious documented national science in-service efforts to foster effective implementation of *Science in the New Zealand Curriculum* in New Zealand primary schools. The Ministry's immediate priorities for science have included the development of teacher resource materials and accompanying professional development. These interventions are being actively delivered to provide teacher support with an anticipated improvement in primary science curriculum implementation and science learning opportunities for New Zealand children. There is no indication from the Ministry of Education that further efforts will follow.

Although these efforts are admirable, it is well known internationally that despite a great deal of effort and enthusiasm devoted to the cause of primary science, the science experience of the majority of children in the first years of schooling is minimal (Harlen, 1978, 1988, 1997). Thomas (1980) stated that in Britain the difficulty that primary teachers have had in taking on and adopting the science reforms of the last two decades suggests that teachers in general are not convinced of this kind of work. In general, a malaise and ambivalence to science education exists in many primary schools internationally (Harlen, Holroyd & Byrne, 1995; Tilgner, 1990; Weiss, Matti & Smith, 1994). For this reason, curriculum reviews, policy changes, and overall reformation in the arena of primary science education are largely seen as rhetoric. Usually what constitutes educational "reform" are ministerial "injections" endeavouring to improve teacher knowledge, attitude, and confidence so that the intended curriculum becomes the achieved curriculum. International efforts indicate that although primary science curriculum reviews and reform efforts are admirable the outcome of the reviews is primarily limited to increased teacher awareness and not teacher change (Harlen, 1997).

These "injection" efforts are certainly contrary to what Stewart and Prebble (1985) identified as necessary in ensuring policy becomes practice through effective implementation. They suggested that effective implementation comes from a

systematic, sustained effort at changing learning conditions in the classroom and other internal conditions within the school. Although the classroom teacher is a critical agent in effecting implementation, a variety of 'curricular antecedents' or preceding factors within the school environment is known to contribute directly to curriculum implementation (Garden, 1996).

Although research associated with curriculum implementation is widespread, the actual identification of factors influencing science curriculum, in particular at the primary level, is very limited. A relevant study by Fullan (1992) involved research on factors influencing the implementation of New Educational Technologies in Britain. The factors he identified were primarily school 'culture' or environment attributes that are strongly influenced by the principal and overall educational administration. Although the actual 'deliverer' of the curriculum is the teacher, the educational administration is a critical agent in influencing school behaviour. Dalin (1993) suggested that the ethos of a school and the climate of the individual classroom have a direct bearing on teaching and learning. Overall, student success is largely influenced by the values and norms; the structural and human dimensions; and procedures and processes manifested within the school environment.

The phenomenon of the school environment is a complex one. Essentially it refers to the 'way things are' in an organisation (Dalin, 1993). It not only describes the organisation's physical environment, but also the psychosocial dimensions of the environment (Fraser, 1994). It pertains to the written and unwritten rules that regulate behaviours; the stories and myths of what an organisation has achieved and intends to achieve; and the values and standards set for its members (Dalin, 1993). The organisational dimensions are dynamically interrelated. They collaborate to silently and powerfully shape the behaviour and experience of people (Owens, 1995).

Consequently, the diagnosis or systematic assessment of the school environment can be used as a means of understanding the forces that are at work in a school and how these may impede or contribute to curriculum implementation. The study and systematic analysis of learning environments and educational climates is a developing area of educational research (Fraser, 1994; Fraser & Tobin, 1998). The research primarily involves the systematic investigation of participants' perceptions of their

educational environment. The systematic analysis is conducted through the use of measurement instruments that are able to assess the various attributes of the educational environment. As an example, the *School Level Environment Questionnaire* (SLEQ) is an instrument that elicits teacher perceptions of their school environment (Fisher & Fraser, 1983, 1990). The instrument assesses dimensions such as relationships among teachers and between teachers and students within the educational structure. The SLEQ provides a means by which a school can systematically identify the quality of the learning environment and by so doing implement strategies for positive change where system dimensions are seen to be suffering. As stated by Owens (1995), the employment of the good diagnostic tool becomes the starting point for the articulation of a reasonable prognosis.

The initial purpose of this study was to investigate the factors that are influencing science curriculum implementation at the primary school level, primarily within the New Zealand context. In a manner similar to which the SLEQ is designed and used, it was anticipated that an instrument suitable for measuring the physical and psychosocial attributes of the school environment could be developed from the information gathered in the initial part of this study. This information could subsequently be used by schools to assist in collectively addressing their identified weaknesses as a starting point for improved science curriculum delivery.

1.3 Rationale for the Study

Although a variety of factors is perceived to be influencing primary science curriculum implementation in New Zealand schools, research would indicate that these factors are much more complex than the recent ministerial reports and in-service strategies would suggest (Fullan, 1992). Although intrinsic factors such as teacher knowledge, skills, and beliefs have been clearly identified as contributors to the present poor science curriculum implementation, various extrinsic factors associated with the school environment are likely to be impinging on the school's overall efforts to implement the science curriculum. These preceding factors need to be addressed in order to ensure the intended curriculum becomes the implemented curriculum. It is not simply a matter of changing teachers. There must be a coherent and sustained

strategy to understand and influence both the classroom and overall school environment in order to foster improvement in science education practice

Consequently, an investigation into the complex factors influencing science curriculum implementation became the initial purpose of this study. Once clarified, this foundation was used to develop a questionnaire that could be used to assist in the systematic assessment of factors influencing science curriculum within their educational context. Finally, once validated, this questionnaire was applied in an educational context in order to ascertain its professional usefulness as a diagnostic assessment tool.

1.4 Research Questions and Intentions

Although a variety of factors were perceived to be influencing primary science curriculum implementation in New Zealand schools, the recent Ministerial efforts indicate that these factors are primarily associated with teacher knowledge, skills, and beliefs. Research indicates that the factors influencing science program delivery are much more complex than the recent ministerial reports would suggest. For this reason, the initial research question emerged from a motivation to determine the factors that were influencing science program delivery within the New Zealand context.

1. What are the factors that New Zealand teachers and school administrators identify as contributors or inhibitors to effective science curriculum implementation at the primary level?

Realising that the concerns associated with New Zealand primary science delivery are echoed in the international science education community, it was important to examine the research literature and determine if factors, not identified in my research study, were mentioned. This prompted the second research question.

2. What does the research literature identify as the critical factors influencing curriculum implementation in general and science curriculum implementation specifically at the primary level?

As this study has been motivated by a professional intent to assist New Zealand schools in improving science program delivery, the subsequent intention of the research study was to develop an instrument that could be used by schools as a data-gathering tool as an initial foundation for science program delivery improvement. This motivation led to the following intention.

3. To develop a quantitative assessment instrument to measure those aspects of teacher behaviour and the school environment known to influence primary science curriculum implementation.

Once developed, it was important to examine if the instrument could be used to determine the factors influencing science program delivery. This led to the final intention of the research study.

4. To apply the assessment instrument within an educational jurisdiction to ascertain its professional usefulness.

1.5 Significance of the Study

The problems associated with the teaching of primary science are not only of concern in New Zealand; they are a worldwide concern (Lloyd & Smith, 1998). Science education is acknowledged as an important part of every child's education, yet there is much evidence to suggest that science education in many countries is in a parlous state (Mulholland & Wallace, 1996). Although the reasons for inclusion of science in national curricula are debated, the concern over the state of primary science is primarily a reflection of an international recognition that science education is seen as the foundation for a scientifically literate society as well as being necessary for national economic development (Lloyd & Smith, 1998). There is an increasing international urgency to implement science programs to allow all students to have equal access to the domain of science and the opportunities it provides (UNESCO, 1989). Although this fundamental "Science for All" aspiration appears to be predominantly economically aligned, UNESCO's affirmations also reflect an explicit desire to see the arousal of curiosity, the development of an appreciation of the natural world, and the fostering of an environmental guardianship attitude in all learners.

Fensham (1985) also develops this utilitarian purpose of science education by asserting that science education can assist people to have a sense of control rather than subservience and to promote individual growth and satisfaction. No matter what the intentions of primary science, the reality of the current situation in many countries would suggest that the many curriculum primary science reforms are still a great distance from being manifested in actual classroom practice. As suggested by Loucks-Horsley, Hewson, Love and Stiles (1998) there is a great distance between the espoused reform policies and the classroom door.

The New Zealand situation would appear to be in a very similar situation. The poor performance of New Zealand children in TIMSS was believed to have possibly been because of the lack of time for New Zealand schools to implement a recently released national science curriculum, *Science in the New Zealand Curriculum* (Ministry of Education, 1993). The recent release of the TIMSS-R results (Ministry of Education, 2000) is likely to challenge the science education community in recognising that New Zealand's poor performance in TIMSS was not due to the inability of the nation to implement a new curriculum science curriculum. The TIMSS data and Ministerial Taskforce suggestions gave clear indication that there are several factors contributing to the disturbing state of primary science education. These factors go beyond the skills, knowledge, and attitudes of the teacher. The determination of what these factors are and how they are interrelated is of significance to a nation presently attempting to move towards a "knowledge society" (Education Review Office, 2000). The exploration of these factors along with the subsequent development of an instrument to ascertain what aspects of the school environment are influencing curriculum implementation is of value in assisting the educational community to ensure that the intended science curriculum becomes the educational experience of every child in New Zealand. By systematically identifying those aspects of the school environment that are impeding curriculum implementation, schools are in a position to systematically address these issues in order to move ahead effectively.

The study also has international significance. The concerns in New Zealand primary science education are concerns, as mentioned earlier, that are echoed internationally. The findings from both the exploratory studies into factors influencing primary science curriculum implementation in New Zealand and the development of the

physical-psychosocial instrument can be of professional value to educational jurisdictions internationally that are endeavouring to improve the effectiveness of science education curriculum implementation.

Furthermore, the depth of study involved in examining the factors influencing primary science curriculum implementation associated with this thesis provides significant contribution to the academic literature in attempting to understand the broad and complex factors influencing curriculum, especially science curriculum, implementation at the primary level. As well, the development of a measurement instrument pertaining to perceptions of factors influencing curriculum implementation is a progressive addition to the area of learning environment assessment.

1.6 Overview of the Thesis

This thesis consists of eleven chapters and several appendices.

This first chapter has outlined the intentions and ramifications of the study.

Chapter 2 provides an historical overview of the development of the primary science curriculum and associated concerns with primary science education in New Zealand in general. In the first part of the chapter there is an examination of the intentions and emphases in the evolution of the current science curriculum. This is followed by a review of the recent discussion that has arisen in the educational community in response to New Zealand's very poor performance in TIMSS and TIMSS-R. The associated reviews have identified many system elements potentially contributing to this poor performance

Following on from the "state of concern" discussed in Chapter 2, in Chapter 3 the background literature that examines the wide variety of interrelated factors that influence curriculum implementation is discussed. The literature review examines these factors both within the context of the general educational environment and specifically within the science curriculum.

Chapter 4 examines the literature relating to learning environments and the professional benefit of instruments developed for assessing psychosocial aspects of educational environments.

Chapter 5 describes the methodologies used in this study and outlines the research questions, samples, and measures used. Both qualitative and quantitative methodologies are outlined.

Chapter 6 provides data from two exploratory studies conducted in New Zealand. The first study ascertains what factors in-service teachers believe are influencing science curriculum implementation. The second study, involving pre-service teachers, examines the dimensions of teacher background and professional preparation.

Chapter 7 provides the data from a case study examination of factors influencing science curriculum implementation at a large intermediate school in New Zealand.

Chapter 8 examines the processes used in the development of an assessment instrument for investigating the factors influencing science program delivery - the *Science Curriculum Implementation Questionnaire (SCIQ)*.

Chapter 9 outlines the procedures and outcomes in the validation of the assessment instrument.

Chapter 10 presents data from an investigation involving the application of the instrument at the Intermediate School investigated in Chapter 7. It also compares the data collected from the qualitative analysis in Chapter 7 with the quantitative analysis collected from the application of the SCIQ.

Finally, Chapter 11 reports the major findings of this study with reference to the research questions and intentions presented. The implications and limitations of the study as well as recommendations for further research are also presented.

Following the references there are several appendices consisting of letters of intent, participant approval forms, questionnaires, and statistical notes.

Chapter 2 Primary Science Education in New Zealand

2.1 Introduction

The purpose of this section is to give an historical overview of the development of the primary science curriculum in New Zealand. Despite the 'best' intentions of the primary science curriculum, the implementation process has consistently been thwarted by a broad and complex amalgam of curricular antecedents. In the first part of this overview (2.1), I briefly examine the intentions and emphases in the evolution of the primary science curriculum. In the second part of the overview (2.2), I examine the recent discussion that has arisen in the educational community primarily in response to New Zealand's poor performance in TIMSS and TIMSS-R. The associated TIMSS reviews have identified many system elements potentially contributing to ineffective curriculum implementation and, as a perceived result of this, poor student performance. In section 2.3, I examine the results of a recent comparative study between New Zealand and several other countries that performed considerably higher than New Zealand in TIMSS. The study examines the system elements potentially contributing to poor science program delivery in New Zealand. The chapter concludes with a summary drawing on the historical and recent developments in New Zealand primary science education and introduces the topic of curriculum implementation, the focus of Chapter 3.

2.2 Historical Review of the Development of the Primary Science Curriculum in New Zealand

Fensham (1980) suggests that since 1960, social changes have been squeezing sciences into curriculum roles that are almost subservient to the political and educational functions of education. Consequently, during the development of a national curriculum, different groups or stakeholders seek to have influence on the outcome of the curriculum development process (Bell, Jones, & Carr, 1992). Although Fensham's comment was made in reference to the Australian context, it is also applicable to curriculum development in New Zealand. From its conception, science curriculum developments have responded to the political and economic aspirations of various stakeholders. This section of the thesis gives a historical

account of New Zealand primary science education with reference to these influential forces.

New Zealand has had a national science curriculum since 1878. This curriculum's intention was to initiate understanding and use of the scientific method by training students in the skill of careful observation and deduction of facts from those observations (Austin, 2001). Despite these intentions, the teaching of primary science was beset by numerous problems including lack of training in science content and pedagogy for teachers, lack of equipment, lack of time, and pressure of what were considered by teachers more important subjects (Austin, 2001). Although these problems beset the delivery of the primary science curriculum in 1878, historical evidence would suggest issues have, to this day, consistently inhibited science program delivery. By early 1904, science in the primary school had been replaced by nature study. The purpose of this *Nature-Study* prescription was to train children at all levels in the careful observation of surrounding objects and common phenomena, and to ask themselves questions such as: "What does this mean?"; "How does it act?"; and, "Why?" (Department of Education, 1904; Ewing, 1969). The curriculum indicated a list of suitable topics that were representative of both the life and physical sciences. Topics included life cycles, plant and animal structure, density and flotation, mechanics, soils, minerals, weather, astronomy, solvents and solutions, and heat and temperature. Emphasis was on selecting topics according to the tastes of the teachers, and, above all, ensuring reference to the local surroundings.

In 1929, a slightly revised syllabus, including elementary agriculture, dairy and general science, was still exhorting teachers to take their classes for nature study, but most found the practice disruptive and the outdoor work continued to be rare (Ewing, 1969). The prescription was strongly influenced by the chemistry and physics of the secondary schools, with the result that many topics could not be presented in a manner suitable for primary students. Facilities in most primary schools were quite inadequate and the usual procedure was that the teacher performed an experiment and the children copied notes. Although the agriculture and, to a lesser extent the dairy science, was reasonably well organised, the general science was taught too formally and too sketchily (Ewing, 1969).

A revised syllabus, *The Nature Study Syllabus*, was issued in 1950. As the name suggests, it swung heavily to the side of nature study. Although the 1904 prescription had clearly identified a requirement for students to study physical science concepts, the revised syllabus placed a particular focus on biological science and, to a lesser extent, agricultural science. A substantial handbook and a scheme for training specialists reinforced the new *Nature Study Syllabus* (Beggs, 1954). There was an appreciable increase in activities such as keeping aquaria and terraria, bird watching, and nature walks (Department of Education, 1950). This direct approach was seen to stimulate more genuine interest amongst teachers and children alike. It was unfortunate that that the vitalising of nature study was achieved at the expense of other sciences that had a contribution to make to children's education (Ewing, 1969). Although this national curriculum provided exceptional learning experiences for students (MacKenzie, pers. com.), there was growing dissatisfaction with not only the science curriculum but also the national curriculum framework in general. In his review of science education, Watson (cited in Ewing, 1969) noted that nearly half of the intermediate schools (Year 7 & 8) were making some effort to break away from an exclusive emphasis on nature study. It was perceived that although New Zealand had moved from being a British farm to a post-industrial, independent trading nation operating in most parts of the world, in particular within the Pacific Basin, the school curriculum was seen to be slow in responding to these changes. In the area of science, the curriculum was perceived to be of limited benefit to New Zealand as an agriculturally based and industrially developing nation (Levett & Lankshear, 1990). Fensham's (1985) comment that science curriculum development is the arena for various stakeholders utilising educational curricula for political and economic functions was again apparent. Further developments would increasingly accentuate this assertion.

Significant events of the late 1950s and early 1960s led to changes in science syllabuses at all levels of the national school system (Department of Education, 1965, 1978). The agricultural emphasis in primary science education was perceived as not aligned with New Zealand's economic goals. As well major developments in American science education and the "Space Race" between the United States and Russia further encouraged the development of a new curriculum (Coles, pers. com.). *Draft Syllabus and Science Guide for Teachers: Forms I and II* was released in 1965

and its contents emphasised this perspective. The development of the scientific conceptual knowledge and investigative methods was deemed essential to national prosperity (Coles, pers. com.). As stated by the General Science Revision Committee (1964), for too long mere knowledge of isolated facts has been accepted as evidence of successful science teaching (Department of Education, 1964). Expected learning and achievement objectives in nine fundamental concept areas and themes were clearly defined in behaviourist terms with the anticipation that a scientifically literate New Zealand might also end up on the moon (Benington, pers. com.)! Although the emphasis on nature study was retained in the lower primary classes, the upper primary student was expected to 'be developing an economy of ideas in a variety of concepts and principles' (Department of Education, 1965). The draft syllabus was followed by the publication of two science syllabuses, one for Forms I and II in 1967, and the other for Forms III and IV in 1969. A series of teacher's guides to the main sections of the syllabus was also published to support teachers with the implementation of the new prescription.

The development of the 1980 *Science Syllabus: Primary to Standard Four* continued to extend such a premise into the lower primary school curriculum. The educational orientation of the 1967, 1969 and 1980 syllabi would be best referred to as academic rationalism (Eisner, 1979, 1981). The major function of the science curriculum was seen to be the fostering of intellectual growth of students in those subject matters most worthy of study. Considering a scientifically literate society was seen to buy prosperity, science was seen in a new-elevated status (Coles, pers. com.). These intentions were thwarted by, again, the same factors at the school level that had impeded implementation of the 1878 and 1904 syllabi – factors that have continued to thwart science curriculum implementation efforts to this day.

The new syllabus identified a variety of scientific phenomena to be covered at the primary level. Through a survey conducted by the Director of Primary Education (1982), it was evident that the biological and earth science sections of the curriculum were being handled properly by teachers but the 'newer' areas of the physical sciences were causing difficulty. Because of the complexity of the content knowledge associated with these phenomena, primary and intermediate teachers, who, in general, were seen to possess little science specific knowledge, were supported through the

development of Science Resource Units. These units (over 200 in all) were released over several years to support the new syllabus and, up until 1999, were unrivalled by any national in-service professional development effort in science.

The early 1980's also saw the development of the *Learning in Science Project* (LISP) at Waikato University in Hamilton. This project, funded by the Ministry of Education, examined the area of children's alternative conceptions in science and presented a constructivist view of science teaching rather than the hierarchical, behaviourist view of learning underlying the existing syllabi. The LISP outcomes became the foundation for the development of a new draft syllabus in middle year's science, the *Form 1 to V Draft Science Curriculum* (1988). The draft syllabus lacked the rigid sequence of detailed content specification that was characteristic of preceding curricula. To enable schools to develop a school curriculum in response to local needs, the scientific knowledge, skills, and attitudes were defined in broad terms (Bell, Jones, & Carr, 1992). As might be expected, the draft curriculum was criticised for its perceived lack of clear learning outcomes and its lack of labour market and economic analysis.

During the late 1980s as part of the Government's *Achievement Initiative* a further revision of the science syllabus statements was undertaken and in 1991, a contract was let for the development of a new science curriculum for all levels of schooling. The Minister of Education approved a draft version of Science in the New Zealand Curriculum in April 1992. It again strongly emphasised a constructivist view of learning. It was published and distributed by the Minister of Education to all primary and secondary schools for comment and trial. Again, the philosophical underpinning of the draft curriculum was the subject of wide media debate and academic discussion (Education Review Office, 1996).

The most recent science curriculum developments have been associated with the modification of the draft curriculum and release of the final version of *Science in the New Zealand Curriculum*. These recent developments have been both quite paradoxical and astounding. Two polarised experimental ideologies, one economic and the other educational, were simultaneously vying for an arena of expression within the soon to be produced national science curriculum.

The *Learning in Science Project* is heralded as one of the most significant long-term science education research efforts in the world. It, along with other research efforts in the domain of the Alternative Conceptions Movement and constructivist ideology, have asserted the need for all educators, not just science educators, to realise that learning is not merely a cumulative accretion of knowledge by passive learners but an active process in which the learner is engaged in constructing or generating concepts to account for novel phenomena (Cleminson, 1990). This constructivist position opposes a view that learning is simply a transmission and accumulation of bits of information, the general educational orientation of preceding curricula. Instead, the information children encounter through a variety of creative learning experiences must be acted on, manipulated, and transformed to have any meaning for the student (Osborne & Wittrock, 1985). The essential tenets of the *Learning in Science Project* (Osborne & Freyberg, 1985) were explicitly defined and incorporated into an upper primary-lower secondary draft curriculum document, the *Form I to V Draft Science Curriculum*. The LISP tenets are outlined in the draft document. They include: (1) learning occurs when students make links with what they already know and existing information; (2) students learn by modifying ideas; (3) children need to learn science in the context of their own world; and (4) children must be engaged in relevant and meaningful science experiences. The consequence of these intellectual assertions has been significant in contributing to international science education reform. Along with other international efforts in the area of the alternative conceptions movement, it has provided pedagogical leadership in the area of curriculum development internationally. In effect, the draft curriculum 'belonged' to progressive educational theorists.

Simultaneously, New Zealand had embarked on one of the most rigorous programs of economic rationalism anywhere in the world (O'Neill, 1997). The 'New Zealand Experiment' of educational reform was about to be driven – not by educational but economic principles. The 1991 Ministry of Education's, Dr. Lockwood Smith's, budget statement clearly expresses this New Right ideology.

The government is committed to an education system that prepares New Zealand for the modern competitive world. Over recent years the word 'competition' has disappeared from the vocabulary of educationalists. Yet, the world is a competitive place. Our standard of living as a nation now depends

on our competing successfully in the international environment. We do our young people a grave disservice if we shield them from that reality if the curriculum ignores it. The imperatives of the modern world require a new culture of enterprise and competition in our curriculum. (Lockwood Smith, p. 91, 1991).

The basic assumption of such an ideology was that changes in education that emphasise an enterprise culture would enable New Zealand to become more competitive within the global marketplace, particularly within Asia (O'Neill, 1997). The New Right National party undertook, through the Ministry of Education, to embark on an educational "Achievement Initiative" that would raise academic standards and update the curriculum to assure national economic recovery (Bell, Jones, & Carr, 1992). The initial curriculum philosophical premise was believed to have been "captured" by a middle class that perpetuated mediocrity and poor outcomes. Suddenly, through the advocacy and influence of various Ministry of Education policy groups, the philosophical premise of the national curriculum was about to change. Within six months the new and existing national curriculum had been written. As would be expected, the haste of writing the document did not allow for a philosophy of science and science education to be negotiated and clarified. Consequently, what exists today is a 'marble cake' curriculum embodying the orientations of the stakeholders – constructivist on one side and neo-behaviourist, 'New Right' on the other. The mixed theoretical perspectives, which were diametrically opposed in the development of the most recent national curriculum, were amalgamated in the most recent national science curriculum. Although the development of *Science in the New Zealand Curriculum* has been the subject of theoretical controversy, these issues appear to be remote from the concerns of the school sector and, specifically, teachers who are at the interface of curriculum implementation. For schools and teachers, these concerns have been much more practical. These concerns are addressed in the next section.

2.3 Overview of Identified Problems Associated with Primary Science Curriculum Implementation in New Zealand.

Science in the New Zealand Curriculum is the current Ministry of Education's official science education policy for teaching, learning, and assessment for New Zealand schools. It was promulgated under the provisions of the *Education Act - 1964* for

implementation in all schools from the beginning of 1995. Centrally provided training to foster implementation of the science curriculum was offered to all schools in 1995. The curriculum statement defines the broad areas of scientific knowledge, skills, and attitudes students should be acquiring as part of all their scientific studies. *Science in the New Zealand Curriculum* asserts that science is both a body of knowledge and a process of enquiry (Ministry of Education, 1993). The curriculum has therefore been organised into six learning strands that reflect these two inextricably linked facets of science. In practical terms, the curriculum document, by its very structure, embodies a 'nature of science' that is about developing understanding through scientific processes of enquiry. There are four contextual strands which identify broad areas of scientific knowledge and understanding – *Making Sense of the Living World*, *Making Sense of the Physical World*, *Making Sense of the Material World* and *Making Sense of Planet Earth and Beyond*. The other two strands are integrating strands. These are concerned with those skills, attitudes, and understandings that students should be acquiring as part of all their scientific studies and are intended to be 'interwoven' and developed within the contextual strands. These integrating strands include *Making Sense of the Nature of Science and its Relationship to Technology* and *Developing Scientific Skills and Attitudes*. Achievement Aims establish the overall goals for each of the six strands identified in the curriculum. More numerous and specific achievement objectives describe the expected learning outcomes for each strand at each of the eight levels of the curriculum. *Science in the New Zealand Curriculum* notes that these objectives can embody a mixture of knowledge, attitudes, and skills, and that the attainment by students may require several units of study based on the learning strands, and incorporating a range of learning experiences (Education Review Office, 1996). Specific learning outcomes are not suggested. Instead possible learning contexts and experiences appropriate at each level of achievement are presented.

In early 1996, the Education Review Office conducted an 'accountability and effectiveness' audit, *Science in Schools*, to consider the impact of the new syllabus on schools, teachers, and students. The specific focus of the audit was to determine the extent to which *Science in the New Zealand Curriculum* had been implemented and to ascertain factors that were influencing the implementation process. The audit involved an in-depth investigation of the day-to-day implementation of the curriculum and its impact on the teaching of science and, therefore, on students. The investigation

involved 88 schools. These schools included 67 primary schools, three intermediate schools, 16 secondary schools, and two composite schools.

Three major issues emerged from the Education Review Office's investigation of the effectiveness of the implementation of the new science syllabus. These included concerns with: (1) the nature of the science curriculum statement; (2) delivering the planned curriculum; and (3) expertise in teaching (Education Review Office, 1996). The Review Office identified that the document presents a complex model of curriculum for teachers to implement. Conceptually it provided a challenge for teachers, especially for those with little background knowledge of science. Schools were generally left to make their own decisions about what, when, how, and how often science is taught. The document charged schools with providing a balanced curriculum but it is recognised that it is very difficult for teachers to know what this means in terms of science and how to provide this balance from the amalgam of strands, skills, objectives, and levels that are presented (Education Review Office, 1996). The Review Office recognised that one of the critical barriers to successful implementation may well have been the nature of the curriculum statement itself and the inability of teachers to professionally deliver what is required. As mentioned by Mavis Haigh, the coordinator of the development team for *Science in the New Zealand Curriculum*, possibly the curriculum is 'too brave' in its expectations (pers. com.).

Although the Review Office found that although a reasonably high level of planning at both school-wide and individual teacher level for the delivery of the science curriculum was evident, what was planned was not always taught. The Review suggested that the curriculum implementation process needed to be more closely monitored at the school level and assistance provided to teachers where necessary. One of the most significant barriers to successful implementation was seen to be teacher expertise and confidence. Some teachers, especially in primary schools, were not sufficiently trained in the science curriculum and had an incomplete understanding of it. These teachers found it difficult to cope with the content, planning, implementation, or assessment demands of the curriculum. Teacher knowledge and understanding were identified as critical factors in promoting effective implementation. Although teacher familiarity with the Living World was seen as a

positive factor in influencing implementation of this strand, teacher confidence with the content of the remaining contextual strands was seen as an area of concern. The Review Office identified the importance of Boards of Trustees planning further training to ensure that all those teaching science are knowledgeable about the content, teaching approaches, and methods of assessment promulgated through the curriculum.

Although these three issues were addressed specifically, the Review Office was concerned about the overall success of the implementation of *Science in the New Zealand Curriculum*. There appeared to be no evidence to suggest that teachers were not favourable to the 'marble cake' philosophical intentions of the curriculum. As well, the Review Office suggested that the 'lead in time' for the implementation of *Science in the New Zealand Curriculum* was appropriate considering that the first national curriculum statement (mathematics) had been introduced two years earlier. Despite these positive 'indicators', the Review Office was 'alarmed' that schools in this study were not planning further training in science for their teachers, even though teachers were identifying their lack of expertise and confidence as impediments to successful curriculum implementation (Education Review Office, 1996). In the conclusion of the Education Review Office's investigation of *Science in Schools*, a challenge is extended to those who manage teacher performance and those who fund and deliver teacher training to acknowledge the importance of improved student knowledge, skills, and attitudes in science and to accord the teaching of science the priority it requires if improvements are to be made.

New Zealand's recent (1995) participation in the *Third International Mathematics and Science Study* (Garden, 1996) has further sparked concern about the effectiveness of science curriculum implementation at the primary level. New Zealand participated in its first International Association for the Evaluation of Educational Achievement (IEA) study in the early 1960s. This study, the Six Subject Survey, gave indication of New Zealand's comparative performance in mathematics and science. It did not provide significant information that assisted countries in examining the educational problems that influenced student achievement. In comparison, TIMSS has been the most ambitious of the IEA's projects (Garden, 1996). It involved the participation of more than half a million students representing 15,000 schools in 45 countries. As well, TIMSS involved the participation of the principals and teachers of the

participating students. Data collection in areas such as teacher academic and professional background, instructional practice, resources, and attitudes towards the teaching of science provided the opportunity to identify the potential relationships between student achievement and data provided by students, teachers, and principals.

TIMSS compared the performance of students in mathematics and science at ages nine and thirteen. New Zealand students performed a little above the international average in science. At the age thirteen level (approximately years 7 & 8), 11 countries achieved significantly higher than New Zealand, five showed no significant difference, and nine achieved significantly lower. The national results from New Zealand's participation were thoroughly examined by the Research and International Section of the Ministry of Education in New Zealand. Although their analysis, *Science Performance of New Zealand Form 2 and Form 3 Students*, examined student achievement, the Ministry's examination also included a brief analysis of issues associated with science program delivery in general. Given that achievement results were not as high as were hoped for, the concluding chapter in the Ministerial Report made reference to aspects of science education, or the context in which it is delivered, that might possibly account for this performance (Garden, 1996).

Within the context of this study, the TIMSS analysis identified the following concerns: (1) lack of confidence in Year 8 teacher ability to teach science; (2) impediments to quality of instruction, primarily problems associated with the management of students; (3) low level of scheduled time for science instruction at the primary level; and (4) shortage of resources. A clear indication is made that science achievement is directly related to what teachers teach in their classroom, and how effectively they teach it. The concerns listed are regarded as impediments to effective science teaching practice. The analysis of these concerns is not fully developed in the TIMSS report. Instead, the analysis highlighted the importance of and encouraged further examination of variables such as those that potentially influence achievement in science. As Garden (1996) suggested in his closing paragraph of the performance review, this data exploration stage (associated with TIMSS) raises issues that should give policy-makers 'food for thought'. It is envisaged that further analysis and research will give added impetus to efforts to improve science learning by students.

In response to New Zealand's disturbing level of science achievement in science at the primary and intermediate level, the Ministry of Education established the Mathematics and Science Taskforce, comprised of individuals representing various sectors of the educational community. Their mandate was to inform the Ministry about possible actions that could be taken to support schools and classroom teachers in their efforts to make the curriculum reforms in mathematics and science work (Ministry of Education, 1997). The Taskforce identified the need for the Ministry of Education to implement a variety of strategies to facilitate the improvement of teacher scientific knowledge, attitude, and overall confidence in order for teachers to subsequently enhance student learning in science. The recommendations suggested by the Ministerial Taskforce focused on the development and provision of resources and associated professional in-service development relevant to Years 1 to 8 of the national science curriculum. These recommendations are being implemented at the present time through what are suggested to be the most ambitious in-service efforts in the history of New Zealand primary science education (Hyland, pers. com.).

The efforts have included the release of the *Making Better Sense of...* series, which are teacher resource booklets designed to support primary teachers in implementing *Science in the New Zealand Curriculum*. These resource booklets provide a wide range of contexts and activities for student learning in science. The topics selected are set within planning schedules that clearly identify and connect selected curriculum objectives, contexts, concepts, learning experiences and assessment samples. The resources provide an overview of the science that underpins the topics covered in the selected topics. The release of the *Making Better Sense of ...* series has been associated with in-service professional support.

Accompanying the release of this series has been the semi-annual release of the *Connected* series. *Connected* is an integrated mathematics, technology, and science student journal that can be used by the teacher in a variety of ways. The journals again make the science ideas explicit within each activity. The Ministry has also released the *Science Toolkit*, a teacher resource guide identifying the science equipment appropriate for use in specified science activities in primary schools. A further resource is an on-line *Resource Bank* that provides teachers with practical science activities and assessment exemplars appropriate for Years 1 to 8 of schooling. A final

effort, also supported by the Ministry, is the redevelopment and release of the *Science Resource Booklets* that were initially released in the early 1980s. This project has been particularly well documented during its development (Hipkins & English, 2000; Hipkins, 2000). Clearly, the focus of all of the Ministry of Education's strategies has been on identifying appropriate science activities and contexts and clarifying and developing the science involved in these contexts in order to assist students in their understanding of scientific phenomena and, to a lesser extent, processes (Ministry of Education, 1997).

A further, more academic, development has been the recent release of *In Time for the Future – A Comparative Study of Mathematics and Science Education* by the Education Review Office. Motivated by the TIMSS results and the concerns associated with science and mathematics program delivery in New Zealand, the Education Review Office, with the support of the Ministry of Research, Science and Technology, has recently conducted a comparative study of science and mathematics programs in countries that performed significantly better than New Zealand in the TIMSS. *In Time for the Future* identifies a number of explanatory factors that contribute to the variations in students' achievement, including differences in curriculum management and teaching practices. Of particular importance to the context of this study is the identification of several factors that, again, potentially may impact on science education curriculum delivery and student performance in New Zealand. These factors include: (1) teacher training and capability; (2) social factors that influence school programs; (3) national programs and school responsiveness; and (4) curriculum prescription and implementation within the school context (Education Review Office, 2000). These factors are explored in considerable detail and clearly indicate that many of the system elements that are fostering effective science curriculum implementation and effective science teaching in high performing TIMSS countries are potentially the same factors impeding curriculum implementation in New Zealand.

The conclusion of *In Time for the Future* gives a clear indication of what needs to be done to enhance the effectiveness of science and mathematics program delivery and teaching practice in New Zealand. The recommendations listed call for a concerted action to address the way school-based teaching practice and modifications to policies

on strategic curriculum management could improve student achievement in mathematics and science. The recommendations are as much courses for further investigation, as they are courses for action (Education Review Office, 2000).

2.4 Summary

The historical review of events examined in this chapter indicates that, potentially, a variety of interconnected factors have inhibited the effectiveness of science curriculum implementation in New Zealand since the introduction of the first national science curriculum in 1878. Although curricula have been developed with best, and often controversial intent, the intended curriculum, for a variety of reasons, has always struggled to become the achieved curriculum. In more recent months the results of New Zealand's performance in TIMSS-R (the 1998-1999 TIMSS) and the National Education Monitoring Project have been released. The preliminary results from both of these studies indicate that New Zealand's performance in Year 5 science has dropped, in comparison to other participating countries, from being 'amongst the international mean' to 'significantly below the international mean' in between 1994 and 1999 (Education Review Office, 2000; Ministry of Education, 2000) despite what is perceived to be a major effort by the Ministry of Education to significantly enhance science program delivery and student achievement at the primary and intermediate levels (Hyland, pers. com.).

As suggested by Mulholland and Wallace (1996) primary science education internationally is in a 'parlous' state. Parlous also aptly describes the New Zealand situation. This 'hard to put a finger on it' situation appears to be confirmed by the fact that a variety of broad and complex factors are quite evidently influencing science program delivery. The purpose of the next chapter is to explore the curriculum implementation process with a particular focus on factors influencing curriculum implementation, especially within the context of primary science education.

Chapter 3 Curriculum Implementation

3.1 Introduction

The purpose of this chapter is to examine the background literature pertaining to the curriculum implementation process and, more specifically, the wide variety of interrelated factors that influence curriculum implementation and program delivery. Section 3.2 begins by defining curriculum implementation and recognising, through a relevant research project in Britain, that factors can influence curriculum implementation. In section 3.3, the literature review examines those environmental or extrinsic factors deemed to influence curriculum implementation both within the context of the general educational environment and specifically within the context of science education. Section 3.4 examines the teacher specific or intrinsic factors that are known to influence curriculum implementation in general and science curriculum implementation specifically. Section 3.5 summarises the chapter by examining, within the context of a primary science education reform project, the interrelationships that exist amongst the factors identified as system elements influencing curriculum implementation in general. It also introduces the topic of learning environments and systematic assessment of learning environments, the focus of Chapter 4.

3.2 Curriculum Implementation Defined

In the New Zealand context, the intended science curriculum, *Science in the New Zealand Curriculum*, outlines the broad achievement aims and objectives for students at all levels of primary and secondary science education. The science content that students are intended to learn is defined in the form of concepts, processes, skills, and attitudes (Garden, 1996). As evidenced in the development of all of New Zealand's previous and existing national science curricula, the intended national science curriculum is influenced by, and derives from, the social, cultural, and economic influence of individual, community, national, and international relationships (Garden, 1996). As stated by Rowe (1973), this curriculum 'on paper' is often a different and remote entity in comparison to an implemented curriculum or curriculum in 'practice'.

Fullan (1992) described implementation as the change in attitudes and behaviours to such a degree that new procedures providing for full policy enactment are occurring. Thus, implementation is often referred to as that which has moved from 'from policy to practice' (Fullan, 1993). According to the IEA model, 'curricular antecedents' influence the implementation or 'delivery' of the curriculum (Garden, 1996). Within a New Zealand context, this means that although the intended curriculum is clearly defined by the Ministry of Education, a variety of 'preceding' factors determines the extent to which the intended curriculum becomes the implemented curriculum. The 'system elements' or antecedents influencing implementation and delivery are suggested by the IEA to be broad and complex. Primarily, factors such as community, school, and teacher characteristics are seen by the IEA as crucial in ensuring the intended curriculum becomes the implemented curriculum.

The literature examining factors influencing curriculum implementation is primarily addressed within the context of curriculum reform or change; that is, in the domain of literature specific to the analysis of those processes which influence the intended curricula becoming the implemented curricula. Although research associated with curriculum implementation is widespread, the actual identification of factors influencing science curriculum implementation projects, in particular at the primary level, is very limited. A closely related study by Fullan (1992) involved research on factors influencing the implementation of New Educational Technologies in Britain and identified several factors facilitating and inhibiting the implementation process. These factors are broadly categorised and are suggested to be common to most curriculum implementation appraisals. They include resource adequacy (teaching resources, materials and facilities); provision of professional support; staff interest (motivation and receptiveness); staff time availability; staff collegiality and collaboration; administrative leadership and commitment; and the difficulty of the task at hand and the ability of the organization to effectively deal with the task.

Fullan further suggested that these factors are primarily school 'culture' or environmental attributes and are strongly influenced by the principal and overall senior administration. Fullan suggested that the senior administration is a primary agent in fostering change and although the actual 'deliverer' of the curriculum is the teacher at the classroom level, the school administration is a critical agent in

influencing school behaviour. From Fullan's research, it is evident that the factors influencing implementation are both specific to: (1) the individuals involved in the implementation process and (2) the environment in which the implementation process is to occur. In the following section these two aspects are examined in more detail.

3.3 Intrinsic Factors Influencing Curriculum Implementation

The future of science education reform does not lie primarily in curriculum or in technology but with teachers of science (Baird, 1988). The recent remediation efforts in New Zealand would support this assertion as the spotlight quite evidently has been placed on teachers of science. Recognition of the critical position of teachers in the successful implementation of curriculum has once more demanded analysis of the traditionally low profile of science within the primary sector (Baker, 1994). Although a list of commonly cited factors (time constraints, equipment, space and facilities) are suggested to impede science program delivery at the primary level, more recent research efforts (Appleton & Symington, 1996; Bell, 1990; Harlen, 1997, Harlen et al, 1995) have primarily addressed intrinsic factors, such as teacher beliefs, knowledge, attitudes, and competencies, as critical agents to successful implementation. Garden (1996) asserted that teachers themselves are curricular antecedents. They are critical agents in making curriculum implementation and any curriculum innovation a reality. When it comes to curriculum reform, teacher change is a critical component of the proposals for spanning the great distance between espoused reform policies and the classroom door (Loucks-Horsley, Hewson, Love, & Stiles, 1998).

Garden (1996) identified teacher attitudes as critical factors in promoting science curriculum implementation within the New Zealand context and that teacher attitudes are presently impeding science-teaching practice. Elementary teachers generally appear reluctant to include science as part of their classroom curriculum (Mulholland & Wallace, 1996). This has been attributed to a lack of science background among science teachers and a negative attitude toward science as a subject (Paige, 1994). Although schools suggest a familiar list of extrinsic factors as impediments to science program delivery, a 'deeper reason' impeding curriculum implementation has been also suggested. Thomas (1980) suggested that in Britain the difficulty teachers have had in taking on and adopting the primary science projects of the last two decades

suggests that teachers in general are not only ill-prepared to deliver science programs, they are also not convinced of the 'worth' of this kind of work. The ineffectiveness of science programs at the primary level is suggested by Koballa and Crawley (1995) and Morrissey (1981) to be, at least in part, attributable to teacher attitude. Paige (1994) also suggested that personal interest, natural curiosity, and experience with the environment are intrinsic motivators to enhancing (women's) expertise in and motivation towards the teaching of primary science. Paige suggested that negative regard for a subject strongly impacts on a teacher's motivation to teach science. Consequently, this applies to efforts to improve teaching practice through curriculum reform. Teachers must be convinced that any innovation in teaching practice meets an important need, and that it will be an improvement over existing teaching practice. Stewart & Prebble (1985) also stated that at the heart of change is attitude and interest. Reluctance to change is a critical impediment to improving practice. As Fullan (1992) asserted staff motivation and receptiveness are crucial ingredients to creating curriculum change.

Professional motivation and interest are often suggested to be associated with a further intrinsic factor, professional adequacy. Many of the problems associated with the problems primary teachers encounter with program delivery in science are attributable to their poor professional adequacy in science. Tilgner (1990) concluded that inadequate teacher background is the most significant obstacle to primary science program delivery. A personal unease and anxiety with science and a lack of confidence in their roles as teachers of science are commonly cited reasons for the perceived reluctance to implement science programs (Appleton, 1992; Jeans & Farnsworth, 1994). Large numbers of primary teachers are anxious about studying science and teaching it to children (Fensham, Navaratnam, Jones, & West, 1991). These anxieties are evidenced through the numerous studies dealing with the attitudes of preservice teachers training to be teachers of science (Appleton, 1991; Skamp, 1989, 1991, 1992). Teachers are less confident about their knowledge and teaching of science than most other areas of the curriculum (Harlen et al, 1995). Deficiency models of teacher shortcomings pervade the literature pertaining to problems associated with primary science. The majority of participants in a study by Jeans and Farnsworth (1994) perceived that a lack of confidence was a major impediment to effective science programme delivery and that a build-up of confidence in teachers

was a necessary pre-requisite to the improvement of primary science. Ineffectiveness in primary science program delivery has been attributed to a poor preparation and science background by Franz and Enochs (1982) and Hurd (1982). Paige (1994) observed that 85 percent of South Australian primary teachers are women and many consider they lack skill and confidence in teaching science. Thus, teacher confidence and competence are seen as critical agents impeding science program delivery (Bearlin, 1990; Tilgner, 1990).

It is apparent from these analyses that teacher perceptions of their own ability to teach science is a major obstacle to science program delivery at the primary level. The way a person responds, behaves or performs in a given situation depends on attitudes of both cognitive and affective attributes of that person (Bandura, 1977, 1986; Hewson & Hewson, 1989; Prawatt, 1985). The instructional approaches adopted by teachers of science in primary schools are clearly influenced not only by their knowledge of science content, the nature of science, and pedagogical knowledge but also by their feelings or attitudes towards these cognitions (Morrisey, 1981). Bandura (1982) defines self-efficacy as a judgement concerning how well one can execute a course of action relating to a prospective situation. In other words, self-efficacy concerns one's perception of their capability of achieving a certain level of performance in a particular situation or a teacher's assessment of their own teaching competence. Self-efficacy is a judgement of a person's capability to carry out an action. Ginns and Watters (1994, 1995) suggested that people develop generalised expectancy about events through life experiences. Many teachers, especially women, bring to science teaching their own school experience of science that was often personally irrelevant, intimidating and alienating (Baker, 1994; Kahle, 1988; Kahle, Daniels, & Harding, 1987; Kelly, 1985). Bandura (1982) further suggested that self-efficacy explains why some people choose to behave one way while others choose to behave in another way; why some are willing to invest much effort into a task while others expend little; and why some demonstrate considerable persistence even when the odds seem against them while others give up on tasks. Thus, reluctance to be involved in a process is attributed to low self-efficacy. Bandura (1986) argued that some situations require greater skill and more arduous performances, or carry greater risk of negative consequences, than others. Bandura (1986) made the point that individuals hold high self-efficacy beliefs in some situations or on some tasks, and low efficacy on others.

Gibbs (1994) clarified this comment by citing the research of Raudenbush, Rowan, and Cheong (1992) involving a study of teachers in 16 high schools. Working on the notion that high school teachers face a number of classes each day that differ in size, academic content to be taught, and grade levels, these researchers found that self-efficacy varied across contexts and was thus domain specific. The self-efficacy of these teachers was influenced by grade level and experience. In a school-based case study involving 37 teachers, Laat and Watters (1995) found that highly self-efficacious science teachers have had, in general, a long history of contact with science that has been successful or at least generated interest.

Professional adequacy and attitude towards teaching science are implicitly related to teacher conceptual understanding and knowledge of science (Franz & Enochs, 1982; Tilgner, 1990). Baker (1994) stated that feelings of inadequacy and lack of interest are linked to primary science teachers' perceived lack of knowledge although other studies would suggest that this link is rather tenuous. Reference to confidence data (Skamp, 1989) would suggest that relationships amongst attitudes towards science, confidence, and knowledge might not be as straightforward as Baker suggests. Gooday, Payne, and Wilson (1993) found in a comparative study, involving first- and fourth-year student in a pre-service training program, that although fourth-year students were considerably more confident in teaching science, their understanding and knowledge of basic science concepts was little different from the first-year students.

Despite the lack of data to confirm the relationship between knowledge and confidence, a lack of background science knowledge of teachers is commonly identified to be a major factor influencing the effectiveness of science program delivery (Baker, 1984; Mulholland & Wallace, 1996; Symington, 1974, 1982; Tilgner, 1990). As Smith (1997) suggested there has been growing evidence that teachers at all stages of education need a sound knowledge of the subjects they teach and that a lack of scientific understanding is a problem for many primary teachers. This assertion is supported by several researchers (Carre & Bennett, 1993; Harlen, Holroyd, & Byrne, 1995; Kruger, Palacio, & Summers, 1990; Kruger & Summers, 1989).

Many studies show that preservice and inservice primary teachers have a limited, sketchy or misinformed knowledge of the subject matter that they are to teach (Atwood & Atwood, 1996; Ginns & Watters, 1995; Groves & Pugh, 1999; Jeans & Farnsworth, 1994; Kruger & Summers, 1989; Summers & Kruger, 1993). Throughout the years of trying to improve science curriculum implementation effectiveness in Scotland, Her Majesties Inspectorate commented in 1980 that the neglect of science at the primary level shows that many teachers lack an adequate knowledge of science (as they do not of history and geography). A similar note was sounded by HMI in England who reported that the most severe obstacle to the improvement of science in the primary school was that many teachers lack a working knowledge of elementary science appropriate to the children of that age (Harlen, 1997). Although a 'poor science background' is commonly cited as a factor influencing science program delivery what constitutes this 'background' is quite complicated to define. Baker (1994) suggested that one aspect of this required background is some knowledge of the subject itself. However, Shulman (1986) suggested that the background knowledge is much broader than the knowledge of the subject area alone.

Shulman (1986, 1987) identified seven subject matter bases as necessary for effective teaching. These include: (1) content knowledge, (2) general pedagogical knowledge, (3) curriculum knowledge, (4) pedagogical content knowledge, (5) knowledge of learners and their characteristics, (6) knowledge of educational contexts and (7) knowledge of educational ends, purposes and values. Within the New Zealand context, science educators have not neglected the issue of content knowledge in the teaching and learning of science within the primary sector, in particular in the aspect of pedagogical content knowledge. The *Learning in Science Project* has helped to increase the understandings in this area enabling science educators to plan and implement school science programs that take account of, and build on, students' existing ideas and interests (Baker, 1994). Research responding to Shulman's (1986) call for more attention to the teaching of specific subject matter has accumulated evidence of the difference that teachers' levels of knowledge can make, especially in the way concepts are represented, and how the structure of a subject is translated for pupils (Smith, 1988; Symington & Hayes, 1989; Wilson, Shulman, & Richert, 1987).

Ellis (1995) developed Shulman's ideas to identify those 'knowledge' aspects necessary for course planning and implementation. They include: (1) substantive content knowledge which consists of the facts, skills, and concepts of a subject together with its explanatory and organisational frameworks; (2) syntactic or process knowledge which includes the methods of inquiry in the subject and demonstration of how knowledge is generated, tested and justified; (3) distinctive aspects of the subject which includes those beliefs and values associated with the subject, the history of the subject and its role in modern society, controversial aspects of the subject, the subject's relationship to and epistemological difference from other subjects; (4) pedagogical content knowledge which consists of those aspects of the subject which relate to teaching and learning, including knowledge about learners, the ways in which adult knowledge is used in teaching and knowledge of the appropriate means of assessment and evaluation; and, finally, (5) knowledge about the management of learning which pertains to knowledge of materials and resources, organising learning environments and working with other teachers.

New Zealand's Teacher Registration Board (New Zealand Qualification Authority, 2001) similarly recognises professional knowledge as a competency required of a satisfactory teacher. *Professional knowledge* is regarded as a multidimensional aspect and is defined in terms of: (1) displaying knowledge of content of what is to be taught; (2) displaying knowledge of relevant curriculum documents; (3) employing teaching practices that reflect current research on best practice; (4) displaying knowledge of the developmental backgrounds, interests, cultural backgrounds, and varied approaches to learning appropriate to students; (5) demonstrating knowledge of appropriate technology and resources to be used in facilitating effective teaching; and (6) demonstrating knowledge of appropriate learning activities, programs and assessment.

The professional knowledge base of teachers provides the basis for the development of (children's) personal engagement with the subject and helps to develop an understanding of the nature of the knowledge within the discipline and, because of this, teachers need a complex knowledge base from which to implement an effective program (Baker, 1994). Teachers are required to bring a dynamic knowledge of learners within concurrent understandings of the curriculum, of the subject and of the

pedagogical content knowledge. All of these components are essential elements in the teaching process (Baker, 1994) and thus essential attributes to fostering effective science program delivery.

3.4 Extrinsic Factors Influencing Curriculum Implementation

Garden (1996) stated that effective curriculum implementation or reform is reliant upon many interrelated factors, several which are recognised to be environmental factors specific to the educational context in which the implementation process is intended. Since these environmental factors are 'external' to the teacher they will be regarded as 'extrinsic' factors within the context of this thesis.

A major factor influencing the effectiveness of curriculum reform is the availability of professional support (Appleton & Kindt, 1999; Fullan, 1992). In order for curriculum innovation projects to be successful, teachers must experience the active, concerned support of their colleagues and be given the opportunity to negotiate their involvement in any curriculum innovation (Stewart & Prebble, 1985). Teachers need support for change – a combination of consensus from below and pressure from above to create a two-way relationship with both bottom-up and top-down influences is essential in fostering change (Fullan, 1993). The support systems provided to foster curriculum reform need to be staffed by competent and committed people with abilities to support the learning needs of adults and build professional networks (Lieberman & McLaughlin, 1992). Participation in long-term, whole-school training and development programs that are properly supported is recognised as a significant factor promoting science program delivery (Paige, 1994).

Resource adequacy is also considered to be a major factor influencing the effectiveness of curriculum implementation efforts. Helgesson, Blosser, and Howe (1977) cited inadequate facilities and equipment as commonly mentioned barriers to effective science program delivery. Tilgner (1990) agreed that inadequate science equipment has been one of the most commonly cited obstacles to primary science program delivery over the past three decades. Adequate funds, materials and human resources are all seen as essential system elements for effective curriculum reform efforts (Evans, 1987). Schools must commit resources and structures to supporting

(curriculum) development so that there are as few obstacles as possible in the path of the innovation (Stewart & Prebble, 1985). Several researchers are now recognising that quality instructional materials, as well as equipment, play a critical role in teacher as well as curriculum change (Louden, 1991). Often the success of a curriculum reform effort is fostered or impeded by the availability of instructional materials (Appleton & Kindt, 1999; Hove, 1970; Tilgner, 1990; Venville, Wallace, & Louden, 1998). Access to exemplary science materials and funds availability are listed as major contributors to the success of primary science initiatives (Venville, Wallace, & Louden, 1998).

Time is a further factor known to influence the effectiveness of curriculum reform efforts. Tilgner (1990) noted that a major cited impediment to science program delivery is the inadequacy of time. Teachers commonly claim that they lack the time to organise activities and resources for science (Scott, 1989). Teachers need time to plan, prepare, interpret, and reflect in order to affect curriculum change. (Hargreaves, 1991). Change, marked by gradual steps rather than leaps, is a product of time.

Curriculum reform is also strongly influenced by leadership. In order to implement change, teachers require positive administrative leadership (Fullan, 1992). As asserted by Stewart and Prebble (1993), the degree of implementation of any school innovation is determined by the action and concerns of the principal. Without modelling and support from the organization, individual teachers are unlikely to sustain their reform efforts over time (Venville, Wallace, & Louden, 1998). Edmonds (1979) suggested that poor instructional leadership is a major factor influencing the effectiveness of the teaching of science. The influence and support from key people such as principals, fellow teachers, family, focus teachers, and coordinators are known to contribute to the effectiveness of primary science programs (Paige, 1994). As suggested by Fullan (1992), change is always associated with key people who are dynamic agents for fostering change.

School culture or ethos, which is strongly influenced by leadership, is also cited as a major factor influencing curriculum delivery projects. Dalin (1993) suggested that the ethos of a school and the climate of the individual classroom have a direct bearing on the effectiveness of program delivery and, more specifically, on teaching and

learning. Overall, the success of program delivery is largely influenced by the values and norms; the structural and human dimensions; and the procedures and processes manifested within the school environment. These dimensions are regarded as aspects of organisational culture. The culture of an organization refers to the habitual patterns of beliefs, attitudes, values, and activities shared and engaged in by the members of that organization. More colloquially, culture is the way we do things in this school and why we think we are doing them this way (Stewart & Prebble, 1985).

The phenomenon of school culture is a complex one. Essentially it refers to 'the way things are' in an organization (Dalin, 1993). It not only describes the organisation's physical environment, but also the psychosocial aspects of the environment (Fraser, 1994). It pertains to the written and unwritten rules that regulate behaviour, the stories and myths of what an organization has achieved and intends to achieve, and the values and standards it sets for its members (Dalin, 1993). Taguiri (1968) suggested that the total organisational environment is comprised of four dimensions: (1) ecology which refers to the physical and material factors in the organization; (2) milieu which refers to the social dimension; (3) social system which refers to the organisational and administrative structure of the organization; and (4) culture which embodies the values, belief systems, norms and ways of thinking that are characteristic of the people in the organization. If environment is defined as 'the way things are', then culture is defined as 'the way we do things around here'. These dimensions are dynamically interrelated and largely are controlled or strongly influenced by an organisation's administration. In effect, the environment includes both intangible and tangible aspects that silently and powerfully shape the experience and behaviour of a people (Owens, 1995). This is evidenced in Appleton and Kindt's (1999) suggestion that the implicit curriculum priorities established in schools often relegate science to a low status. The low perceived priority of science resulted in science being given short time allocation within the overall curriculum and limited expenditure in terms of professional support and resource provision (Appleton & Kindt, 1999).

Problems associated with primary science are also attributed to its perceived low status within not only the overall school culture but also the greater school community (Eriksson, 1997). According to Robitaille and Maxwell (1989), a wide variety of social factors influence the implementation process. These factors are referred to as

'societal factors' as they include aspects such as the goals and expectations the society holds for schooling. Parents consistently concerned about mathematics and reading rarely complain about the minimal attention given to science (Mulholland & Wallace, 2000). As stated by Laat and Watters (1995), the teaching of science at the primary level has consistently been a low priority reflecting societal perceptions of the importance of science in the primary curriculum. Despite significant efforts to raise the status of science in British schools, science is still considered a low priority in the curriculum in many schools (Paige, 1994).

Extrinsic factors potentially either accentuate or less commonly mitigate the personal aspirations of teacher. The influence of school culture, which is likely to be influenced by societal perceptions, clearly influences teacher behaviour when one examines studies pertaining to the teacher socialisation process. Case studies conducted by Yates and Goodrum (1990) found that even well qualified and confident teachers struggle to teach and implement science programs. Veenman (1984) suggested that the socialisation into the profession evaporates even the best intentions of beginning science specialists. Clandinin (1989) suggested that workplace constraints have an equally neutralising influence. Even the best intentions of beginning and experienced teachers are known to be often overwhelmed by the school environment. These accounts not only identify intrinsic aspects but also extrinsic aspects, such as the influence of the school environment as critical aspects influencing science program delivery. Clearly, the pervasive nature of school culture also influences the effectiveness of science program delivery.

3.5 Summary

International studies (Venville, Wallace, & Loudon, 1998) testify to some of the common features of strategies that promote teacher change and science curriculum implementation. These features quite evidently address many of the factors highlighted in this chapter. One reform that is of particular importance to the New Zealand situation is The Primary Science Teacher-Leader Project in Western Australia. It is noteworthy that Western Australian performance in TIMSS was equal first in the world. Although there is no suggestion that the purported success is due to this state-wide initiative, it is evident that there has been significant state-wide

progress in improving primary science teaching over the past five years through this centrally initiated and funded professional development mentoring mode (Venville, Wallace, & Louden, 1998).

The characteristics of this model and other successful models include a common list of features. Teachers require concrete experience in order to become more knowledgeable and confident in their professional science ability. As Hargreaves (1991) suggested teachers need opportunity to experiment, tinker, and play around. The experiences provided must be based on both the practical and theoretical levels and provide opportunity for both cognitive and affective change. As well, teachers must have the time to plan, prepare, interpret, and reflect (Venville, Wallace, & Louden, 1996). Change, marked gradually rather than through leaps, is a product of time. Teachers need to work within a sustained and well-resourced collaborative and supportive environment with colleagues and support staff. Personal contact and social interaction is imperative. Harlen (1997) suggested that teacher development is fostered when teachers are provided the opportunity to collaboratively develop and discuss ideas through practical experiences. As Fullan (1993) suggested support staff are critical to teacher change. Teachers need to operate within an environment of consensus from below and pressure from above to create a two-way relationship with top-down and bottom-up influence. The centre and the local units need each other. What is required is a sustained two-way relationship of pressure, support, and continuous negotiation. The supporting staff need to be effective leaders. Effective leadership is characterised by the commitment and competence to address the learning needs of the participants and progress towards identified targets. Finally, teacher change is associated with a climate of readiness. Teachers need to be more than willing; they must want to work towards change.

In summary, teacher change is best facilitated when professional development combines structural features of quality professional development within a sustained cultural environment of networking, readiness, co-operation, and support (Venville, Wallace, & Louden, 1998). Although some of these aspects are evident in the New Zealand's Ministry of Education's current primary science inservice program, the unsustainable nature of the effort would suggest that the overall outcome is likely to be less than satisfactory in the long term. Although recently published Ministry of

Education reports suggest a variety of factors are perceived to be influencing science program delivery in New Zealand schools, the international research literature would suggest that these factors are much more complex than the ministerial reports propose. Changing practice by changing teachers through inservice programs is not enough. Although intrinsic factors such as teacher knowledge, skills, beliefs, and attitudes are influencing science program delivery, various extrinsic factors associated with school environment directly impinge on teachers at the classroom level as curriculum implementers. The preceding factors or curricular antecedents that need to be met to ensure that the intended curriculum becomes the intended curriculum are achieved by not only being directed at changing teachers. They instead require a coherent and sustained strategy to understand and influence both the classroom and overall school environment in order to foster improvement in science education practice.

Consequently, efforts to develop an instrument to systematically assess the intrinsic and extrinsic aspects of the school environment that are known to influence implementation of the primary science curriculum are encouraged. The systematic identification of factors influencing science program delivery is a critical stage in allowing a school to learn more about itself and in establishing an acceptable and effective solution to foster curriculum change (Stewart & Prebble, 1993). Therefore, the systematic analysis of learning environments is the focus of Chapter 4.

Chapter 4 Learning Environments

4.1 Introduction

The purpose of this chapter is to establish a conceptual framework to justify the need for the development of a measurement instrument to quantify both intrinsic and extrinsic aspects of the school environment that influence science curriculum implementation and program delivery. Section 4.2 begins by providing a historical overview of learning environment instrument developments and applications. Section 4.3 looks at specific examples of learning environment instruments pertinent to the context of this study. Section 4.4 examines the format of learning environment instruments. Section 4.5 provides a justification for developing an instrument to assist schools in identifying and addressing the factors influencing science program delivery. Finally, section 4.6 concludes with a summary that draws on the information presented in the chapter and introduces the intent of Chapter 5, the methods used to develop an instrument that is able to assist primary and intermediate schools in identifying factors influencing science curriculum implementation.

4.2 Learning Environments – An Historical Analysis

During the past 30 years, there has been remarkable progress in conceptualising, assessing, and investigating the determinants and effects of social and psychological aspects of the learning environments of classrooms and schools (Fraser, 1998). It is suggested that a motivating source for the development of the many assessment instruments in the study of learning environments has been the field theory work of Lewin (1936) and Murray (1938). Lewin stated, in his *Lewinian Formula*, that human behaviour is a function of both the personality of the individual and the environment. Both the environment and its interaction with personal characteristics of the individual were recognised by Lewin as potent determinants of human behaviour (Fraser, 1998). Murray, similarly, proposed a *Needs-Press Model* which describes an individual's personal needs and environmental press as critical aspects influencing individual behaviour. Needs were seen by Murray to be the personal goals, motivations and requirements of an individual and were identified as a 'factor' in every individual's personality. The movement towards goals was strongly influenced

by this intrinsic factor. Press, on the other hand, was described as an extrinsic factor that either enhanced or retarded the individual's achievement of their personal goals. Murray used the term *alpha press* to describe the environment as assessed by a detached observer and *beta press* to describe the environment as perceived by milieu inhabitants (Fraser, 1998). In both the Lewin and Murray models, individual actions and behaviours are influenced by both intrinsic and extrinsic factors. In the context of this study, Lewin's theory would suggest that the way in which a teacher will respond to a situation, such as the requirement to implement a science program, will be influenced by both the teacher's behaviour and the teacher's environment. As stated in Chapter 3, Fullan's research on New Technology Innovation affirms this theoretical premise by identifying that the factors influencing New Educational Technologies implementation, and any curriculum innovation in general, are specific to both the individuals involved in the implementation process and the environment in which the implementation process is to occur.

The work of Lewin and Murray has been the theoretical foundation for the systematic assessment of the social and psychological aspects of the learning environments of classrooms and schools (Fraser, 1998). The independent, evaluative research conducted by Rudolf Moos and Herbert Walberg is seen as the seminal work on the quantitative assessment of learning environments by its inhabitants (Fraser, 1998). Walberg developed his widely used *Learning Environment Inventory* (LEI) as part of the research and evaluation activities of Harvard Project Physics (HPP) (Walberg & Anderson cited in Fraser, 1998). Walberg's motivation was to develop a method of evaluating the effectiveness of the HPP curriculum innovation. Moos, at the same time, was researching human relationships in a wide variety of environments including school classrooms, psychiatric hospital wards, military companies, and work places (Fraser & Walberg, 1991). Moos (1974) found that three general categories are characteristic of social environments. These include Relationship Dimensions, Personal Development Dimensions, and Maintenance and System Change Dimensions.

These categories are evident in the many classroom-level and school-level environment instruments developed over the past three decades (Fraser, 1998). This

aspect is examined in more detail in association with other features of learning environment instruments in the next section.

4.3 Examples of Learning Environment Instruments

Few fields of educational research have such a rich diversity of valid, economical, and widely—applicable assessment instruments as does the field of learning environments (Fraser, 1998). Although a variety of data gathering procedures are utilised in assessing educational environments, it is suggested that the use of an evaluative instrument, although much more superficial than formal school reviews, provides an ‘energy and time efficient’ method of collecting useful information (Prebble & Stewart, 1993). Typically, learning environment research focuses on either the classroom-level or school-level environment (Fraser & Walberg, 1991). In this study, it is evident that the factors influencing science curriculum delivery are associated both with the teacher at the classroom level (intrinsic) and the wider school environment (extrinsic). For this reason, an example of a classroom and school assessment instrument is discussed.

Because of its influence on the development on other more recent instruments, the development of the *Classroom Environment Scale* (CES) (Moos & Trickett, 1987) is an important classroom environment instrument to consider. Relationship Dimensions in the instrument identify the nature of personal relationships and the extent of the support and collegiality within the environment. Personal Development Dimensions assess personal growth dimensions such as personal growth and self-enhancement. Finally, System Maintenance and System Change Dimensions assess the extent to which and how the organization is organised and responds to change. Each category typically has one or more scales. As an example, in the Learning Environment Inventory Cohesiveness, Friction, Favouritism, Cliquesness, Satisfaction, and Apathy are scales within the Relationship Dimension category. In total there are 15 scales each of which contains seven items or statements pertinent to the scale. The LEI contains a total of 105 statements descriptive of typical school classes (Fraser, 1998). The respondent expresses degree of agreement or disagreement with each statement using the four response alternatives of Strongly Disagree, Disagree, Agree and

Strongly Agree. The scoring direction (or polarity) is reversed for some items. The perception scores obtained from the questionnaire are gathered from students.

An example of an instrument for assessing school environment is the *School-Level Environment Questionnaire* (SLEQ). The SLEQ was developed to assess school teachers' perceptions of psychosocial dimensions of the environment of the school (Fisher & Fraser, 1990). Two scales on the SLEQ measure Relationship Dimensions (Student Support, Affiliation); one measures the Personal Development Dimension (Professional Interest); and five measure System Maintenance and System Change Dimensions (Staff Freedom, Participatory Decision Making, Innovation, Resource Adequacy, and Work Pressure). It consists of 56 items, with each scale being assessed by seven items. The response scale is a five-point scale including Strongly Agree, Agree, Not Sure, Disagree, Strongly Disagree.

The two questionnaires discussed exemplify some of the instruments used in school- and classroom-level evaluation. Interestingly, Fraser (1998) states that the fields of classroom-level and school-level environment have remained remarkably independent. In the context of this study, it is evident that the teacher is at the interface of the curriculum requirements and the student. Although personal attributes or intrinsic factors such as professional adequacy, interest, and knowledge all influence science program delivery, these attributes are strongly influenced by and strongly influence environmental aspects (extrinsic factors). Consequently, although the focus of past research in science education has been primarily at the classroom level, the examination of factors influencing science program delivery requires an investigation at both the classroom and the school level.

4.4 Learning Environment Instrument Format and Applications

Learning environment questionnaires typically exist in two accompanying forms. The *actual* form allows participants to identify how things actually are in the environment being evaluated. The *preferred* form is concerned with values and goals orientations and measures participant's perceptions of the environment preferred (Fraser & Walberg, 1991). As an example an item such as, "The school is adequately

resourced”, in the actual form would be worded, “The school would be adequately resourced”, in the preferred form.

The application of the instrument further requires researchers to decide whether their analysis will involve the perception scores obtained from individual students or teachers (private press) or whether these will be combined to obtain the average of the environment scores of all students and/or teachers within the same class and/or school. A growing body of literature acknowledges the importance and consequences of the choice of level or unit on statistical analysis and multilevel analysis of data (Bock, Bryk, & Raudenbach cited in Fraser, 1998).

Some of the questionnaires have been modified to suit particular research purposes and research contexts (Fraser, 1998). For example the *What is Happening in My Classroom* (WIHC) has been translated and back-translated and applied to Taiwan educational environments (Huang & Fraser, 1997). As well, the *My Class Inventory* (MCI) has been modified to enhance readability and ease of completion for younger children (Fisher & Fraser, 1981).

Scoring procedures can either be completed by hand or computer. In hand scoring items are arranged in ‘blocks’ so that all items from the same scale are put together. All responses are assigned a score from 1 to 5, 1 for Strongly Disagree, 5 for Strongly Agree. If the item is a reverse order item the score is assigned in the reverse manner. To obtain score totals and averages, the items in the block are added and divided by the total number of items for the category. By completing both the actual and preferred forms discrepancies between the actual and preferred environment are evident.

These discrepancies become the diagnostic tool that serves as a useful starting point for considering what efforts can be made to address the discrepancies. As an example Fraser (1991) has proposed a simple, approach by which teachers can use information obtained from evaluations to guide attempts to improve practice. This sequence involves the initial assessment being followed by processing of the data and a report back to staff. The data provide ready identification of aspects of the environment that need to be addressed in order to reduce differences between the actual environment

and preferred environment. Opportunity is then provided for participants to reflect and discuss the implications of the results. Stewart and Prebble (1983) asserted that this reflective stage is a critical stage in the overall School Development process. They regard the quantitative data provided by instruments as being somewhat superficial and, consequently, these data need to be accompanied by narrative. Their suggested feedback model again provides opportunity for school staff to discuss the accuracy and meaning of the data providing justification for the results. The data become a foundation for discussion that allows the school to learn more about both a problem and the organisation generally. They also state that this discussion is critical in reaching collective decisions about potential solutions and embarking on remediation efforts that are purposeful rather than needless (Stewart & Prebble, 1993). Emanating from this reflection stage is an intervention stage that systematically identifies and addresses the discrepancies through selected strategies. As an example, if time constraints are identified as a factor influencing program delivery, staff may decide to remove selected elective programs that are identified as intrusions on classroom instruction time. After the intervention, a reassessment, using the actual form of the instrument, is conducted to determine if the discrepancies have been reduced. A further review of the data and a further cycle of intervention may subsequently follow.

4.5 Justification for the Development of a Science Curriculum Implementation Instrument

Within the context of this study, it has been identified that a variety of intrinsic and extrinsic factors influence primary science curriculum implementation and program delivery in general. As suggested by Mulholland and Wallace (1996), primary science education internationally is in a parlous state. This 'hard to put a finger on it' situation arises from the fact that there are several complex and interrelated factors influencing curriculum delivery. No one single factor can be targeted alone to effect change in primary science education. As Fullan suggested (1993), curriculum interventions tend to leave the basic policies and practices of school unchanged. They tend to ignore the fact that changes in the core culture of teaching require major transformation in the culture of the school. Change, instead, requires a coherent and sustained strategy to understand and influence both the classroom and overall school environment. Understanding the context in which change is to occur is at the heart of school

development (Stewart & Prebble, 1983). Consequently, in order for any significant change to occur in primary science education in New Zealand schools, the intrinsic and extrinsic aspects of the school environment that are known to influence implementation of the primary science curriculum need to be identified. From this diagnostic foundation, efforts can be made to systematically assess these factors through the development of a measurement instrument is possible. Not only is systematic analysis possible, it is also valuable. Not only to New Zealand primary schools but also to other nations and educational jurisdictions that are facing the same complex problems associated with science program delivery as New Zealand.

4.5 Summary

The purpose of this chapter has been to establish the justification for the development of a measurement instrument to quantify both intrinsic and extrinsic aspects of the school environment that influence science curriculum implementation and program delivery. Initiating effective change in schools requires changing those aspects of the educational environment seen to be inhibiting change (Dalin, 1993). The employment of a good diagnostic tool allows a reasonable prognosis to be made (Owens, 1995). Consequently, the diagnosis or the assessment of the dimensions of an educational environment can be used as a means of understanding the personal and environmental forces that are at work in a school and how these may impede or contribute to changes, such as science curriculum implementation. Both the Learning Environment Inventory and The School-Level Environment Questionnaire, discussed in this chapter, are examples of tools that can be used for such purposes. Clearly, a further instrument that is able to systematically evaluate the extent to which factors are influencing science program delivery is equally valuable.

Having established a premise for the development of such an instrument, the purpose of Chapter 5 is to describe the methodologies used in the development, validation, and application of an instrument used to assess the factors influencing primary science curriculum delivery.

Chapter 5 Methodology

5.1 Introduction

The purpose of this chapter is to describe the methods used in the various data collection, development, and application stages of this investigation. Section 5.2 describes the events leading up to the initiation and implementation of the study. Section 5.3 describes the methods used in a data collection in-service questionnaire survey of practising teachers in the Central Districts of the North Island of New Zealand. Section 5.4 describes the methods used in a further data collection survey of pre-service teachers at a teacher training institution in the Central Districts of New Zealand. Following on from this, section 5.5 describes the methods used in a further data collection case study of factors influencing science curriculum implementation at a large intermediate school, again, in the Central Districts region. Section 5.6 outlines the methods used in reviewing the literature on curriculum implementation, especially within the context of science education, in order to identify items valuable for inclusion in the evaluation instrument. Section 5.7 examines the use of a focus group in the development of a science curriculum implementation evaluation instrument. Section 5.8 explains the methods used in developing the instrument. In section 5.9, the statistical methods used to validate and refine the evaluation instrument are discussed. Section 5.10 describes the methods used in the application of the refined evaluation instrument at the same intermediate school that participated in the case study outlined in section 5.5. Finally, section 5.11 summarises the chapter and introduces the intent of Chapter 6, the presentation of findings based on investigations associated with pre-service and in-service science education in New Zealand.

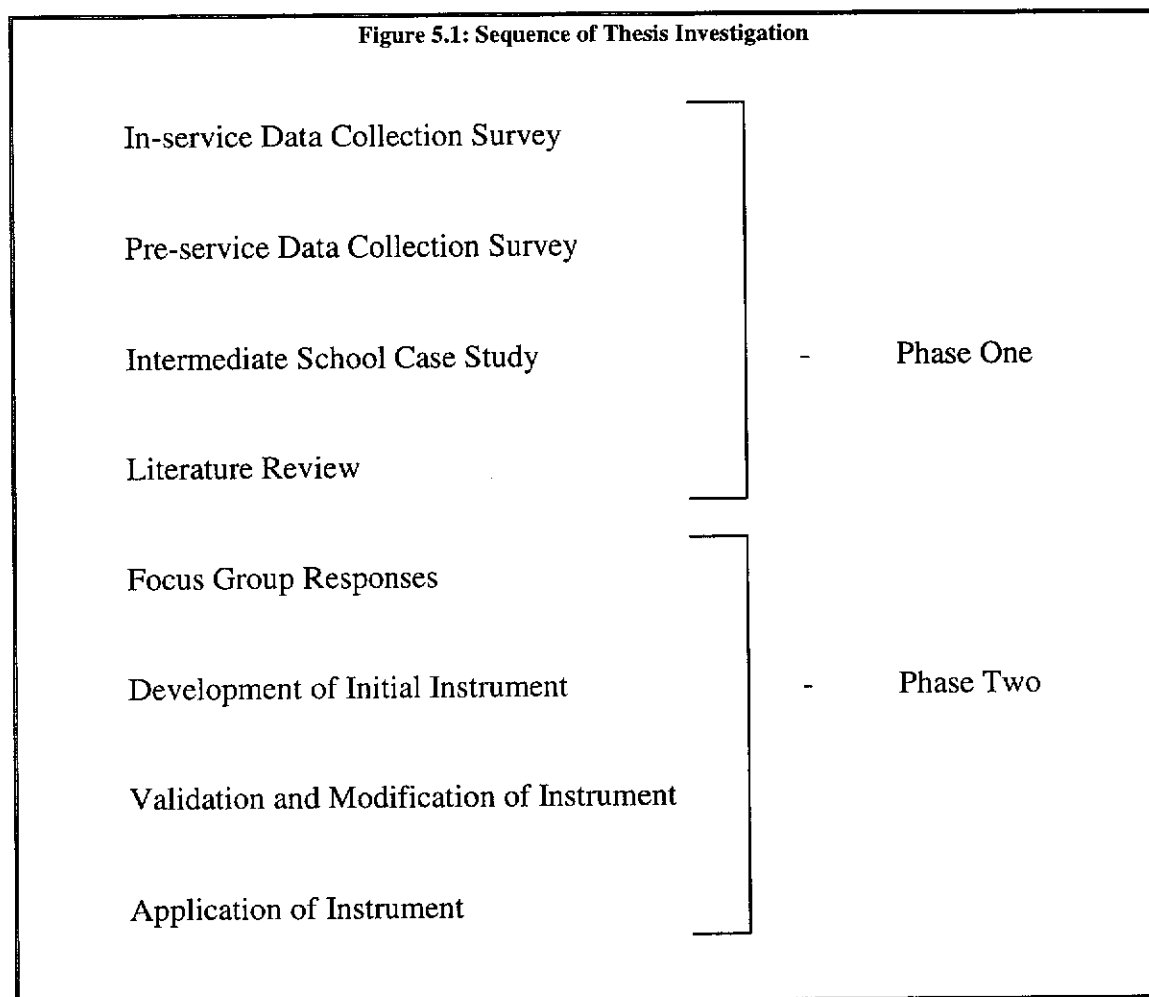
5.2 Preparation for the Study

Between 1988 and 1992, as a recently immigrated secondary science teacher with an interest in indigenous science education, the author completed a Master of Education that included a research project involving predominantly indigenous Maori schools in New Zealand (Lewthwaite, 1992). The focus of the study was to determine Year 7 and 8 teacher perceptions of the educational value of teaching science content within

the context of indigenous experience. Surprisingly, teachers suggested that one of the critical aspects reducing their effectiveness to teach in a contextual manner was not their knowledge of indigenous science but, instead, their knowledge and understanding of western science. The author was surprised that teachers did not know the science they were expected to teach! In the years that followed, the author moved from middle-years and secondary science teaching to tertiary science teacher training and became acutely aware that science education in New Zealand at the primary level was struggling and that at the centre of this problem was teacher perceptions of their own limited professional adequacy to teach science. Although professional adequacy appeared to be a central problem, other factors, on observation, also appeared to be a part of the problem. In order to improve my awareness of the factors influencing science curriculum implementation and delivery, a systematic effort to unravel the complexities of this phenomenon ensued. At all times my motivation has been to understand the phenomenon so that once understood, practical professional development strategies can be put into place, with the support of other members of the professional science education community at a regional and national level, to improve the effectiveness of science program delivery and the science education experiences provided for children in schools today.

In response to this professional motivation, the initial focus of the research exercise was to determine the factors influencing science curriculum implementation in New Zealand and to align these findings with the background literature. From this foundation, the subsequent focus was to develop a questionnaire in the format of other learning environment instruments that could be used as a tool to assist schools move forward in addressing barriers to effective science program delivery. Finally, in order to evaluate its effectiveness, it was necessary to apply the instrument to an educational context.

The research sequence involved several data collection stages. These are outlined in Figure 5.1.



For a number of years, workers in various areas of educational research, especially the area of educational evaluation, have claimed that there are merits in moving beyond the customary practice of choosing either qualitative *or* quantitative methods and instead combining qualitative *and* quantitative methods (Firestone & Pennell, 1997; Fraser, Williamson, & Lake, 1988; Howe cited in Fraser & Tobin, 1998). Such is the nature of the methods used in this study. The methods used in the first phase of the study (in-service questionnaire, pre-service questionnaire, case study, and literature review) are qualitative and interpretivist as they attempt to explain the meaning of a social phenomenon – factors influencing science curriculum implementation (Merriam, 1998). The task of the research was to work with and make sense of the phenomenon through the frames and pre-understandings of the researched (Scott,

1989). The overarching aim of this first phase was to obtain information that could be analysed so that patterns associated with factors influencing science curriculum implementation in New Zealand schools could be extracted and comparisons made (Bell, 1992).

The second stage of the study associated with the development and validation of the Science Curriculum Implementation Questionnaire (focus group, development of the questionnaire, validation, modification and application) uses primarily quantitative methodologies associated with pattern identification and statistical analysis.

All methodological aspects of the first and second phase of the study are explained in detail in the sections that follow.

5.3 In-service Teacher Survey

The purposes of this initial investigation were to:

- (1) ascertain teacher perceptions of their competence in delivering Level One to Four Objectives of the national science curriculum (Years 1 - 8);
- (2) ascertain teacher perceptions of the factors influencing the effective implementation of science programmes and *Science in the New Zealand Curriculum*; and
- (3) examine the biographical details within the context of science education of the participating teachers in order to
- (4) identify any causal links between teacher perceptions and professional science background.

The aim of the investigation was to obtain information from a large school and teacher sample so that patterns associated with factors influencing science curriculum implementation could be extracted and comparisons made (Bell, 1992). For this reason, the questionnaire survey was selected as the preferred method in order to ascertain the features commonly identified by schools and teachers as factors influencing implementation.

A letter of intent (Appendix A-1) was sent to principals of primary, full primary, and intermediate schools and Kura Kaupapa throughout the Central Districts of the North Island. Teachers of year 2, year 6, and/or year 8 were invited to participate (Appendix A-2) in a survey that was directed at identifying trends in teacher perceptions of factors influencing the implementation of *Science in the New Zealand Curriculum*.

The introductory section of the four-part questionnaire (Appendix A-3) addressed teacher biographical details including gender, length of teaching service, teaching level, secondary school, and teacher training details, and relevant in-service and personal experiences pertinent to science as an Essential Learning Area.

The second section of the questionnaire addressed specific achievement objectives and concept areas identified in the Contextual and Integrating Strands of *Science in the New Zealand Curriculum*. A Likert scale ranging from 1 to 3 (1 - Competence not a significant problem, 2 - Competence somewhat of a problem, and 3 - Competence a serious problem) allowed teachers to state the degree of difficulty associated with the teaching of each concept or objective. Teachers were also provided with the opportunity to elaborate on any concerns they might have with regard to the areas listed.

A further section of the survey identified areas, both intrinsic and extrinsic, that potentially could be influencing the effectiveness of science curriculum implementation. Most of these areas had previously been identified by teachers in a survey of teachers' perceptions of factors influencing the implementation of science programmes within the context of indigenous culture (Lewthwaite, 1992). A Likert scale ranging from 1 to 3 (1 - not a significant problem, 2 - somewhat of a problem, and 3 - serious problem) allowed teachers to state the degree of perceived problem associated with each area.

A final section included a series of open-ended questions that asked teachers to:

- (1) suggest the major factors that are contributing to the successful implementation of an effective science education program in their school/classroom;

- (2) suggest the factors considered to be the main barriers preventing or inhibiting the effective implementation of quality science education programs in their school/classroom;
- (3) identify the factors that teachers perceived would ensure the effective implementation of *Science in the New Zealand Curriculum*; and, finally,
- (4) make any general concluding comments that they believed were valuable pertaining to science curriculum implementation.

The open-ended questions were asked in order to provide an opportunity for teachers to elaborate on their perceptions of factors influencing science delivery with the expectation that the responses would provide some insight into the causal relationships between their professional background and curriculum delivery requirements.

5.4 Pre-service Teacher Survey

In order to further examine the importance of professional background on teacher perceptions of their own ability to teach science a survey was conducted on pre-service teachers. The purposes of this research exercise were to determine the prior professional science background of pre-service teachers and to understand the influence a pre-service science education course has on the development of teacher knowledge and attitude in the domain of science education. Again a questionnaire format was used in order to obtain sufficient data so that trends in student responses could be identified.

All students (n=156) participating in this survey had just completed a compulsory science curriculum "methods" paper at a university based teacher education program in New Zealand. The students were in either their second or final year of a newly implemented three-year teacher education degree program. The curriculum studies course explicitly introduced students to the principles and practices of science education relevant to Years 1 to 8 of schooling. The focus was on developing the planning skills and teaching strategies through practical experience necessary to implement a range of science topics relevant to *Science in the New Zealand Curriculum*. Particular emphasis was placed on portraying science as both a process

of enquiry and a body of knowledge (Ministry of Education, 1993). As well as participating in a wide range of valuable investigative-oriented science experiences addressing selected scientific phenomena that are pertinent to the national science curriculum, students were expected to read and reflect on a series of articles addressing issues in science education such as children's thinking, the nature of science, changing and varying approaches to the teaching of science (transmission, discovery and constructivist), gender, and ethnicity. Students also engaged in a series of topic linked 'micro-teaching sessions' at local schools that provided them with the opportunity to plan, teach, and evaluate activities that they themselves had experienced during the curriculum studies course. Students were also expected to independently gather, evaluate, and develop resources for 'stand-alone' and 'linked' lessons that, when taught, promote the sequential development of key scientific ideas and skills. As well, students conducted an open-ended individual or group independent investigation accompanied by a research diary emphasising the investigative process endorsed by the national curriculum. Furthermore, students were expected to keep a reflection diary during the course, which contained their perceptions gathered through formal questions and personal reflections throughout the entirety of the course. Several times during the course these reflections were aired in 'in-class' discussions. Their perceptions of their experiences during the course were formally incorporated into an end-of-course essay addressing their personal development as a primary science educator.

It is considered that the overall course culture was constructivist by nature. Students were encouraged in their scientific and science education skill, knowledge, and attitude development to realise that their learning and development was an active process of accumulation, transformation, and accretion within an environment that is supportive, authentic, intentional, and reflective. These course components were not suggested to be unique to this teacher-training programme. They, instead, reflected the course providers' professional understanding of what constitute best practice in a foundation level science education course.

At the completion of the science curriculum course students were invited to participate (Appendix A-4) in a Likert-scale type questionnaire composed of a series of questions addressing perceptions of their prior experience in science, their

experiences during the science curriculum course, and their considerations of their degree of preparation for their future role as science educators. Since the problems associated with primary science education in New Zealand were, at least partially, associated with teacher perceptions of their own attitude, confidence, and ability (Ministry of Education, 1995), most of the questions on the questionnaire related to their own science and science education experience prior to and during the course (Appendix A-5). All students agreed to participate in the study. Selected students were further invited to disclose their personal reflection comments to support and personalise the patterns identified through the questionnaire analysis.

5.5 Case Study

A case study was conducted at a large, urban New Zealand Intermediate school in an effort to:

- (1) identify what factors, both intrinsic (behavioural) and extrinsic (environmental), within the school environment influenced primary science program delivery;
- (2) determine if some factors collaborated to either mitigate or inhibit science program delivery; and
- (3) ascertain the 'multi-dimensional' nature of some of the phenomena that influenced science program delivery.

From the author's previous research in the area of determining the factors influencing science curriculum and program delivery in general, it was known that a multiplicity of factors interacted to produce the unique character of the entity that is the subject of study. Consequently since a complex network of phenomena was known to influence science program delivery the preferred methodology was the case study. Burns (1990) claimed case studies have the aim of probing deeply and analysing intensively the many phenomena that make up the activities of the unit under study. Yin (1988) suggested that a case study is an empirical study that investigates a contemporary phenomenon within its real-life context; when the boundaries and context are not clearly evident; and in which multiple sources of evidence are used. Haigh (2000) suggested that the case study is the preferred research strategy when *how*, *what* and

why questions are being asked and the researcher has little control over the event or when the research is carried out in a real-life context. These aspects further confirmed using case study as the preferred research method.

In line with the many faces of case study, the method adopted in this study involved a range of data gathering approaches. The in-service and pre-service surveys summarised in Chapter 6 had identified several factors that were influencing science program delivery throughout the Central Districts. Now, the case study was seen as a vehicle for further understanding the multidimensional nature and the inter-relatedness of these factors. Thus the range of data gathering approaches included both qualitative and quantitative strategies. These included a questionnaire survey of all teachers and administrators at Intermediate (Appendix A-7). The questionnaire was divided into four sections. The first section investigated teacher perceptions of their ability to deliver the requirements of the six strands and associated achievement objectives of *Science in the New Zealand Curriculum*. Teachers were asked to rank their perceived confidence in addressing these requirements on a 1 (very easy) to 5 (very difficult) Likert-type scale. The second section required teachers to sort and rank a series of factors according to what degree they perceived these factors influenced science program delivery in their classroom. These factors had been previously identified in the open-ended components of the in-service and pre-service questionnaires as being critical factors influencing science program delivery. These aspects were again ranked on a 3-point Likert-type scale. A second series of items similarly addressed factors influencing science program delivery at the school level. The latter part of this section, an open-ended response question, required teachers to identify the major factors that they perceived were inhibiting science program delivery at the classroom and school level. The third section of the questionnaire illustrated two collections of cards identifying aspects known to influence science program delivery at the classroom and school level. Several of the cards identified various dimensions of the same aspect eg. time, knowledge. Teachers were asked to rank the cards according to their perceptions of how important the factors were in inhibiting science program delivery. A final section of the questionnaire asked teachers to suggest what would be needed to change in order to improve the effectiveness of science program delivery at the classroom and school level.

In line with the range of data gathering approaches used in case study research, interviews were also conducted with representative teachers and administrators at Intermediate School. It was anticipated the questionnaire survey would suggest that teachers would be able to identify and rank the various aspects that would be influencing science program delivery but the interviews would be the most appropriate strategy to deeply probe and intensely analyse the phenomenon of science program delivery (Burns, 1990). It was envisaged that the interviews would 'put flesh on the bones' of the survey and potentially identify processes or interaction among processes that may remain hidden in the survey (Bell, 1992). Those interviewed included three science 'specialist' teachers who were in their first, fifth, and tenth year of teaching. The most senior teacher had also been recently appointed to the senior management team as the Deputy Principal. As well, three non-specialist teachers were interviewed. These again were teachers in their first and fifth and a Senior Teacher in her twenty-third year of teaching. The questions associated with the interviews were both closed- and open-ended and explored more fully teacher perceptions of factors influencing science program delivery (Appendix A-8). As well, the interviews required teachers to repeat the 'card-sort' exercise used in the initial school-wide questionnaire and justify their ranking of factors influencing science program delivery at the classroom and school level. All interviews were tape recorded, transcribed, and verified by the interviewees. In line with Drever (1997) and Bassey (1999), the purpose of the questionnaires and interviews was to collect data that would contribute to theory making in regards to identifying 'what' was influencing science program delivery. In order to more fully understand the complexity of factors influencing science program delivery at Intermediate School, follow-up interviews were also conducted with two of the initial interviewees, one of whom was the present Deputy Principal of Intermediate School. As well, two further people were interviewed. One, a previous Assistant Principal of the school and, the second, a tertiary science educator who has had consistent professional contact with Intermediate School over the past decade. In particular, this individual was the deliverer of the in-service science program at Intermediate School that accompanied the release of *Science in the New Zealand Curriculum* (1993). These two individuals were interviewed in order to validate some of the trends in the responses collected from the questionnaire survey and interviews. In addition, documentation relating to Intermediate School such as recent Education Review Office Reports, *2001 Intermediate School Prospectus* and

Newsletters, Science Curriculum Implementation Plan and local newspaper articles were also reviewed in order to identify any explicit indication of the factors influencing science program delivery at Intermediate School.

5.6 Reviewing and Using The Literature

Literature relating to the implementation of curricula, especially within the context of science education, was also an integral aspect of the first phase of this study. This information has been discussed within a national historical context in Chapter 2 and in Chapter 3. The literature presented in Chapter 3 examined factors influencing curriculum implementation primarily within the context of curriculum reform or change; that is, in the domain of literature specific to the analysis of those processes which influence the intended curricula becoming the implemented curricula. Although research associated with curriculum implementation is widespread, the actual identification of factors influencing science curriculum implementation projects, in particular at the primary level, is very limited.

The literature review was conducted with a dual intent. Firstly, it provided insight into the factors that have historically influenced curriculum, especially science curriculum, implementation. The identification of these factors was essential in providing a validation to the identification of factors influencing science program delivery as ascertained through the in-service and pre-service surveys as well as the case study components of this study. Secondly, it assisted in the identification of 'items' that could be included in the Science Curriculum Implementation Questionnaire.

The analysis of the data collected from the in-service survey, pre-service survey, and case study were anticipated to provide insight into the variety of factors influencing science program delivery at the primary school level. Each of the factors identified in these studies would be added to an 'Instrument Items' list. The list would be a compilation of every statement identified in the literature review and the in-service and pre-service questionnaire surveys and case study analysis. As factors influencing implementation were identified they would be modified to fit the proposed format of the questionnaire.

5.7 Focus Group Consultation

It was anticipated that many of the items would 'repeat' themselves or, at least, belong to general groupings or categories of factors known to influence science program delivery. The identification of these groupings and classification of items was seen as the next critical stage of the instrument development. A focus group, comprised of three couples, was established. The six people each represented a different sector of the primary education community. These included a primary principal, a primary science advisor, a senior teacher, an assistant teacher, a science school syndicate leader and a tertiary science education lecturer. As Knight and Meyer suggested (1996) the focus group is used to identify any gaps in the development of questionnaires, and identify patterns and trends in the data, and trial questionnaires. In order to assist in the development of the questionnaire, the focus group separated into three groups and each group was given the Item List. Each pair was also given a Task Completion Sheet that clarified their role as focus group members (Appendix B-2). The Item List was cut into individual items to assist the focus group members in identifying common groupings of factors. In line with Knight and Meyer, the major role of the members was to sort the items into common groupings. As well, the focus group members were asked to rank the items in each category according to how significant they perceived the items were in influencing science program delivery in the educational context in which they worked.

These average rankings became the central criteria for selecting items for each category to be included in the initial instrument.

5.8 Development of the Instrument

The development of the initial instrument in this study was further guided by the following considerations:

1. *Consistency with existing instruments.* Although many of the factors influencing science curriculum delivery are unique, consideration was given to the physical layout, dimensions, and scales existing in other learning environment instruments. The School Level Environment Questionnaire, in

particular, provided a practical example on which to model the format of the SCIQ.

2. *Economy of use.* Because of the time constraints imposed on teachers and administrators, it was essential to ensure that the instrument would require a relatively short time to complete and process. In order to ensure this, the instrument would ultimately contain 7 items for each of the “factor” scales identified. In order to provide some flexibility in refining the instrument, each scale on the initial instrument would contain 10 items. Thus the top ten average ranked items from each category were included in the instrument.
3. *Coverage of Moos’ general categories.* The dimensions chosen for the Science Curriculum Implementation Questionnaire provided coverage of the three general categories that Moos (1994) identified for all human relationships. These categories Relationship Dimensions, Personal Development Dimensions and Maintenance and System Change Dimensions are all inherent within the extrinsic or intrinsic factors known to influence science program delivery.
4. *Recognition of Lewin’s and Murray’s theories as critical descriptors for understanding human behaviour.* Both Lewin and Murray regarded human behaviour as a function of both the personality of the individual and the environment. Both the environment and its interaction with personal characteristics of the individual were recognised by Lewin as potent determinants of human behaviour (Fraser, 1998). Similarly, Murray’s *Needs-Press Model* described an individuals personal needs and environmental press as critical aspects influencing individual behaviour (Murray, 1938). Incorporating both personal and environment attributes was regarded as essential in the development of the instrument.

5.9 Validation and Refinement of the Instrument

In order to validate the instrument, a large participation of schools and teachers was required. A letter of intent (Appendix C-2) was sent to the principals of 172 primary, intermediate and full-primary schools in the Central Districts of New Zealand inviting principals and teachers to participate in the validation exercise. Statistical analysis was performed to ensure that the Science Curriculum Implementation Questionnaire would measure what it claims to and that there were no logical errors in drawing conclusions from the collected data (Cook & Campbell, 1979). Since the perception measures of the SCIQ are measures of social concepts, Construct Validity analysis was conducted (Cook & Campbell, 1979). The Construct Validity analysis included determining each scale's: internal consistency (Cronbach Alpha coefficient), mean and standard deviation; uniqueness or ability to differentiate it from other scales (discriminant validity - using the mean correlation of a scale with the other scales in the same instrument as a convenient index); and the ability of the scale to differentiate between the perceptions of teachers in different schools (significance variance test). The statistical analysis further provided the necessary data to both refine the SCIQ by reducing, if necessary, the number of scales and the number of items in each scale.

5.10 Application of Instrument

Once refined, the Science Curriculum Implementation Questionnaire was applied at Intermediate School. The initial case study had identified several intrinsic and extrinsic factors influencing science program delivery at Intermediate School. The completion of the SCIQ by the staff at Intermediate School was seen to be a practical context in which to apply the validated questionnaire. Results of the questionnaire were compared to the data collected in the case study analysis. Although the instrument is seen as a somewhat superficial means of assessing the psychosocial and physical dimensions influencing science program delivery, the data collected by the application of the SCIQ was anticipated to parallel the data collected from the more time-consuming case study analysis presented in Chapter 7.

5.11 Summary

The purpose of this chapter has been to describe the methodologies used in the development, validation, and application of an instrument to assist in the identification of factors influencing the effectiveness of science program delivery. The methodologies used in Phase One of the study (in-service questionnaire, pre-service questionnaire, case study, and literature review) are qualitative and are interpretivist as they attempt to explain the meaning of a social phenomenon – factors influencing science curriculum implementation. The overarching aim of this first phase was to obtain information that could be analysed so that patterns associated with factors influencing science curriculum implementation in New Zealand schools could be extracted and comparisons made. Phase Two of the study associated with the development and validation of the Science Curriculum Implementation Questionnaire (focus group, development of the questionnaire, validation, modification and application) uses primarily quantitative methodologies associated with pattern identification and statistical analysis. Chapter 6 presents the findings from the first two research exercises associated with the first phase of this investigation, in-service and pre-service science education.

Chapter 6 Qualitative Data From Pre-service and In-service Teacher Education

6.1 Introduction

This section will present the findings of two exploratory studies into factors influencing science curriculum implementation. Section 6.2 involves the analysis of data from a questionnaire survey of 122 teachers to ascertain what factors they believed were influencing science curriculum implementation at their school. Section 6.3 presents data collected from a study involving 155 students in their final year of a teacher education program. It examines the dimensions of teacher background and teachers' perceptions of their level of preparation and professional science adequacy for their future role as educators. Finally, section 6.4 summarises the information collected from both of these surveys and introduces the intentions of Chapter 7.

6.2 Preliminary Surveys

6.2.1 In-service Education

In all, some 122 teachers representing 92 schools participated in the survey. Twenty-two percent of the participants (n=27) stated that they were science "specialists" and had either been nominated, recommended, or chosen to participate in the survey because of their perceived strength or leadership in the school science program. Several of these teachers (n = 19) had been or were presently responsible for science curriculum implementation at the whole school and/or syndicate level and were able to identify through recent experience factors that promoted and/or inhibited the implementation process.

6.2.2 Perceived Confidence in Science Content Areas

Table 6.1: Teacher Perceptions of Perceived Competence in Content Areas / Achievement Objectives

	Not a Significant Problem		Somewhat of a Problem		Serious Problem	
Living World						
diversity of living organisms	90	(74%)	31	(25%)	1	(1%)
special features of NZ plants/animals	90	(74%)	31	(25%)	1	(1%)
structure/function in living things	94	(77%)	28	(23%)	-	
growth/reproduction in living things	106	(87%)	16	(13%)	-	
interdependence of living things	95	(78%)	24	(20%)	3	(2%)
Physical World						
Light	79	(65%)	37	(30%)	6	(5%)
heat and temperature	90	(74%)	25	(20%)	7	(6%)
Sound	75	(61%)	41	(34%)	6	(6%)
electricity	63	(52%)	44	(36%)	15	(12%)
Energy	53	(43%)	56	(46%)	13	(11%)
magnetism	83	(68%)	32	(26%)	7	(6%)
flotation	102	(84%)	18	(15%)	2	(1%)
how pieces of everyday objects work	79	(65%)	37	(30%)	6	(5%)
Material World						
Nature and properties of substances	53	(43%)	55	(45%)	6	(5%)
properties of substances and their use	51	(42%)	58	(48%)	7	(6%)
how materials undergo change	67	(55%)	47	(39%)	2	(1%)
grouping substances according to their similarities	77	(63%)	36	(31%)	5	(6%)
how selected materials are manufactured	49	(40%)	62	(51%)	4	(3%)
materials and their effect on the environment	67	(55%)	45	(37%)	4	(3%)

Planet Earth and Beyond						
composition of Planet Earth	70	(57%)	43	(35%)	10	(8%)
processes that shape Planet Earth	72	(59%)	39	(32%)	9	(7%)
New Zealand geological history	58	(48%)	55	(45%)	13	(11%)
movement of Planet Earth in relationship to other objects in the heavens	68	(56%)	45	(37%)	11	(9%)
relevant environmental issues	83	(68%)	37	(30%)	4	(3%)
Scientific Skills and Attitudes						
promoting investigative activities	70	(57%)	48	(39%)	6	(5%)
developing skills associated with investigating	60	(49%)	56	(46%)	6	(5%)
The Nature of Science and its Relationship to Technology						
how simple items of technology work	75	(61%)	39	(32%)	8	(7%)
how items of technology have developed	68	(56%)	43	(35%)	11	(9%)
fair testing	75	(61%)	37	(30%)	10	(8%)

Similar to international trends (Tilgner, 1990; Weiss, Matti, & Smith, 1994), Table 6.1 suggested that many New Zealand primary teachers tend to find difficulty in teaching physical science concepts, especially in comparison with their perceived difficulty in teaching biological science concepts. Thirty-eight percent of the participants (n=46) stated that they found the Making Sense of the Material World strand difficult to teach, while 31% (n=38) and 30% (n=36) respectively, found the Making Sense of the Physical World and Making Sense of the Planet Earth and Beyond strands difficult to teach. Participant comments pertaining to the Physical and Material World strands included:

I know I can provide activities in these areas but the learning about them is quite complex. (Year 6 Teacher)

I have trouble enough with some areas myself let alone teaching it. (Year 2/6 Teacher)

Too much is expected. I'm not comfortable with it. It's good our syndicate works at it together. (Year 6 Teacher)

As a primary teacher I always thought I was to be a generalist teacher. The level of understanding I am expected to have for some areas makes me think I am no longer allowed to be just a generalist. (Year 2 Teacher)

Consideration must be given to the large number of participants perceiving a competence problem in all science concept areas. Although the area of teacher competence and confidence is a well-researched phenomenon (Abell, 1990, 1992, 1994; Skamp, 1992), the high incidence possessing a perceived poor competence in the Living World concepts (as high as 25%) is disturbing. While many of the teachers surveyed perceived themselves to be competent in their ability to teach science, it is quite apparent that many others were not secure in their own knowledge, even in the life science area.

A further concern that arises from the survey results is the significant number of teachers who perceived a competence problem with the Planet Earth and Beyond strand. This strand also registered the greatest number of concepts and objectives where competence was perceived as a serious problem. The three areas included composition of planet Earth, New Zealand geological history, and movement of planet Earth in relationship to other objects in the heavens. The *Report of the Mathematics and Science Taskforce* (1997) placed an earnest need for increased emphasis on teacher professional development in the physical sciences because of poor students' performance in TIMSS. This survey would suggest that the Planet Earth and Beyond strand is equally an area in need of inservice support. Teacher comments included:

It is difficult to find meaningful activities for students in areas of the Planet Earth and Beyond strand. (Year 2 Teacher)

(It was noted that several participants stated a similar response for the Material World strand.)

Some of the curriculum (strand) statements are really abstract - especially in Planet Earth and Beyond - it is hard to address them practically. (Year 8 Teacher)

The Planet Earth and Beyond ideas are quite complex ... even at the earliest level. (Year 2 Teacher)

Geology isn't too bad but geological history ... that's a hard area to deal with with my children. (Year 6/8 Teacher)

Even more disturbing is the number of teachers who stated that their competence in implementing an investigative approach was problematic and in need of in-service support (n=62). The majority of participants suggested a competence problem in this area. The central activity of science is investigating and this is embodied as the central theme in *Science in the New Zealand Curriculum*. A philosophical underpinning of the document suggests that children make sense of their world when they are provided with key opportunities to explore their world creatively and systematically. The introductory words of *Science in the New Zealand Curriculum* state that "science involves people investigating...". Teachers, however, in this study, stated that providing these key "children as scientists" opportunities for students was not an easy task. This is a serious issue. The central activity, let alone several of the conceptual areas, was seen as difficult to teach. Teacher comments included:

Science is supposed to require a problem solving approach. I am afraid I just don't have the confidence to let it be as open-ended as it probably should be. (Year 4 Teacher)

More than any other subject, the equipment and management demands of investigating are too much. It's an area I really struggle with. (Year 8 Teacher)

I really want to give it a go, but it is hard to find proven ideas that really fit well with the message of the curriculum. Children are supposed to be 'doing'. I would like to have a better idea of what they should be doing! (Year 1 - 8 Teacher)

I know what science is supposed to be like - it's just hard to get my class doing it in the way I know it should be going. (Year 4 Teacher)

It is clear that not only were many of the concept areas perceived as difficult but so was the integrating of the investigative approach that is necessary to foster this developmental understanding.

6.2.3 Problem Areas in Science Education

Table 6.2: Degree of Problem of Specific Areas for the Teaching of Science for School as a Whole

	Not a Significant Problem		Somewhat of a Problem		Serious Problem	
a. Facilities	52	(43%)	59	(48%)	15	(12%)
b. Funds for purchasing equipment and supplies	52	(43%)	60	(49%)	20	(16%)
c. Children's reading abilities	68	(56%)	50	(41%)	8	(6%)
d. Children's interest in science	104	(85%)	18	(15%)	1	(1%)
e. Children's absences	108	(89%)	16	(13%)	1	(1%)
f. Teacher interest in science	77	(63%)	48	(39%)	2	(1%)
g. Teacher confidence to teach science	50	(41%)	61	(50%)	1	(1%)
h. Time available to teach science	59	(48%)	57	(47%)	19	(15%)
i. In-service education opportunities	43	(35%)	55	(45%)	21	(17%)
j. Large classes	63	(52%)	37	(30%)	20	(3%)
k. Maintaining discipline	95	(78%)	25	(20%)	4	(3%)
l. Parental support	97	(80%)	24	(20%)	7	(6%)
m. Availability of Science Curriculum document	107	(88%)	7	(6%)	-	-
n. Understanding of Science Curriculum document	77	(63%)	41	(34%)	4	(3%)
o. Emphasis school programme places on science education	90	(74%)	29	(24%)	4	(3%)
p. Science equipment	42	(34%)	63	(52%)	17	(14%)
q. Supplementary resources (units, kits) that support science education	46	(37%)	52	(43%)	23	(18%)

In line with international trends, Table 6.2 compiled from a closed-response section of

the survey, suggests that the factors regarded as problematic for the teaching of science were primarily extrinsic (Davis, 1983). Inadequate facilities (60%), insufficient funds (65%), and the lack of equipment (66%) were identified by the majority of respondents as problem issues for teaching of science at the school level. Similarly, in the analysis of the schools participating in TIMSS, primary schools, which in the past have needed a minimum of specialised science equipment, reported shortages in equipment (Garden, 1996). This survey would support this statement. Effective implementation of *Science in the New Zealand Curriculum* cannot take place without the materials necessary for supporting an investigative approach. The prescribed treatment of various concept areas, such as electricity, light, magnetism, and temporary and permanent changes to materials, necessitates an adequate resource base and associated funding. Principals identified equipment shortage as a critical factor restricting their school's ability to provide science instruction. Assuming principal and teacher evaluation is correct, the recent New Zealand Association of Science Educator's effort to compile a science inventory for schools suitable for the implementation of *Science in the New Zealand Curriculum*, is a positive move in providing informed support to schools. Mention must also be made of the large number of participants who recognised the perceived lack of inservice education opportunities (62%) and time constraints (62%) as problems for the teaching of science.

One response virtually summarised all the comments made in response to inservice support.

The value of inservice support is pivotal to effective implementation of Science Education. They can educate and ensure teachers are kept up to date and informed. The teacher training and support associated with the (Science) Contracts was limited but the ongoing support we have received has been critical to ensuring successful implementation. (Year 6 Teacher)

The only intrinsic factor identified by the majority of respondents as a problem for the teaching of science in this closed response section of the survey was teacher confidence. Fifty-nine percent perceived that teacher confidence was a significant problem for teaching science for their school as a whole. Likewise, the *Report of the Mathematics and Science Taskforce* identified teacher confidence as a suggested

reason contributing to the poor performance of students in TIMSS. If a teacher is not confident about teaching science the result is likely to be poorly constructed and implemented programs of learning (Ministry of Education, 1997).

6.2.4 Factors Inhibiting Curriculum Implementation

Table 6.3 identifies the factors perceived to be inhibiting the implementation of science programs. Forty-two percent of respondents again identified resources as the main inhibitor.

A further factor that was commonly referred (31%) to as an inhibitor to effective science curriculum implementation was time availability. Time was referred to in two different respects. Seventeen percent of teachers made reference to the curriculum being too "big" and that to complete all the required components of the Essential Learning Areas was a difficult task.

We are experiencing a 'crowded curriculum syndrome' in our schools. Something has to give. (Year 2, 3, 4 Teacher)

The time factor - the curriculum is too big to fit anything more than four, two-week units per year. With (even) some extra one-off lessons and integration with other Curriculum areas, we still can't cover more than a sample from each of the four worlds (Contextual Strands). (Year 2, 3, 4 Teacher)

Everybody at this school is implementing the curriculum to the best of their ability given their training and background. The important thing is the time factor. It is only one of many to give full credence to with more to come. (Year 2 Teacher)

Not enough hours in the school day! Science has to fit in with everything else we must teach. (Year 2 Teacher)

Table 6.3: Factors Inhibiting Successful Implementation of Science Programs

Resources	52	(42%)
Time	38	(31%)
Confidence	28	(23%)
Facilities	13	(11%)
Attitudes to Science	9	(7%)
Class Size	9	(7%)
Behaviour/Management	8	(6%)
Lack of School Expertise	7	(6%)
Budget	6	(5%)
Problematic Document	4	(3%)
Planning	3	(2%)

A further 14% referred to their own inability to find the time to develop effective science programs. Professional and/or personal commitments were commonly cited as impediments to implementation. Although respondents were affirming a desire to facilitate change, time was a barrier to fostering this process. Changing (the) teaching (of science) is not the same as changing a factory production line. Teachers are having to work over a period of time in order to implement new curriculum policy (Bell & Baker, 1997). Participant comments affirming this dilemma included:

Just having the time to learn and prepare. (Year 8 Teacher)

I have never felt like I have got on top of science. It has always been something I have wanted to do, I just haven't managed to do it. (Year 6 Teacher)

Time! Time! Time! Instead of more curriculum documents from other areas - fewer demands so science could have been focused on instead of squeezed into integrated units which often lack any science identity just so that all curriculum requirements are met. (Year 6 Teacher)

A further inhibitor, personal confidence (sometimes referred to by participants as competence), was mentioned by 23% of the respondents. The comments made often referred to particular Contextual Strands or a general approach to teaching science. As described earlier in this report, difficulty in teaching concepts associated with all the Contextual Strands, even Making Sense of the Living World, and in promoting an investigative approach to science were areas where personal confidence was seen as problematic.

6.2.5 Teacher Background

Table 6.4: Highest Level and Area of Secondary Science Education (Total Responses n=122)

Level	Subject Area	Number of Teachers	
Form 3-4	General	3	(2%)
Form 5	General	40	(33%)
Form 6	1 subject (e.g. physics, chemistry, or biology)	48	(39%)
Form 6	2 subjects (e.g. physics and chemistry)	16	(13%)
Form 6	3 subjects (e.g. physics, chemistry, and biology)	7	(6%)
Form 7	1 subject	5	(4%)
Form 7	2 subjects	2	(2%)
Form 7	3 subjects	1	(1%)

Table 6.5: Teacher Perceptions of the Relevance of Tertiary Science Papers for the Teaching of Science (n=24)

Perceptions of Relevance	Number of Teachers	
Very Relevant	6	(25%)
Somewhat Relevant	11	(46%)
Not Relevant	7	(29%)

Similar to international trends (Tilgner, 1990; Harlen, Horoyd & Byrne, 1995) Table 6.4 suggests that New Zealand primary teachers have a very limited secondary and tertiary science background. Although 58% (n=71) of the participants had undertaken science study at Year 12 (Form 6), only 7% (n=8) had carried this study onto Year 13

(Form 7). Tertiary science experience was limited to 20% (n = 24) of participants while 3% (n = 6) perceived their formal science experience to be relevant to their primary science responsibilities (Table 6.5).

Some comments that pertain to the secondary and tertiary science experience of participants included:

My study in science has given me a great understanding of our natural environment. I refer to these experiences constantly. (Year 6 Teacher)

These courses were helpful in giving me an overall understanding of science concepts and topics but not particularly relevant to teaching science at year 6 level. (Year 6 Teacher)

Only relevant in giving me a big picture understanding. (Year 2 Teacher)

It is essential background knowledge - it is this knowledge I draw on. (Year 2/6/8 Teacher)

It was relevant because it provided me with a basic knowledge base from which to teach. (Year 2 Teacher)

It was inappropriate - little was of relevance to what I am required to teach today. (Year 6 Teacher)

Not relevant in the least. I thought that it would be of benefit in my professional development. It missed the target! (Year 8 Teacher)

These comments give testimony to a varied opinion of the value of secondary and, to a greater extent, of tertiary science courses in preparing teachers to teach primary science. Although some participants selected science subject studies as a curricular emphasis in their pre-service training, not all regarded these courses as relevant to their teaching role. Studies have attempted to ascertain the transferability and appropriateness of both "science for teachers" and "science for scientists" courses typically provided by colleges of education and colleges of science respectively (Kennedy, 1998). Positive comments were primarily attributed to courses that were applicable and appropriate to the content areas and topics covered in Levels 1 to 4 of *Science in the New Zealand Curriculum*. Overall, science is not a subject that most teachers of primary schools have had much experience with at secondary or tertiary level. For those that have, the appropriateness of their experience, especially at the

tertiary level, is questionable.

This limited science experience was also applicable to the professional component of their pre-service training. Fifty-eight percent (n=71) of teachers perceived that their pre-service teacher training was inadequate or limited in its preparation for their present science teaching responsibility. Emphasis in pre-service science education courses is on process, methods, and curriculum rather than content (Tilgner, 1990). This was quite evident from participant reflections on pre-service preparation:

It gave me the basics, but just enough to understand the document. (Year 6 Teacher)

We were introduced to some useful activities and resources, but that was about all. (Year 6/8 Teacher)

I collected very valuable resources but not enough to start to sustain or understand what I am expected to do now. (Year 2/6/8 Teacher)

These findings raise serious concerns about the adequacy of the preparation of teachers for their role as primary science educators, especially if their preparation is limited to curriculum methods courses essentially devoid of a broad, fundamental understanding of scientific phenomena. This report has previously highlighted the degree to which teachers perceive that their own understanding, confidence, and competence in both science content and the investigative process is a problem in delivering science programs.

All (New Zealand) primary school teachers teach science, and teachers must complete a core course of at least 72 hours in science content and pedagogy as part of their pre-service training. More advanced courses are available (but are an optional component of the teacher training program) (Garden, 1996). As mentioned in Chapter 1, The Mathematics and Science Taskforce (1997) was established by the Ministry of Education in response to New Zealand's poor performance in TIMSS to advise on suitable strategies for improving science and mathematics education in schools. The taskforce heard that in some pre-service programs, trainee teachers get as little as 50 hours science in a three-year course. This was regarded as too little to ensure that teachers have the skills and knowledge required. The science taskforce sub-group emphasised that pre-service teacher trainees need the opportunity to develop their

understanding of scientific knowledge and processes as well as expertise in the teaching of science. A larger proportion of the time available in pre-service programs needs to be allocated to science (Ministry of Education, 1997). After all, a good pre-service program is the first step in preparing qualified teachers (Tilgner, 1990).

Recent developments at most of New Zealand's Colleges of Education and other teacher training institutions have seen the implementation of three year teaching degrees replacing the traditional sequence of a three year diploma followed by an optional additional year at university to complete a Bachelor of Education degree. Associated with this change is a confirmed reduction in the length of compulsory science curriculum in the new degree structure, in most cases much below the 72 hours alluded to by Garden.

Table 6.6: Recent Graduate Perceptions of the Adequacy of Pre-service Preparation (n = 24)

Perceptions of Preservice Training	Number of Teachers	
Very Good	4	(10%)
Acceptable	16	(45%)
Inadequate/Limited	16	(45%)

One might assume that the difficulty many primary teachers have in teaching science is due to the relatively recent implementation of *Science in the New Zealand Curriculum*. Table 6.6 suggests that recent graduates are not any more prepared to effectively implement and teach science programs than their more experienced colleagues. Of the 36 year-one teachers, 45% (n=16) perceived their preparation to teach science as inadequate.

Overall, participant responses raise serious concerns about the adequacy of the preparation of new primary teachers for developing science understanding in pupils. Based on respondent comments, it would appear that pre-service education is not challenging but perpetuating the existing malaise in primary science education. The majority of new graduates appear to be in need of the same support that the more experienced teachers suggested they require.

6.2.6 Factors Presently Promoting Implementation

Table 6.7: Factors Contributing to Successful Implementation of Science Programs

Resources	53	(43%)
Teacher Enthusiasm	45	(37%)
Teacher Confidence	44	(36%)
Good Planning	31	(25%)
Student Interest	23	(19%)
Advisory Support	20	(16%)
Supportive School	21	(17%)
Supportive Community	12	(10%)
Science Focus in School Programme	9	(7%)
Presence of a Science Co-ordinator	8	(6%)
Facilities	9	(7%)
Good Integration with Other Curricula	3	(2%)
Responsiveness of Students	3	(2%)
Class Size	2	(2%)
Easy to Understand Curriculum	2	(2%)

Table 6.7 supports the assertion that resource adequacy was a major factor promoting effective science education implementation in schools in the Central Districts. This table is compiled from teacher responses to an open-ended question asking teachers to identify the factors that have contributed to the effective implementation of science programs. In most cases (n=61) teachers identified more than one factor. "Resources" was a loose collection of responses that included such things as prepared units of work that were completely transferable to existing school programs, computer software, and individuals in the community that were recognised as having a

significant expertise appropriate to topics of study. Most commonly, resources were referred to as written/material resources and equipment that had been prepared or purchased that were kept in a central location where they were accessible and used by the school/syndicate.

Reference was made to resource providers such as the National Library, Teacher Support (Advisory) Services and Colleges of Education. Of the 44% that referred to resources as a major factor contributing to effective implementation, only 2% of the total number of respondents made mention of using written resources/kits in the “just add water” manner. Typically teachers were adapting appropriate resource packages to suit their needs. Comments also indicated the evolutionary nature of the development of the school science program and associated resources.

We are well resourced and are well aware (informed) of the resources we have available. There really can't be any excuses! (Year 6 Teacher)

The Report of the Mathematics and Science Taskforce (1997) asserted that Ministerial effort in supplying resource material to support teachers in their efforts to implement *Science in the New Zealand Curriculum* is vital. The recent release of the Mathematics, Technology and Science school journal, *Connected*, as well as the *Making Better Sense of ...* series, together with Science Resource Units and accompanying professional development in selected areas is, based on respondent comments, a valid effort.

The second major factor perceived to be contributing to the effective implementation of science programs was, an intrinsic factor, teacher enthusiasm and motivation. Thirty-seven percent of respondents made reference to a general motivation to “make science work” in their schools. Motivation emanated from a variety of sources.

Many teachers mentioned intrinsic personal interest for the subject that provided the impetus for the teaching of science.

My personal background – I have always had a love for exploring our environment. I see that as the essence of science and I want to pass that interest on to my students in all areas, not just science. (Year 2 Teacher)

I had a great experiential education. I want the same for my students.
(Year 8 Teacher)

Several others mentioned external motivators such as student or colleague interest in science or the “obligation” they felt to provide students with a well-balanced program.

Children’s curiosity. (Year 2 Teacher)

I don’t think our students would let us away with not studying our world!
(Year 6 Teacher)

It was evident that some teachers were motivated through prescription. Comments included:

I (We?) never enjoyed science, but that does not prevent us from delivering what is required – a good science programme. (Year 2 Teacher)

I have learned to like science and enjoy teaching the science that we do. The fact that we work at it together has made all the difference. (Year 6 Teacher)

For others the motivation could be described as simply a strong professional ethic.

Teacher willingness. (Year 2 Teacher)

Personal motivation. (Year 2 Teacher)
Teacher enthusiasm and focus. (Year 6 Teacher)

Attitude – it’s more than just interest and enthusiasm – it’s just getting committed to what is expected. The majority of teachers in primary school are “Arts/Language” based. Emphasis is on learning to read which is OK but then, learning by reading ... that’s so limited. Science provides a further way of learning. So much of it is just attitude. (Year 2 Teacher)

Thirty-six percent of respondents made reference to personal confidence being a factor in contributing to effective science delivery. This confidence commonly emanated from personal experiences, inservice involvement, and teacher training. Comments pertaining to teacher training included:

I was a science major at T.Col. (Teachers’ College). (Year 6 Teacher)

My previous science training at College and willingness to do my own thing and not follow the trend of the rest of the school. (Year 6 Teacher)

6.2.7 Factors Perceived To Be Able To Promote Effective Implementation

Table 6.8: Factors that Teachers Perceive Will Make Implementation of Science in the New Zealand Curriculum a Reality

Professional Development	41	(34%)
Resources	34	(28%)
Time	32	(26%)
Facilities	12	(10%)
More Specific Curriculum Directive	11	(9%)
Budget Allocation	9	(7%)
Planning	9	(7%)
Assessment	9	(7%)
Class Sizes Made More Manageable	7	(6%)
Improved Attitudes	1	(1%)
Science Leadership in School	1	(1%)
Distinguishing Science From Technology	1	(1%)

So what were the major factors believed to contribute to effective science program implementation? Teachers identified several factors that they believed would promote effective curriculum implementation. These are summarised in Table 6.8. The most common factor cited was the need to develop teacher expertise in science and/or the teaching of science. Thirty-four percent of respondents saw the need for further in-service training in order to ensure effective science implementation in their own classroom. Advisory support, access to good science practitioners, videos, refresher courses, and a school-based professional development focus were often referred to. Teachers were openly identifying a personal or school need for ongoing professional development.

Ongoing support for teachers. Support that allows them to see the practical and creative part of science. (Year 6/8 Teacher)

Adequate training on using the document - with a particular emphasis on the 'spirit' of the document. (Year 6 Teacher)

I have a few basic starter units. I would need further assistance if I was teaching at a higher level in the school. (Year 2 Teacher)

As would be expected time (26%) and resources (28%) were commonly cited as factors that would foster the effective implementation of *Science in the New Zealand Curriculum*. A further 10% suggested that school facilities also needed to be addressed. For older students and larger classes, the practical nature of science was seen to be often incompatible with the typical classroom.

The more specialised nature of some of the things we do is really awkward in our senior school. We really give thought to what we will try with our students because of how cramped we are even before we start to think about spreading out. (Year 6 Teacher)

Smaller classes or more space. (Year 8 Teacher)

A final question in the survey provided the opportunity for teachers to make any further comment related to the survey focus. Fourteen teachers took the opportunity to make comment. What was particularly evident was a repeated comment that pertained to how a collaborative effort to implementing the curriculum had made all the difference. As one respondent stated:

None of us would feel particularly strong in the area of science. Our limited training and the initial and ongoing Curriculum Development Contracts provide us with a base to work from. Since then we just continue to work together towards what is required and what we know our children enjoy. (Year 4, 5 Teacher)

This one comment summarised the present situation in New Zealand science education. Teachers, by and large, see themselves as inadequately prepared to implement *Science in the New Zealand Curriculum*. Whilst it is recognised that recent efforts by the Ministry of Education to affect change are admirable and valuable, a more concerted effort must occur to bring about reform in primary science education. Although system elements such as practical resources (eg *Connected*, the *Making*

Better Sense of ... series, and now appearing Science Resource Units) are integral components towards affecting teacher change, various other preconditions and mechanisms appear to be necessary to bring about fruitful curriculum implementation. When commonalities of strategies promoting teacher change are identified, it is apparent that the recent Ministerial efforts are likely to bring limited success. The strategies appear to be more of a short-term "injection" rather than a long-term commitment to fostering improvement in primary science education. Although the release of quality instructional materials with associated professional development will be a critical positive factor in fostering change, the lack of long-term support, is unlikely to sustain curriculum change.

International efforts would indicate that the most probable positive outcome of the recent efforts will be an increased awareness by teachers of the present situation (Harlen, 1997). Although there will be teacher change, it will not be enough to remedy the situation - especially since there is no accompanying national strategy to address pre-service teacher education which appears to be contributing to the perpetuation of the existing malaise. TIMSS results identified the need for teacher change. Even though the present Ministerial efforts are the most ambitious documented efforts in science education, nationally, a massive and sustained pre-service and in-service strategy is needed to bring about change in science education practice in New Zealand primary schools.

6.2.8 Summary

It also should be noted that nowhere during this analysis has there been reference to the "resistance" that is often suggested to exist in the primary school program to the implementation of science programs. Tilgner (1990) suggested that for a variety of reasons the teaching of primary science is often avoided. It is well known internationally that despite a great deal of effort and enthusiasm devoted to the cause of primary science, the science experience of the majority of children in the first eight years of schooling is minimal (Harlen, 1988). Although schools suggest a familiar list of factors influencing implementation (equipment, space, background knowledge, and confidence of teachers, as well as outside support) a "deeper reason" impeding implementation is often suggested. Thomas (1980) stated that in Britain the difficulty

that primary teachers have had in taking on and adapting the various primary science projects of the last two decades suggests that teachers in general are not convinced of the worth of this kind of work. Thirty-seven percent of respondents in this survey identified teacher interest in science as an inhibiting factor to effective science program implementation. Consequently, a very important intrinsic factor, a general negative ethos to science as an Essential Learning Area, may continue to inhibit the effective implementation of science programs in schools. Not only for a generation of practising teachers, but also for future generations, if pre-service training does not address the problems of competence expressed by TIMSS and confirmed by this study. Section 6.3 follows and describes pre-service training teacher perceptions of their science background and professional capabilities as science teachers.

6.3 Pre-service Education

All students (n=156) participating in this survey had just completed a compulsory science curriculum "methods" paper and were in either their second or final year of a newly implemented three-year teacher education degree program. The 3 year program provides students with opportunity to do further study in science education through either selected science studies in subjects courses (emphasising subject matter knowledge) or science curriculum studies courses (emphasising pedagogical and pedagogical content knowledge). Because of the transitional arrangements associated with the implementation of the degree only eight of the students involved in this sample had completed or were intending to complete further science courses in their pre-service training program. Thus, of the 156 students involved in this study, 148 students (95%) would be graduating from the program having completed only this foundational science education course. In comparison to preceding and, the present, succeeding years, this number is considerably higher than usual.

6.3.1 Prior Science Experiences

Table 6.9 below represents teacher trainee perceptions of their science background.

Table 6.9: Prior Science Experience

	Strongly Agree	Agree	Neither Agree Nor Disagree	Disagree	Strongly Disagree
I have a strong science background.	5 (3%)	11 (7%)	24 (15%)	80 (52%)	36 (23%)
I was a successful science student at secondary school.	9 (6%)	22 (14%)	58 (37%)	38 (24%)	29 (19%)
Boys were more successful at science than girls during my school years.	7 (5%)	11 (7%)	91 (58%)	26 (17%)	21 (13%)
I had a positive science experience at secondary school.	8 (5%)	13 (8%)	59 (38%)	42 (27%)	34 (22%)

Similar to international trends (Gustafson & Rowell, 1995; Harlen, Hoyroyd, & Byrne, 1995; Mulholland & Wallace, 1996; Symington, 1974, 1982; Symington & Hayes, 1989), Table 6.9 suggests that New Zealand primary teachers, including those training to be primary teachers, have a very limited science background and an overall weak science experience. Of the 156 students participating in this study, only 10% (n=16) considered that their science background was strong. The data do not substantiate whether 'strength' of science experience was perceived to have its foundation in the amount of science they have studied or the quality of their experience. Personal reflection comments provided some clarification by those who perceived their science background to be strong.

Although my formal experience in science has been quite limited, the informal experiences I have had have provided me with a very good understanding of the topics relevant to primary science. I feel quite confident in addressing

most of the areas identified (by the national curriculum).

I never considered myself to have been a science student (at school), but relative to the background of others (at college) I see that I have a very good science background.

We were strongly encouraged to study science (in high school). It was an unspoken compulsory subject at the sixth form level and most everyone continued that on to bursary. I feel very comfortable with science.

Comments such as these would suggest that 'strength' of science background was interpreted as being the degree to which students felt comfortable or familiar with science as a product of both formal and informal experiences. Indications from this analysis would suggest that today's pre-service teacher trainees, similar to the participants in the in-service survey, continue to have a very limited formal and informal science background. This creates cause for continued concern since as Tilgner (1990) identified, inadequate teacher background in science is one of the primary obstacles to the effective teaching of science frequently cited by elementary teachers.

Teacher trainees also identified that they have had limited success in science. 20% (n=31) of students perceived they were successful as science students in secondary school. What constitutes 'success' is not clarified by this study although student reflections suggest success is interpreted primarily on the basis of formal achievement.

I managed to do well in the sixth form. Bursary was beyond me.

My bursary grades were a surprise.

I completed biology and chemistry up to and including the seventh form. I did quite well in my bursary exams.

National surveys (Chamberlain cited in Garden, 1996) would indicate that although girls' attitudes towards and interest in science continues to decrease at the Form 2 and Form 3 level, their performance continues to be on par with, at least at this level, with boys. Training teachers in this survey did not see boys as being significantly more successful than girls in science at secondary school.

Indications from this survey suggest that not only have many primary teachers had a poor or science 'nonexperience', they also enter teacher education programs having had a 'misexperience' (Appleton, 1991; Skamp, 1989, 1998). Only 13% of the participants in this survey regarded their science experience at secondary school to be positive.

I knew that science was a compulsory part of my (pre-service) training and I faced this event with self-induced intrepidation! My school science experience was terrible. It was a foreign world and I was made to feel I didn't belong.

I appreciated the discussions we had early in the course regarding our prior science 'experience'. I quickly realised that my negative perceptions of science were typical of many other students - both male and female, recent school leavers and more mature students. This was reassuring.

Openly expressing and discussing our views on the nature of science based on our past experience was important to me. I appreciated being able to express my views I was not the only one that believed science had been like a foreign language.

I can't recall studying science at primary school and in secondary school I can remember 'watching' science. I can remember that when we did try experiments they were followed by demonstrations to show us the 'right' methods leading to the right answers.

White (cited in Skamp, 1992) suggested that student perceptions of or attitude towards science is the person's collection of beliefs about it, and episodes that are associated with it, that are linked with emotional experiences. These comments would indicate that students are able to provide reasons to substantiate their perceptions regarding how positive their secondary science experience has been.

Overall, student responses would indicate that a large majority of students currently entering teacher education programs perceive, and probably quite accurately, that their science background was not strong and that they have had limited success in science at secondary school. In addition, the majority of students perceived that their science experience had not been positive. This provides for a difficult situation for science teacher educators. As Mulholland and Wallace (1996) suggested, breaking the cycle of poor experiences with school science leading to a lack of confidence in teaching elementary science is a particular challenge for preservice science educators.

Although there are explicit requirements detailed in terms of learning outcomes for all teacher education courses, science educators are also faced with the task of implicitly addressing the negative perceptions and misunderstandings teacher trainees generally have of the nature of science and their future role as teachers of science.

6.3.2 Pre-service Science Education: Present Experience

Table 6.10 presents a summary of student responses to a variety of questions related to the science education experience provided by the foundation curriculum studies course.

Table 6.10: Pre-Service Education Experience

	Strongly Agree	Agree	Neither Agree Nor Disagree	Disagree	Strongly Disagree
I have found that the hands-on experiences I have had in Curriculum Science sessions have developed my confidence in teaching science.	59 (38%)	64 (41%)	27 (17%)	4 (3%)	2 (1%)
I have found that the opportunity to microteach science lessons on Placement Days has helped me to develop a confidence in my ability to teach science.	76 (48%)	64 (41%)	10 (6%)	6 (4%)	2 (1%)
I have found that the supportive collegial environment of my Curriculum Studies class has contributed to my ability to teach science.	38 (25%)	46 (29%)	50 (32%)	13 (8%)	9 (6%)

The personal investigation I undertook has improved my confidence in the scientific process.	27 (17%)	32 (21%)	86 (56%)	7 (4%)	4 (2%)
The Course Readings have developed my understanding of issues relevant to the teaching of science.	27 (17%)	59 (38%)	43 (27%)	15 (10%)	12 (8%)
I would have liked more emphasis on scientific knowledge during this course.	4 (3%)	17 (11%)	82 (53%)	42 (27%)	11 (7%)
The Reflection Task Assignment gave me an opportunity to put together the theoretical and practical components of this course.	16 (10%)	60 (38%)	54 (35%)	20 (13%)	6 (4%)
The resource file I have compiled will be valuable to me as a teacher of science.	68 (44%)	34 (22%)	34 (22%)	10 (6%)	10 (6%)
My overall impression of this course is positive in regards to its effectiveness in promoting my ability as a teacher of science.	69 (45%)	64 (41%)	10 (6%)	10 (6%)	3 (2%)
I am pleased with the overall progress I have made as a teacher of science during this course.	79 (50%)	62 (40%)	10 (6%)	4 (3%)	2 (1%)
My attitude towards science has become more positive during this course.	79 (50%)	64 (40%)	9 (6%)	4 (3%)	1 (1%)

The majority of students identified several areas in which they had experienced personal development during the course. The supportive collegial classroom environment was recognised as having a positive contribution to their confidence development and ability to teach science. The constructivist nature of the classroom environment was seen to be a critical factor in promoting this development (Mulholland & Wallace, 1996). Practices that are learner-centred and issue or context-centred incorporating practical hands-on, experiential, teaching-related and non-threatening, collaborative learning strategies are known to promote positive attitude changes and confidence (Bearlin, 1990). Some personal reflections in this area included:

The greatest difference that I see in the nature of science as presented (in the national curriculum), is that science is a process that 'involves' people investigating. My prior science experience emphasised a nature of science that isolated people from the process as it emphasised only science as demonstrations and knowledge based. I enjoy being involved with science in this course.

Science has always been to me only a body of knowledge. This course has emphasised that science is more than just knowledge; it is a process of activity leading to knowledge outcomes.

I have experienced the importance of being involved in science. My own personal confidence in science as a student has been enhanced by the opportunity to be involved with a variety of practical science activities. This opportunity to participate in the activity of science is one I have not had before.

Student perceptions of the value of the microteaching sessions provided during the course gave clear indication that these opportunities helped develop confidence in their ability to teach science. Student comments in this area included:

The opportunities I have had to teach science in a structured environment have been invaluable. I feel I have been eased into the 'teaching of science culture'.

I think that it has been important to experience science in the last year of training. The resource, management and knowledge preparation requirements associated with the teaching of science really challenge my teaching ability.

The placement day opportunities, although in a somewhat 'insulated' environment, exposed me to the sheer delight children can have in learning. I

see the value of incorporating investigative opportunities in all aspects of my teaching.

"The children's response was excellent. The activities required no motivators, they were motivating themselves. I look forward to my own classroom and the opportunity to practice what I have learned."

The perception of the placements was that they were beneficial to the development of student confidence in their ability. The practical experience is perceived as a useful opportunity for students to apply their theoretical classroom learning under authentic conditions (Cooper & Orrell, 1999). It provides opportunity for immediate socialisation into the profession within a system of guidance and instruction with immediate feedback on their performance (Cooper & Orrell, 1999). Students placed considerable value on the concrete experience provided by the practicum components of their course primarily because it was seen to foster their socialisation into their future professional role.

The majority of students also recognised the value of the course readings (55%) and, to a slightly lesser extent, the reflection essay (48%) in integrating the theoretical and practical components of the course.

I can identify with the fact that science is wrestling to remove the 'men in white coats' image (described by Weiss, 1979). I myself have wrestled with that idea during the course. I sometimes wonder if we have actually been doing science because the nature of science endorsed has been totally different to my own experience.

"The changing approaches to science education (described by Lewthwaite, 1992) are so familiar to me. I can see through my own experience and the response of the children (on placement days) that a variety of teaching approaches are necessary as a teacher of science.

Students were also very comfortable with the degree of emphasis on the development of scientific knowledge during the course. As other researchers have noted (Biddulph, 1990; Jones, 1991; Osborne & Simon, 1985; Skamp, 1998) students overcome some of their initial fear about science education when they realise that the course is about 'teaching us to teach science' not just 'teaching us science'. Rather than experiencing science as an accretion of a transmitted body of knowledge students are involved in the same activities in which their own students will be with the clear

identification of the ideas and processes being developed by the activities. Although the majority of students (67%) perceived that they needed to develop a better understanding of scientific phenomena in order to be more effective as a teacher of science, only 14% would have liked more emphasis on scientific knowledge during this course.

Only 6% (n=11) of students did not agree that their involvement in a personal scientific investigation had improved their confidence in the scientific process. The in-service study of practising teachers identified that many New Zealand teachers are not confident in not only teaching, but also in their general understanding, of the investigative process as defined in *Science in the New Zealand Curriculum*. The opportunity to carry out a personal investigation provided students with an opportunity to not only develop their confidence in the investigative process but also enhance their understanding of the nature of science.

The central theme (in the national curriculum) is investigating. Not just the accumulation of knowledge. From my own experience (in carrying out the investigation) I can see that the verb part of science (science as a process of enquiry) provides an opportunity for children to develop a better understanding of the noun part(science as a body of knowledge).

Investigating provided the opportunity for me to see the variety of skills and attitudes at work by scientists and children when they are investigating. I, in particular, understand the importance of 'scientific' perseverance and honesty!

Overall, student perceptions suggested that their experiences during the foundation curriculum studies course were very important in not only developing their knowledge and confidence in science and the teaching of science but also improving their overall attitude towards science as a curriculum area. Students gave strong indication that the course had been effective in promoting their ability as teachers of science.

6.3.3 Looking Ahead to My Role as a Teacher of Science

Table 6.12 provides a summary of responses to questions related to training teacher perceptions of their future role as a science educator.

Table 6.12: Looking Ahead to My Role as a Teacher of Science

	Strongly Agree	Agree	Neither Agree Nor Disagree	Disagree	Strongly Disagree
I need to further develop my understanding of scientific phenomena in order to be more effective as a teacher of science.	74 (48%)	46 (29%)	23 (15%)	5 (3%)	8 (5%)
I feel adequately prepared to teach Year 1 to Year 8 science.	11 (7%)	48 (31%)	52 (33%)	31 (20%)	14 (9%)
The foundation Science Curriculum course is sufficient in preparing me to be a more effective teacher of science. A further course is not necessary to my training.	4 (3%)	21 (13%)	75 (49%)	46 (29%)	10 (6%)

Even though student responses gave clear indication that they had experienced considerable personal and professional development during the course, students recognised their personal need for further development. Only 16% (n= 25) perceived that the foundations course was sufficient in preparing them to be a more effective teacher of science. For these students, a further course was not necessary during their training. Thirty-five percent (n=56) suggested that the foundations course was not sufficient. This result closely parallels the trends identified in the survey of practising teachers, outlined in the previous section, where 45% of first year teachers perceived their pre-service training to be inadequate in its preparation for their future role as primary science educators. Although, in this study, 38% (n=59) felt adequately trained to teach science, these professional reservations of 'adequacy' could potentially

have been indicative of their reservations concerning their future role as educators in general. Whilst students indicated that 'more' is 'preferred', personal reflections indicated the development in knowledge, skill, attitude, and overall confidence had provided a certain assurance about their role as future primary educators.

Prior to this course and the opportunities it provided, science would have been a subject I would have continued to ignore as a teacher just like I did in my studies at (secondary) school. I'm on track now!

Probably the most important development for me is the removal of a personal fear barrier. I realise the importance of me giving attention to the poor understanding I have, but with the better confidence I have in my own ability in science, I do not see this as a problem anymore.

Just like a child's ideas are not fully formed so aren't mine in terms of my understanding of scientific things. I recognise that I have much more learning to do. I am not threatened by that.

We learned that science has an evolving 'body of knowledge' and that new developments in technology lead to new understandings. I can identify with this in my own life as I move on to a career as a teacher. I feel the experiences I have had over the past semester have been the technology contributing to my own professional development.

Although this survey would indicate that students have made considerable progress in their attitudes, knowledge, and overall competence as science educators during their pre-service training, the ultimate measure of success of a pre-service teacher education program is the performance of graduates when they commence teaching (Appleton & Kindt, 1999). Of particular importance is determining what happens to students' good intentions once they experience the constraints of the school system (Appleton, 1984). Veenman (1984) suggested that socialisation into the profession often evaporates even the best intentions of the beginning science specialists. Clandinin (1989) suggested that workplace constraints tend to have a neutralising influence on starting specialist teacher's ability to effectively implement science programs. Accounts such as these identify several intrinsic factors such as teacher knowledge and attitude as critical agents influencing curriculum implementation. As well, they identify extrinsic factors that constitute the school environment (resource adequacy, affiliation, time, curriculum priority placed on science, collective professional interest, etc.), as agents that overwhelm even the best intentions of beginning science educators. If this is the case for the primary science specialist what

becomes of those students (such as those participating in this survey who are likely to be representative of the generalist primary teacher) with only a foundational exposure to science as an Essential Learning Area? Even though a new teacher may be able to affect significant change it is unlikely that a teacher still questioning their adequacy will be able to resist 'compliance' and effectively implement a quality science education program.

6.3.4 Summary

Clearly, the recent ambitious efforts by the Ministry of Education of New Zealand need to recognise that pre-service science education also has a part to play in addressing the disturbing state of primary science education in New Zealand. The Third International Mathematics and Science Study and subsequent Report of the Ministerial Taskforce on Mathematics and Science Education have identified the need to address the level of knowledge, skills, and confidence of practising teachers in New Zealand. This study would affirm that in order to address the existing maladies in primary science education in New Zealand, a more coherent and sustained strategy must be developed by the various sectors of the educational community. This strategy must give attention to not only continued in-service teacher development but also pre-service science education and teacher recruitment as further critical agents in effecting teacher change.

6.4 Chapter Summary

In making this statement we need to also be aware that the factors influencing science program delivery go beyond the professional science adequacy of the teacher. Extrinsic factors as well strongly influence science program delivery. This chapter has outlined the data collected from both an in-service and pre-service questionnaire survey that identify the many factors influencing science program delivery in New Zealand schools. In order to more deeply probe the phenomenon of science program delivery and the factors that influence it, in Chapter 7, the findings from a case study analysis of factors influencing science program delivery at a large intermediate school in New Zealand are presented.

Chapter 7 Case Study: Intermediate School

7.1 Introduction

This chapter presents the findings of a case study examination of factors influencing science curriculum implementation at a large urban intermediate school in New Zealand. Section 7.2 provides a description of the school in the context of science program delivery. Section 7.3, which is based on results gathered from a questionnaire survey, examines teacher perceptions of their perceived ability to teach to the skills, attitudes and conceptual knowledge requirements of the national science curriculum. Section 7.4, which is also based on information gathered from the same questionnaire survey, examines teacher perceptions of the factors influencing science program delivery at the classroom and school level. As well this section examines teacher perceptions of the strategies that would need to be employed to improve individual classroom and school-wide science program delivery. Section 7.5, which is based on information gathered from selected teacher interviews with current and past teachers at Intermediate School, further examines factors influencing science program delivery at the classroom and school wide level. Finally, section 7.6 summarises the findings of the case study and aligns the data collected from the Intermediate School case study with the background literature presented in Chapter 3 and the data collected from the previous studies associated with this thesis outlined in Chapter 6.

7.2 Intermediate School

Intermediate School is a large Year 7 and Year 8 school in an urban centre in New Zealand. The school has student enrolments of 640 and caters for students from seven contributing schools and two integrated catholic primary schools. It is the oldest and largest of the intermediate schools in the city area and is classified as decile 9 (on a scale of 1(lowest) to 10 (highest)) in terms of socio-economic profile. Students come from a wide area of the Manawatu province and bring with them a generally high level of academic attainment. The school consists of 33 staff members, 23 of whom are fulltime classroom teachers, including a principal, deputy principal, and assistant principal. As a “normal” school (from l’ecole Normale) the Intermediate has a close association with the local College of Education, primarily to facilitate programs that prepare trainees for teaching. The School Mission Statement states that the purpose

of the school is to promote growth (Intermediate School, 2001). It aims to help students develop skills, attitudes, and knowledge for growth now and in the future. It endeavours to achieve this in a happy, secure, and challenging environment that is conducive to learning for all students no matter what their cultural background or academic ability. It endeavours to provide for both accelerate students and those with identified learning needs. The school aims to provide well-balanced programs with emphasis on Mathematics, English, Science, Social Studies, Technology, Health & Physical Education, and The Arts. It ensures through program monitoring that all students will be taught these core subjects.

Within the context of science program delivery, the Science Curriculum Implementation Plan forms the framework for student learning and is reflective of the intentions of *Science in the New Zealand Curriculum*. Although there is no specified time allocation or timetabled 'spot' for science in the school program, it is expected that science will be taught as part of the school curriculum. As part of the school science program students are responsible for the on-going monitoring and maintenance of a rejuvenating native bush remnant in the vicinity of Palmerston North. The school, unlike most intermediate schools, has a science room (laboratory) that is equipped to assist, when appropriate, with the delivery of more specialised activities within the school's science program. This facility is booked on a first-come, first-served basis and is maintained by a Teacher Aide as part of her school-wide Teacher Aide duties. Most of the science equipment required for the science program is stored in this laboratory. Teachers are responsible for ensuring that the equipment, once used, is replaced and returned to this central location. The Teacher Aide ensures that the equipment is replaced and organised properly. The science school scheme and school-based prepared units of work are kept in the school staff room.

As part of the annual Teacher Review Process teachers are asked to identify individually and collectively areas of required professional support. If science is recognised as an area requiring support, endeavours are made to ensure that this identified need is addressed. Over the past few years, several teachers have identified science as an area requiring professional support. The in-service support provided in these cases primarily has been through advisory programs offered by the local College of Education. In the year in which the case study was completed, three teachers, all

non-science specialists, were involved in in-service programs. The majority of the school staff were involved in the initial Ministry of Education Science Facilitation Contracts that accompanied the release of the national science curriculum in 1993. Only one of the teachers presently at the school, the current Deputy Principal, participated in this science contract.

All teachers at Intermediate School, aside from the three technology specialist teachers, teach science. Teachers work in syndicate 'teams' and each team, although responsible for their own planning, curriculum implementation, and delivery, generally teaches to the specifications of the school-developed Science Curriculum Implementation Plan. Although there is room for considerable flexibility in the manner in which the science curriculum is delivered in the school, teachers tend to teach to the requirements of the four Contextual Strands of *Science in the New Zealand Curriculum*. Teachers do this by addressing at least two of these strands in any given year. A particular emphasis is placed on 'investigating' as a central theme of the school science program especially in units of work preceding the annual, mid-year science fair. Students are encouraged, through teacher facilitation, to work and think scientifically and to participate in a process of enquiry in order to develop their understanding of their world (Intermediate School, 2000). In addition to the prescribed science program, all teachers are required to include an opportunity for students to complete an independent science investigation. The 'investigation-type' encouraged, with its emphasis on systematic and creative processes of enquiry, is 'fair-testing'. All students are expected to take part in the school-wide annual Science and Technology Fair and if successful, the provincial and national Science and Technology Fair. Selected students are further encouraged to participate in the Science and Technology Challenge and national and international Science competitions.

Very few teachers at Intermediate school would consider themselves primary science specialists. During the time the case study was conducted, a starting teacher (who has recently left), a fifth year teacher, the Deputy Principal and the recently appointed Principal would consider their curriculum strengths to include science. This specialisation is recognised by the pre-service training that these three teachers have received. A teacher taking extra optional science curriculum (pedagogical and

curriculum knowledge studies) and subject studies (subject knowledge studies) (Shulman, 1987) during their teacher training usually typifies specialisation in primary science in New Zealand. The Deputy Principal is an exception to this case. She completed a degree in science prior to completing her professional teacher training qualification. For the past 20 years, several individuals in the Senior Management Team, including both Principals and Deputy Principals, and teaching staff have been primary-trained science specialists. This number is significantly less than it has been over the past two decades.

7.3 Teacher Perceptions of Perceived Competence in Contextual Strands and Achievement Objectives

In all, 21 of the 23 fulltime teachers at Intermediate School participated in the questionnaire survey. Because of the relatively small sample size, percentages were not calculated.

Table 7.1: Teacher Perceptions of Perceived 'Easiness' of Teaching to the Requirements of the Contextual and Integrating Strands of Science in the New Zealand Curriculum.

	extremely easy	easy	neither easy or difficult	difficult	extremely difficult
Strand	1	2	3	4	5
Living World	4	4	8	2	2
Material World	1	7	7	4	2
Physical World	2	5	9	3	2
Planet Earth and Beyond	2	9	7	3	1
Scientific Skills and Attitudes	3	7	8	2	1
Science and its Relationship to Technology	1	6	7	9	1

Table 7.1 suggests that very few teachers at Intermediate School found it ‘very easy’ to teach to the requirements of the Contextual and Integrating Strand requirements of the national science curriculum. Similar to the trends identified in data collected from the in-service questionnaire analysis of teachers in the Central Districts, teachers perceived themselves to be more capable of delivering the Living World contextual strand than the three physical science strands. Similarly, very few teachers found the Integrating Strands, which embody the skills of science, easy to teach. In contrast to the in-service survey more teachers, at least in this section of the survey, were ‘uneasy’ with the Nature of Science and its Relationship to Technology Strand than the Scientific Skills and Attitudes Strand. The data collected from the questionnaire suggested that there were as many teachers that found teaching to the strands ‘extremely easy’ as there were those that found it ‘extremely difficult’. The majority of teachers suggested that teaching to the curriculum requirements was neither easy nor difficult.

Table 7.2: Teacher Perceptions of Teacher Knowledge of the Science in the Strands of Science in the New Zealand Curriculum

	very well developed	well developed	neither well nor poorly developed	poorly developed	poorly developed
Strand	1	2	3	4	5
Living World	3	5	10	2	1
Material World	1	5	11	2	2
Physical World	-	8	8	5	-
Planet Earth and Beyond	2	6	6	7	-
Scientific Skills and Attitudes	1	10	4	4	-
Science and its Relationship to Technology	-	6	7	7	1

Similarly teachers suggested that their knowledge and understanding of the science in the strands was not 'well developed' (Table 7.2). Although more teachers saw their knowledge more developed in the biological sciences, the majority of teachers saw their knowledge as neither poorly nor well developed in any of the Contextual Strands. The knowledge requirement in these strands is primarily associated with the knowledge of science 'procedure' and is appropriately called science procedural knowledge (Duggan, Johnson, & Gott, 1996; Gott & Duggan, 1995). Again teachers recognised that the area where their knowledge and understanding was the most poorly developed was in the Nature of Science and Its Relationship to Technology, quite alarmingly, the Integrating Strand which contains the curriculum requirements for teaching 'fair-testing' investigations, the school encouraged investigation-type for the annual science fair.

Similar to international trends (Tilgner, 1990; Weiss, Matti, & Smith, 1994) and trends evident in the Central Districts in-service survey, teachers at Intermediate School tended to find more difficulty in teaching physical science concepts than biological science (Table 7.3). Although the majority of teachers perceived no significant problem in their competence in dealing with the Living World concepts, the majority of teachers identified some degree of problem with all but three of the nineteen concepts or achievement objectives contained within the Making Sense of the Physical World, Making Sense of the Material World, and the Making Sense of the Planet Earth and Beyond Strand.

In what appears to be a contradiction to the initial responses in this survey, the majority of teachers indicated that their competence in dealing with the requirements of the two Integrating Strands was not a significant problem. Although the majority of teachers identified their knowledge and understanding of the Integrating Strands as poorly or not well developed, the majority of teachers still did not have a significant problem in dealing with these strands as teachers. This suggests that although teachers recognised they are limited in their understanding of the procedural science knowledge contained in these strands they still considered they were competent to teach to the requirements of the strands.

Table 7.3: Teacher Perceptions of Their Competence in Teaching to Specific Concept Areas

Strand	Conceptual Area	1. Not a significant problem	2. Somewhat of a problem	3. Serious problem
LIVING WORLD	• diversity of living organisms	13	7	
	• special features of NZ plants/animals	12	9	
PHYSICAL WORLD	• structure/function of living things	15	5	1
	• growth/reproduction in living things	16	5	
	• interdependence of living things	16	4	1
	• light	8	13	
	• heat and temperature	14	7	
	• sound	11	9	1
	• electricity	9	7	4
	• energy	8	10	1
	• magnetism	8	11	1
	• flotation	9	9	1
MATERIAL WORLD	• how pieces of everyday objects work	8	12	1
	• nature and properties of substances	7	14	1
	• properties of substances and their use	7	13	
	• how substances undergo change	9	12	
	• grouping substances according to similarities	11	10	4
	• how selected materials are manufactured	5	11	1
	• materials and their effect on the environment	10	10	
PLANET EARTH & BEYOND	• composition of Planet Earth	10	11	1
	• processes that shape Planet Earth	9	11	3
	• NZ geological history	9	9	4
	• movement of Planet Earth in relationship to other objects in the heavens	11	6	1
	• relevant environmental issues	15	5	
SCIENTIFIC SKILLS & ATTITUDES	• promoting investigating activities	15	6	
	• developing skills associated with investigating	12	9	
NATURE OF SCIENCE & ITS RELATIONSHIP TO TECHNOLOGY	• how simple items of technology work	12	8	
	• how items of technology have developed	10	11	
	• fair testing	15	5	

In summary, teachers at Intermediate School possess perceptions of their science teaching ability, competence, and knowledge and understanding that were similar to both international and national trends. Although some saw these aspects as well developed, similarly, a few saw these aspects as poorly developed. Their perceptions suggested that, in general, they were quite in the 'middle of the road' in terms of their professional science capabilities. Indications from this part of the questionnaire would support the accuracy of the Ministerial Taskforces recommendations and ensuing current in-service efforts to enhance teacher science professional adequacy.

7.4 Factors at the Classroom and School Level Influencing Science Program Delivery

In the second part of the questionnaire teachers were asked to identify how great a problem specified intrinsic and extrinsic factors were for them as a teacher of science at the classroom level. The factors listed were primarily extrinsic and attempted to discriminate amongst several dimensions of the same aspect, e.g., knowledge and time.

Teachers identified that the major problems they faced at the classroom level were associated with time availability and knowledge (Table 7.4). Teacher responses suggested their lack of knowledge was not confined to subject matter knowledge but equally to curricular knowledge (knowledge of curriculum) and a synthesis of pedagogical knowledge – pedagogical content knowledge (knowledge of strategies and appropriate activities). These results would further support the accuracy of the Ministry of Education's recent efforts to address teacher professional adequacy in the domain of knowledge. As Baker (1994) suggested, the spotlight needs to focus on teacher knowledge. Not just knowledge of the subject itself but also the knowledge of the curriculum and the appropriate pedagogy to bridge between the learner and the subject.

Table 7.4: Degree of Problem of Specific Areas at the Classroom Level

	Not a significant problem	Somewhat of a problem	Serious problem
Factor	1	2	3
Facilities – classroom and science room suitability	15	4	2
Children’s interest in science	17	4	
My confidence to teach science	10	8	2
Science resources – equipment, booklets etc.	10	11	-
My knowledge of curriculum – curriculum knowledge	9	12	-
My knowledge of appropriate activities/teaching strategies	7	13	1
My interest in teaching science	16	4	1
Time available to teach science	8	8	5

Teachers suggested that an equally important problem for them as teachers was the time availability to teach science. Time was also commonly cited by participants in the in-service questionnaire as a major factor inhibiting science program delivery. Although time was recognised by the respondents as a multidimensional factor in the initial survey (time for planning, time in the school year, time in the school day, etc.), the aspect defined in this question was the time available to teach science. Five teachers identified time available to teach as the most serious problem influencing science program delivery at the classroom level.

Teacher confidence and resources were also recognised by the majority of the Intermediate School staff as ‘somewhat of a problem’ areas. Again these problems are commonly cited in international surveys (Appleton, 1992; Tilgner, 1992) and the New Zealand TIMSS report (Garden, 1996). Two teachers identified their own confidence

as a serious problem for them in their teaching of science responsibilities at the classroom level.

This section of the questionnaire suggested that teachers were again able to identify that several intrinsic and extrinsic factors were influencing science program delivery at the classroom level. These factors included time and resource availability required to teach science, as well as teacher confidence and subject matter, curricular, and pedagogical knowledge.

Table 7.5: Degree of Problem of Specific Areas at the School Level

	not a significant problem	somewhat of a problem	serious problem
Factor			
Facilities	14	7	
Children's interest in learning science	13	8	
Our confidence to teach science – subject matter knowledge	4	14	3
Our interest in teaching science	5	16	
Time available to teach science	5	9	7
Science resources – equipment, booklets etc	12	9	
Our knowledge of the curriculum – curriculum knowledge	4	16	1
Our knowledge of appropriate science activities and teaching strategies	4	15	1
Professional development opportunities	7	9	4
Curriculum leadership in science at the school level – school scheme, clearly identified coherent programme	16	4	1
Emphasis we place on science as a curriculum area	10	10	1

At the school level, teachers identified several extrinsic and intrinsic factors as problem areas in the teaching of science (Table 7.5). Again the factors listed in this section attempted to discriminate amongst dimensions of the same phenomenon eg. knowledge. The majority of teachers identified time availability to teach science; teacher confidence; and a lack of curricular, subject matter, and pedagogical knowledge as problem areas for the staff collectively. Seven teachers identified time availability to teach science and subject matter knowledge as 'serious' problems.

The majority of teachers also saw that a lack of professional development opportunities was a problem for teachers at Intermediate School. Four teachers saw this factor as a 'serious' problem. The majority of teachers further suggested that a professional interest in science was also 'somewhat' of a problem. As well, the emphasis that the school placed on science as a curriculum area was also identified by the majority of respondents as 'somewhat' or a 'serious' problem. Interestingly, the curriculum leadership in science at the school level was perceived to be 'least significant' problem influencing science teaching at Intermediate School.

The responses in this section re-emphasised that a variety of extrinsic and intrinsic factors were problem areas for the teaching of science at the school level. These factors were predominantly associated with factors that were consistently identified in previous surveys associated with this thesis and other New Zealand surveys (Garden, 1996). Amidst these commonly cited factors were less commonly cited dimensions such as the emphasis the school places on science as a curriculum area, curriculum leadership, and professional interest.

In the open-response section of the questionnaire teachers identified teacher knowledge and confidence as the major factors inhibiting the effective implementation of a quality science program at the classroom level at Intermediate School (Table 7.6). Again 'knowledge' was regarded multi-dimensionally. For the nine teachers who identified knowledge as a major inhibitor to effective science curriculum implementation, a lack of subject matter and curriculum knowledge were seen as the major 'deficient' knowledge aspects. Six teachers again saw time as a

major factor influencing science program delivery. Five of the six teachers that identified time as a factor perceived ‘time to teach’ science as a critical factor. Only one teacher identified time to prepare science activities as an issue. Four teachers identified resource availability as a factor inhibiting science program delivery. The ‘availability of resources’ was identified by all four teachers as an issue associated with being able to use the science resources when required. All suggested that the issue was more one of ‘timing’ rather than actual ‘availability’. The resources were present in the school, they were just not available because of the manner in which the resources were managed and timetabled.

Table 7.6: Major Factors Inhibiting Effective Science Implementation at Classroom Level

Factor	Number of Teachers Identifying Factor as a Problem
Teacher knowledge and confidence	9
Time availability to teach science	6
Timing of programs and resource availability	4
Negative teacher attitudes towards teaching science	2
Lack of resources in school	2
Professional development availability	2
Time for preparation	1

Although the majority of teachers had identified professional development opportunities and teacher interest in science as ‘somewhat’ of a problem for the teaching of science in the previous section of the questionnaire, very few comments were made about these aspects in this section. In general, the factors influencing effective implementation were typical of those cited in other national surveys (Garden, 1996) and the surveys presented previously in this thesis.

The results gathered from section three of the questionnaire, the card ranking exercise, again identified time availability as the main factor inhibiting science curriculum

implementation at the school level (Table 7.7). Seven teachers ranked it as the main factor inhibiting effective implementation. Again poor teacher confidence and inadequate teacher knowledge were also identified as major factors influencing implementation. In accordance with this, the lack of professional development opportunities was also considered a major inhibitor.

Table 7.7: Ranking of Factors Influencing Implementation at the School Level

	main factor									least factor
Factor	1	2	3	4	5	6	7	8	9	10
• inadequate science resources	1	0	1	1	2	1	3	6	3	0
• poor teacher interest	0	1	1	6	7	3	1	0	0	0
• inadequate science curriculum leadership	0	0	0	1	0	1	5	5	4	3
• inadequate professional development opportunities	0	5	4	0	4	4	1	2	0	0
• children's interest in science	0	0	1	1	2	1	1	3	1	8
• poor science facilities	0	0	0	1	1	0	3	4	4	6
• time availability	6	0	2	2	4	1	3	1	0	0
• inadequate teacher knowledge	2	4	4	3	2	1	2	0	1	0
• low priority placed on science	0	1	2	2	3	1	2	5	3	0
• poor teacher confidence	4	4	2	3	2	0	3	0	0	0

Poor teacher interest in science and the low priority placed on science as a curriculum area were not 'main' nor 'least' factors inhibiting implementation. The 'moderate' ranking of these factors suggested that all teachers identified these as factors influencing the effectiveness of implementation but not, in comparison to time availability, teacher knowledge and confidence, and availability of professional development opportunities, as critical factors. Teachers also recognised that inadequate science resources was a factor influencing effective science program delivery. Very few teachers ranked inadequate science curriculum leadership, science facilities, and students' interest as factors having any inhibiting effect on science program delivery.

Table 7.8: Ranking of Factors Influencing Implementation at the Classroom Level

	main factor									least factor
Factor	1	2	3	4	5	6	7	8	9	10
• limited interest in teaching science	0	1	2	3	3	0	1	2	4	2
• perception that science is not that important at intermediate level	0	0	1	1	1	1	2	4	4	2
• limited knowledge of effective teaching strategies/activities	1	1	3	4	3	0	5	1	0	0
• limited knowledge of how to develop investigation type activities	0	2	8	1	2	1	2	2	0	0
• time inadequate available to prepare for and teach science	7	1	1	2	3	0	3	0	0	0
• limited knowledge of science curriculum at intermediate level	0	1	7	1	2	1	2	4	0	0
• limited subject matter knowledge of science concepts	2	3	3	2	5	1	1	0	0	0
• perception that science is messy to teach – messy, classroom management	0	0	3	1	6	2	2	1	0	0
• limited knowledge of how to translate scientific ideas to children’s language	0	2	3	4	3	4	1	0	0	0
• children’s poor interest in science	0	0	1	0	2	1	3	0	3	1

At the classroom level, teachers again identified inadequate ‘time available to teach and prepare for science’ as the main factors inhibiting science curriculum implementation at the classroom level (Table 7.8). Seven teachers identified it as the main factor. Limited (1) science subject matter knowledge, (2) knowledge of how to translate science subject matter into a language appropriate for children (pedagogical content knowledge), (3) knowledge of how to develop and teach investigation-type activities (pedagogical procedural knowledge), and (4) knowledge of the curriculum at the intermediate level (curriculum knowledge) were also seen as major factors

inhibiting science program delivery. Limited teacher interest in teaching science and the perception that science is 'messy' and difficult to manage were also regarded as factors important, albeit less critically important, to the inhibiting of science program delivery. A perception that science was not that important at intermediate level and, again, children's interest in science were seen as the least significant factors inhibiting curriculum delivery.

The questionnaire survey verified that the factors identified as impediments to science program delivery in both national and international studies, are common to Intermediate School. Teachers identified that their own knowledge and confidence were impediments to effective science program delivery. As Baker (1994) suggested the spotlight in New Zealand is on teacher knowledge and confidence. The teachers at Intermediate School agreed that this was an issue. The survey further suggested that some aspects such as facilities and resources were not as serious as those commonly cited in other surveys but still factors of importance. As well, the survey suggested that some less commonly cited or exposed factors such as teacher interest and the emphasis that is placed on science as a curriculum area at Intermediate School also influenced and inhibited science program delivery. As well, the results from the questionnaire survey suggested that Intermediate School teachers, more readily than most primary teachers, identify that the school facilities and curriculum leadership positively influence the science curriculum implementation process. Conversely, time availability was seen as a major factor inhibiting the implementation process.

As well, the questionnaire survey revealed that several of the factors influencing science program delivery were multi-dimensional. Teachers were able to identify that the professional science knowledge, resources and the time required to teach science are complex, not simple phenomena. For example, what actually constitutes the 'science content' required by teachers of science to teach science is rather more complex than that implied by a 'background in science' (Baker, 1994). Teachers at Intermediate School were able to differentiate amongst the various forms of knowledge and identify which knowledge dimensions or combination of knowledge patterns were inhibitors to effective science program delivery at the classroom and school level. Similarly, teachers were able to differentiate amongst the dimensions of time and resources. Further to this, teachers were able to recognise that teacher

knowledge, interest, and confidence are not the same phenomena and all contribute to their overall effectiveness in teaching science.

7.5 Probing the Phenomenon of Science Program Delivery – Teacher Interviews

The interviews with the personnel presently or previously teaching or involved with curriculum management and development at Intermediate School and the review of Intermediate School documentation relevant to science education were conducted to deeply probe and intensely analyse the phenomenon of science program delivery (Burns, 1990). Although the data collected from the interviews and documentation search were extensive, the presentation of these data in this section is limited to identifying views that provide insights and themes of interpretation that explain the factors and combination of factors that are influencing science program delivery at Intermediate School, especially at the classroom level. The participants were considered 'knowing' beings and that this knowledge they possess has important consequences for how behaviour and actions associated with the teaching of science and science program delivery are interpreted (Magoon, 1977).

Five of the six teachers that agreed to be interviewed are presently teachers at Intermediate School. Prior to conducting the interviews one teacher, the first year science specialist, because of personal circumstances, declined the invitation to be interviewed. She is no longer at the school.

In the initial phase of the interview, which examined science program delivery at the school level, teachers were asked to manually rank a series of 10 cards that identified factors known to inhibit curriculum implementation. Once completed, the sorting exercise teachers were asked to justify and elaborate on their ranking order. Questions were then asked that related to some of the multidimensional aspects of the factors known to influence science curriculum implementation. As well, several questions were asked that attempted to probe the influence a multiplicity and interconnectedness of factors had on curriculum delivery. Particular emphasis was placed on how certain less salient features of the school environment influenced science program delivery. The second section of the interviews, which examined classroom factors influencing science program delivery, again started with a card ranking and justification exercise.

This was followed by an investigation into how intrinsic factors such as professional interest in science, knowledge, and confidence influenced program delivery at the classroom level. Attention was also given to determine the influence aspects of the school environment had on teachers at the classroom level. What follows in this section is a description of the themes that precipitated from the interviews and document observation.

Intermediate School has a tradition of emphasising science as an essential area in the school curriculum. This tradition has strongly influenced science program delivery at not only the school but also the classroom level. Several comments from senior staff conveyed this message.

The school has always recognised three 'main' curriculum areas - mathematics, English and science. (Janet, science specialist, Deputy Principal)

The administration at Intermediate School has always emphasised science as a core curriculum area. (Jack, past Deputy Principal, Local School Advisor).

The school has always placed a high emphasis on science. The (science curriculum) leadership has always been good and the schoolhas always tried to make it happen. It is one curriculum area that has been implemented quite well. (Mary, non-science specialist, Senior Teacher)

The presence of a specialised science facility, maintenance of a local native bush remnant and long-term full student participation in the annual science fair are physical elements of the Intermediate School environment that would support these assertions. These aspects were seen by some staff members as clear reminders of the established status and high priority science holds as a curriculum area.

I can remember seeing the science room on my posting here while at College. It seemed odd to see one in a school (as I hadn't seen one in a primary-intermediate school before) Now as a teacher here I'm reminded of the 'fair go' science gets at the school. (Brad)

I am personally not that enthused about the science fair..... it does take up a great deal of time. But it is something we value and continue to do. It is a very important part of the overall school year. (Mary)

When you think of it some of the things we have established like the science fair participation and the science room have been very important steps. You don't think of it that much but they are important. (Janet)

The influence of key people at Intermediate School in the past has been an integral part of establishing science as a key curriculum focus in the school program. These key people, in particular several who were in senior management, were vital leaders in fostering a commitment to work toward a shared institutional value (Hargreaves & Hopkins, 1981; Nias et al, 1989) by strongly influencing others to teach science.

There have been many people, especially senior teachers and principals, who have been very enthusiastic about science. They all went out of their way to ensure that children always were experiencing science. (Janet)

There has always been strong encouragement to teach science..... and leadership – many of the senior teachers in the school in the past have had a strong science leaning. (Mary)

The school has had some of the most enthusiastic science teachers I have known of. The school, especially senior teachers, nurtured that enthusiasm in the staff and these people strongly influenced the school. (Bill, tertiary science educator)

During the contract I worked with three schools. The staff, especially some key people, from Intermediate was so committed and enthusiastic. They were committed for several months after that to get the whole school on board with the new curriculum. They strongly influenced the entire staff. (Bill, tertiary science educator)

Hall and Hord (1987) stated that the degree of implementation of any innovation is different in different schools because of the actions and concerns of senior management, in particular, the principal. Fullan (1992) suggested that school change and improvement in any area bear the mark of the principal as central for leading and supporting change. It is they that carry the message as to whether some innovation is to be taken seriously (Hall & Hord, 1987; Hopkins, Ainscow, & West, 1994).

It is suggested that small organizations have more potential to be greatly influenced by individuals who are in a position of influence and possess a vision or mission of what that organization should be (Robbins, Millett, Cacioppe, & Waters-Marsh, 1998). It is evident that key individuals had a pervasive influence and impact in shaping and creating the normative behaviour and curriculum culture of Intermediate School.

Although several current and past staff mentioned this tradition, indications were that **this status is perceived, by some of those interviewed, especially Senior Teachers, to persist.** This perception continued to influence teachers in their motivation to incorporate science as a regular part of their school program. Comments in this area included:

There is a clear expectation that science is to be taught as a regular part of the school program...the school curriculum is really well balanced but science is given a 'fair go' in comparison to other areas. (Brad, non-science specialist, First Year Teacher)

There is a perception at Intermediate School that science is an important part of the school curriculum. (Janet)

Many teachers teach science because they realise that there is an expectation that science is required to be taught.....although not strong (at teaching science) themselves. (Janet)

We have good ties with Intermediate School. They have always been willing to be involved with new science contracts and projects. Its great to have teachers and schools you can count on to participate. (Bill, Science Education Lecturer and Curriculum Contractor)

I wouldn't say science is taught more than some of the other curriculum areas but you do know that you are especially encouraged to teach science, maths and English. (Natalie, fifth year science specialist)

Clearly, Intermediate School possesses a 'science curriculum culture'. As stated by Robbins, Millett, Cacioppe, & Waters-Marsh (1998), this culture is defined by the shared meanings towards science as a curriculum area that the school possesses. In accordance with organisational behaviour theory, this 'culture of science' is manifested through a variety of characteristics. These include a history of science curriculum innovations, attention to detail in terms of curriculum planning and delivery, a focus on science outcomes as evidenced in achievement and participation in science activities, a team orientation towards science program development and delivery, and an effort through a variety of strategic measures to maintain science as a key curriculum area.

Some teachers would suggest this 'science culture' is not being sustained. The majority of teachers suggested that the emphasis that the school placed on science as a curriculum area was a 'factor for concern' in regards to its influence on science

curriculum implementation. Some teachers perceived a reduced shift in science emphasis over recent years. This is affirmed by the following comments.

It's never been said to me that science is more important (at this school). I just teach what I know I am required to (in terms of a balanced curriculum). At the same time though it isn't like it was when I first came. The Arts seem to be pushed lately and that has an effect because it does come down to how much time you have. I think it is really just a matter of everything being busier and with the new curriculum releases this is having an effect. (Natalie)

We are a busy school. It's important to decide what is change for the benefit of the students and what is change just for the public. I think we might be changing but not for educational reasons. This is probably true everywhere..... I like the learning opportunities and challenges science brings and with emphasis in other areassubjects like science just lose out. (Natalie)

I think that a few regard science as more important but it comes down to personal interests. We all, to some extent, teach to our strengths - so for some social studies is more important, or P.E. (physical education) is more important. (George)

There were some very strong science people here in the past. There were some major (positive) events that occurred here simply because of them. We (the staff collectively) didn't always like it but it was for the benefit of the children and that made it worthwhile so we all supported it. Science IS just another one of the curriculum areas. It has no special place over the rest.....not as much now. (Mary)

I think if one person (in particular) left Intermediate School I think things would change. In the past there were several people who were really strong in science. It was evident in the contract. They were really committed and involved as a group and were committed to share their experience with the entire staff. They did that for the six-month follow-up to the Contract. I don't think that it is that way now. (Bill)

Even though some perceived that the status of science as a curriculum area, at least to some extent, was waning, a variety of factors were seen to be contributing to the perpetuation of an expectation to see science maintained as a key area in the overall school curriculum. These factors were encouraged by an expectation from various sectors of the Intermediate School community who uphold science as a key curriculum area. Some of the comments made that affirm this positive regard included:

Parents always ask if the school science fair is on. We know that sometimes the 'work' isn't all (the student's) doing but the parents expect us to continue it. Many of the parents expect science to be taught as part of the school program. I don't think we could get away with not teaching science and having the science fair. (Mary)

I think many parents send their children here knowing that science is pushed in the school. That does work positively in ensuring science is a regular part of the program. (Janet)

When Jock left he told me to make sure that science, especially the science fair, continues to be pushed. I haven't thought about that too much but I do think we have a responsibility in that area. (Janet)

The appointments that have been made at the school over the years suggest that there is this unspoken thing that if you're strong in science that can be to your advantage. (Janet)

When (the new principal) arrived he made it very clear that mathematics-numeracy, English-literacy and science – these were the ones that had to work. (Janet)

We identified a few years ago that the science room needed someone to look after it and make sure it was used. I think the fact that we give that much (support in terms of resources, facilities and teacher aide time) to science shows we're committed to it. (Mary)

I am not that strong in science but it is one area that we know children really, really enjoy. They are always really enthusiastic about it – especially when they are investigating – it does encourage us to teach science. (Mary)

The positive working relationship we have with College (Massey University College of Education) is good. We seem to be able to help each other out. There is a good relationship and this is good for us. It keeps us up to datecurrent.....knowing that you are a part of something that is worthwhile. If it helps us in our efforts with children it's good. (Janet)

It is suggested that once a culture is in place, there are practices both within and outside the organization that act to maintain and perpetuate this 'normative' culture (Robbins, Millett, Cacioppe, & Waters-Marsh, 1998). These practices are often associated with human resource practices such as the selection process, training and development opportunities, socialisation processes, and actions of top management. All of these practices were identifiable in the statements made by those interviewed.

Teachers recognised that the availability of science curriculum support was a major factor influencing science program delivery. This support was seen as being

available both formally, through science curriculum contracts and other advisory services, and informally through support networks within the school and the community. As well as being a system of support, it was also a system of ensuring that new teachers are 'socialised' into the beliefs and customs of Intermediate School. Although this socialisation process was not as overt as exists in many organizations, the implicit expectation to include science as a regular part of the classroom curriculum was supported by the school administration by the opportunities it provides for its staff.

I don't think many of us would feel particularly strong in teaching science but the support we get (from others within the school) to help us in teaching science is always there. (George, fifth year non-science specialist teacher)

I think the access we have to courses and College has always been a major part of it (the success of science program delivery) as well. Bill (a lecturer at College) was of great help during the Contract (Implementing the new science curriculum). He is always so enthusiastic about helping out and being involved. (Janet)

The LISP (Learning in Science Project) was probably my most beneficial experience. It emphasised the 'investigative' side of science and for me, at that stage, it helped me to see the way science should be taught, especially to intermediate children. That was great support and since then I've never felt really strong at it but I do feel very comfortable with it. (Mary)

I'm not that interested in science personally.....but I do know that the support is there when I need it. (George)

The 'Grab Bag' series (Advisory Support Services) at College was really great. The offer was there to attend and a couple of us went. The activities were really practicalreally good value. (Brad)

Just knowing that the support is there is great. It's there in other curriculum areas as well. Teachers do have reservations about teaching science.....but the support we can get (from Janet) is great. (Natalie)

There are people here that are able to foster the capabilities in teachers that have difficulties in teaching science. (Brad)

You know that if you want to do something in science, the support will be there. (Brad)

Teachers at Intermediate School were able to identify that time availability was a major factor impeding effective science program delivery. They were equally able to identify that time availability was a multidimensional factor.

I guess, for me, time is the key thing. Time - mainly to look into new and creative ways to teach science. I feel quite confident in teaching science but I see new resources coming in and really with everythingit's just hard to find the time, the uninterrupted time, to spend looking over and improving the way you do things..... time for preparation. (Janet)

It's always about time. It's time in the day to fit in what you know you should be doing. It's time to just get it all organised. I never seem to have enough time even though I give a lot to my teaching. (Natalie)

Science requires more time than other subjects. It demands more of us than other subjects. Just getting set up for science activities is a real issue. (Margaret)

Time, time, time.....science has to take its place along side all the other parts of the curriculum.....and really there isn't enough time. (Mary)

Four strandsfour terms.....one per term.....that is the way it should be.....but there just isn't enough time in the school year to fit it in. I feel really good about we did (in science) this year. Next year different strands – different topics. (Brad)

Time..... in terms of the breadth of the curriculum. (Janet)

There is so much going on in the school and it seems that it's easy to let some things go. I think I let some subjects go more than others. The students notice that I do this too! (Natalie)

The production was on (this term) and that really interfered. You have to do it when you have to. When you're not teaching that much science and you miss a few afternoons that really affects the continuity. (George)

With the increased emphasis (our contributing) schools are placing on numeracy and literacy I can see that science will get even less exposure. That will mean that what we will do will need to take this into consideration. It worries me. (Janet)

Teachers were able to identify that professional science knowledge was a major factor reducing the overall effectiveness of science curriculum implementation at Intermediate School. They were also able to identify the multidimensional nature of professional science knowledge.

The most important knowledge is knowledge of the subject. Understanding the science itself. But it's more than that. I've never found the science curriculum very clear. I would like a better knowledge of exactly what it is I am to teach.

What exactly is required of me at the Intermediate level? As well, there is knowledge of how to manage science activities better.....and assessing science.....I would like more knowledge on how to assess in science.

(Mary)

Background content knowledge of the subject.....in my last unit I knew I could have extended the students more if I knew more. I'd like to be able to go that further bit and really get them more curious. I guess it's useful knowledge appropriate to the concepts we are teaching. Also knowledge of strategies to draw from.....and effective teaching strategies.....interesting ways.

(Brad)

Knowledge of the subject.....I don't have a very good science background and knowing more science would be really helpful. (George)

Scientific knowledge.....and knowledge of how to manage science activities.....especially when it comes to investigating. But also knowledge about children and the views they have. I've become quite interested in that and would like to know more. How can I help children to learn science? I think I need to know about them as well. The science knowledge is fine for me but the ways children think.....and what I can do to help them learn.....it's really interesting and I'd like to know more. (Judy)

Both knowledge of the science and how to best teach the science. Intermediate (age) students respond really well to challenges and working together. Science fits in well with that. I think knowledge of the science and how to get it across in a way that is motivating and interesting way for them. (George)

Knowledge of the subject and how to teach it with a lot of practical activities. They (the students) really enjoy that. I sometimes feel I limit them just because of my own limitations with what are really exciting things to do that are appropriate to their level. (Natalie)

These comments affirmed the trends identified in the questionnaire survey. Teachers were able to clearly identify the various knowledge aspects they believe to be critical to effective science teaching. Teachers recognised that their professional knowledge provides the basis for the development of (children's) personal engagement with the subject and helps to develop an understanding of the nature of the knowledge within the discipline. Because of this, teachers identified that they needed a complex professional knowledge base from which to implement an effective program (Baker, 1994). Limited (1) science subject matter knowledge, (2) knowledge of how to translate science subject matter into children's language and the pre-instructional views of children (pedagogical content knowledge), (3) knowledge of how to develop and teach investigation-type activities (pedagogical procedural knowledge), and (4)

knowledge of the curriculum at the intermediate level (curriculum knowledge) were all repeatedly identified and justified as major factors influencing the overall success of science program delivery.

Teachers identified the adequacy and availability of resources as factors influencing science program delivery. All teachers made reference to the positive effect that the science room had in promoting science curriculum delivery at Intermediate School.

The facilities are a real asset.....just the fact that it is there. Everything is ready to go. (Brad)

With the science room.....there really can't be excuses. There will always be subjects that you'd rather not teach and you will justify your actions for not teaching it. It comes down to you and the subjects. You can't use equipment and space as an excuse when you've got the science room. (George)

Our classrooms are not that big and they are carpeted. The science room, although not always available, gives you the opportunity to teach practical science activities..... less difficulty. I think we are very fortunate to have it. (Mary)

Although the science room facility was seen as a positive factor influencing science program delivery, the availability of this facility and the adequacy of resources were seen to be problematic.

There has been a lot of work just getting things ready. The units are ready to go, the equipment. That's a good thing about the school. The curriculum teams have done their job and that makes it easier for everyone. It is a problem though when what you need has been booked out. (Brad)

The management of science resources is a problem. Having everything on portable trolleys and having a few extra sets would be valuable. There have been several times that by the time you have organised your program the timing conflicts with other teams. (Mary)

These comments would support the assertions made by Harlen (1988) who cited inadequate facilities and equipment as commonly mentioned barriers to effective science program delivery. Tilgner (1990), as well, stated that inadequate science equipment has been one of the most commonly cited obstacles to primary science program delivery over the past three decades. It would appear that although

Intermediate School was a well-resourced school, it still experienced, at least to some extent, the resource constraints that many other schools experience as well

Teacher professional interest in science was recognised as a major factor either promoting or inhibiting science at the classroom level. Professional interest influenced various aspects of their professional behaviour, as examples, the amount of time they spent preparing to teach, the amount of time they actually allocated to teaching the subject and the way in which they taught the subject.

Ultimately it's a matter of whether you are interested. We all ultimately make the decisions about what we teach and how much we teach it. We all teach to some degree to our interests and strengths. The major factor (that influences science curriculum implementation) at the classroom level is the teacher.....whether we want to teach it or not. People will always have reasons to say why they don't teach subjects, and you've got them here (referring to the cards) but the REAL reason is our own interest. (George)

It's (interest) really important. It gives you a desire to want to do more. It's a professional interest that influences your desire to teach science. If you're interested in something you'll more likely take the time to do something about it. You not only see the need to develop, you are motivated to develop. I can see it influencing me to do more in science and mathematics because I am interested in them personally – but it's the same for areas that I'm not that interested in. (Janet)

The way we feel intrinsically about a subject, strongly influences our teaching of the subject. We devote more time to it and we teach it more passionately. I don't think many of us are that intrinsically interested in itwe see it in many of the children though.....it all has a real effect on science. (Mary)

I can see that my interest in a subject is even noticeable to the children, especially the girls. Without me ever saying it they have been able to identify that I am not that interested in mathematics but quite passionate about science and English. (Natalie)

Teachers were able to identify that personal interest in a science as a curriculum area is influenced by the experiences they have had in the subject. These experiences were associated with contact with both formal and informal science settings both prior to and during their teaching career. Included in these settings were several environmental aspects such as student and parental interest and expectation that strongly influenced teacher interest and this strongly influenced their responsiveness to their science teaching duties.

I have had many positive experiences with science. Growing up it was just a part of our everyday life. I was always interested and encouraged to be interested. My formal study of science at high school and university was just an extension of that. When I started to teach I was pretty well immediately asked to lead the science program. I said I would mainly because of my long interest in the subject. (Judy)

I would never have considered myself to be a teacher that was that interested in teaching science. The positive experiences I had at school and I have had in teaching just carry over more and more to your teaching. Now it's the responses from the children that encourage my further interest. I know I've moved a long ways down the road in terms of where I am at with science. (Mary)

I know my prior experiences influences me. These are prior experiences as students ourselves and now as teachers. Personal experiences that might be good or bad. Personal experiences influence our motivation to teach science. This year the units I taught went really well. That was a real accomplishment. The students made it easy because they were into it but the fact that it went well means I'm looking forward to doing more next year. (Brad)

I was never really interested in science and I know that influences the amount of time I devote to it. I teach science but not with the same enthusiasm I teach social studies. I know my interest in a subject impacts on how much I put into the teaching of it. (George)

Teachers identified their own professional adequacy as a major factor influencing their science program delivery at the classroom level. Professional adequacy strongly influenced their perceptions of the subject, the amount of time they took to teach the subject and the way in which they taught the subject. As well, teachers were able to identify relationships that exist between their professional interest, professional knowledge, and professional adequacy in the subject.

I would like to be better at teaching practically based science lessons. As well be able to manage science activities better. That's what we're encouraged to do. It'll come with time. For me, further personal development in science is critical to my ability to implement the science curriculum fully in my class. The knowledge I learn needs to be really practical and relevant and I want to put into action. (Brad)

It's progressive – your perceptions of your ability to teach science well. You want to have the confidence in yourself that you can do a good job. But it's just not there immediately. It comes mainly from experience – good experiences. You have positive experiences and this helps the way you see yourself as a teacher. (Janet)

If you don't feel that strong or confident in an area, you probably stay away from or approach it cautiously. I know that was the way I first felt with the new curriculum and the Physical World. It was an apprehension that came from knowing you didn't know much about it. But the more you do it, the more you prepare for it and the better it goes, the more you're inclined to do it later. Your knowledge leads to confidence and good experiences in trying the activities increase your interest. I've thought a few times that it wasn't that bad after-all! (Mary)

The key, as I said, is interest. If a teacher were more interested they'd do more about it. They'd spend more time preparing and teaching it. It's all in stages. I can see it in my own teaching across the curriculum. One leads to the other..... I can see it in (another teacher). He took the course and he really enjoyed it. It got him going. He used the activities in class and it went well. That got him going more. So the knowledge of what to do and how to do it was the start. I think as teachers we experience this in all aspects of our work. (George)

These responses from Intermediate School teachers suggest that similar to the teachers that participated in the in-service questionnaire and several international studies, teacher confidence and competence were seen as critical agents impeding science program delivery (Abell, 1994; Appleton, 1992; Bearlin, 1990; Harlen, Holroyd, & Byrne, 1995; Venville, Wallace, & Loudon, 1998).

7.6 Science in the Intermediate School Curriculum

The purposes of this case study were to (1) identify what factors, both intrinsic and extrinsic, within the school environment influence primary science program delivery; (2) determine if some factors collaborate to either mitigate or inhibit science program delivery; and (3) ascertain the 'multi-dimensional' nature of some of the phenomena that influence science program delivery.

It is evident that Intermediate School, in the context of science education, is both a *typical* and *atypical* school. Similar to many primary and intermediate school teachers, both nationally and internationally, teachers at Intermediate School considered their professional science adequacy and knowledge to be factors that impeded effective science program delivery. Some further included their personal interest in science as a curriculum area as a further impediment to effective science delivery. They also regarded time availability as a further impediment to effective

curriculum implementation. The school is recognised as being an innovative and motivated school, but because of forces such as a broad curriculum delivery requirement, recent curriculum changes associated with the National Curriculum Framework and staff decisions to participate in a variety of events, teachers felt particularly 'busy'. Time to plan, prepare and effectively deliver science programs was a critical factor impacting on science program delivery. Teachers were also able to identify the multidimensional nature of several factors influencing science program delivery.

The school, unlike many primary and intermediate schools in New Zealand, has a strong science culture. This culture has been established primarily through the leadership efforts and pervasive influence of a series of senior teachers and administrators who have been able to foster through staff collaboration and commitment an innovative and thorough science curriculum program. These innovations are manifested in a wide range of physical and sociological aspects of the school and include the existence of a specialist science teaching room, full school science fair participation, and selected participation in science competitions. Their efforts also have been instrumental in encouraging staff participation in major science curriculum in-service contracts. As well, the science leadership has consistently endeavoured to support new teachers and teachers expressing difficulty with the teaching of science. It encourages participation in in-service professional support opportunities and commits itself to the adequate resourcing of science programs. Selection processes at the school have traditionally seen science expertise as a positive professional attribute in teaching applicants. Selection processes are but one way in which the school science culture is sustained. The school community has come to expect a strong science presence in the overall school curriculum and encourages staff to ensure that the science emphasis is maintained. As well, the students at the school are very positive about their science experience and this positively influences teachers to teach science.

Many documented accounts of the influence of school culture on science curriculum delivery are not so positive. Veenman (1984) suggested that socialisation into the profession often evaporates the best intentions of the first year science specialists. Clandinin (1989) similarly suggested that workplace constraints tend to have a

neutralising influence on starting specialist teacher's ability to effectively implement science programmes. Accounts such as these identify several factors that overwhelm even the best intentions of (beginning) science educators. In contrast to these accounts, it is evident that a variety of physical and psychosocial elements, that are unlikely to be found at most New Zealand primary and intermediate schools, positively influence science curriculum implementation at Intermediate School.

7.7 Summary

The data collected in this case study would support the premise that although the spotlight needs to be focused on the professional science adequacy of teachers because of the critical position they hold in the successful implementation of curricula, the process of improving curriculum delivery is mitigated or inhibited by several other factors, many of these associated with the physical and psycho-social dimensions of the school environment. Although teachers may be the critical agent in the curriculum implementation process, this study affirms that teacher professional adequacy is only one dimension in the complex matrix of factors that influence primary science delivery. The spotlight should not just be focused on teachers alone. As Nias and Yeomans (1989) suggested, whole school curriculum implementation is fostered by shared institutional values and norms, organisational structures, leadership and resources such as time, commitment, and materials. A larger cast of 'characters', as identified in this study, contribute to the overall effectiveness of science program delivery. Of particular significance is the role that school based curriculum leadership, professional support and, in general, school culture, have in influencing science curriculum implementation and program delivery. Clearly, as in the case of Intermediate School, curriculum focused leadership and a school culture that advocates collaborative curriculum development to enhance educational opportunities for students, are factors that strongly influence science program delivery. These factors need to be further included in the spotlight of systematic evaluation and remediation in order to effectively address the factors influencing primary science curriculum implementation both nationally and internationally. As asserted previously in Chapter 6, in order to address the existing maladies in science education in New Zealand, a more coherent and sustained strategy, both at the school and national level, must be developed by the various sectors of the educational community. This strategy

must not only give attention to developing the professional science adequacy and interest of individual teachers but also to understanding and addressing the influence of the educational environment on curriculum delivery. These factors need to be further included in the spotlight of systematic evaluation and remediation in order to effectively address the factors influencing primary science curriculum implementation both nationally and internationally.

Overall, the case study analysis of Intermediate School accompanied by the data collected from the inservice and preservice surveys have provided valuable information to assist in the identification of the many factors that influence science program delivery. These data become the foundation for the development of an instrument to systematically evaluate factors influencing science curriculum implementation, the focus of Chapter 8.

Chapter 8 Development of the Science Curriculum Implementation Questionnaire (SCIQ)

8.1 Introduction

This chapter outlines the procedures used in the development of the Science Curriculum Implementation Questionnaire. Section 8.2 details the procedures used in the identification and inclusion of items in the initial Instrument List. Section 8.3 outlines the procedures used in consultation with a focus group in selecting items for the initial instrument. Section 8.4 follows by explaining the procedures used in development of an 70-item initial instrument. Finally, section 8.5 summarises the chapter and introduces the purposes of Chapter 9, the validation and modification of the initial SCIQ.

8.2 Item List Compilation

The analysis of the data collected from the in-service survey, pre-service survey and case study as well as the literature review provided insight into the variety of factors influencing curriculum delivery, in particular, science program delivery at the primary school level. As stated by the IEA model, 'curricular antecedents' influence the implementation or 'delivery' of the curriculum (Garden, 1996). The analysis of data from the Phase One studies confirms that a variety of 'preceding' factors determines the extent to which the intended curriculum becomes the implemented curriculum. As suggested by the IEA and confirmed by this study, these 'system elements' or antecedents influencing implementation and delivery are broad and complex. Although the recent Ministry of Education efforts are an attempt to address the deficiencies in teacher knowledge and resource adequacy, the Phase One studies would suggest that the factors influencing science program delivery include other dimensions as well. Environmental factors such as time availability, school ethos, curriculum leadership and support, as well as teacher characteristics such as

professional interest and adequacy are also crucial in ensuring the intended curriculum becomes the implemented curriculum.

Each of the factors identified in the Phase One studies was placed on an 'Instrument Items' list. The list was not categorised or ranked, it simply 'listed' all the specific factors that had surfaced during the Phase One studies. As the factors influencing implementation were identified, they were modified so that they would be appropriate for a learning environment questionnaire. That is, a teacher would be able to answer or respond to the statement in the context of their classroom or school environment.

As an example, Mary had mentioned in the case study that:

The way we feel intrinsically about a subject strongly influences our teaching of the subject. We devote more time to it and we teach it more passionately. I don't think many of us are that intrinsically interested in itwe see it in many of the children though.....it all has a real effect on science. (Mary)

In order to change it into an item appropriate to the intent of the questionnaire it was modified to:

Teachers at this school are intrinsically interested in teaching science.

and:

Children's interest in science at this school motivates us to teach science.

In all, 223 items identified in the Phase One study were developed (Appendix B-1).

The 223 items were then cut into individual paper strips and sorted according to common themes. The items were easily identified as being resident within one of several general clusters, themes, groupings or categories of factors known to influence science program delivery. Several of these categories (resource adequacy; provision/availability of professional support; staff interest; staff time availability; staff collegiality and collaboration; and administrative leadership and commitment) were those identified by Fullan (1992). Most of these categories were primarily school culture or environmental attributes and failed to address the personal attributes of professional knowledge and professional adequacy/confidence consistently

identified in the Phase One studies. Thus two further categories not specifically identified by Fullan were evident. Although Fullan had listed “teacher capability in dealing with the task at hand” as a factor influencing curriculum implementation, he had not specifically identified professional knowledge and professional adequacy (self-efficacy) as individual, critical conditions contributing to or inhibiting effective delivery.

In sorting the items, some confusion arose in distinguishing between administrative leadership and staff commitment to the task of delivering science programs. Most of the items relating to these two dimensions were more general comments about the school’s beliefs about the ‘collective’ status of science in the school and the staff’s collective willingness to work together. Although the administration was identified as an integral part of the delivery process because of the influence it had on the total ‘school belief’, these two dimensions were difficult to isolate and were thus merged into a single ‘school ethos’ category. This category could be best described as the school’s overall beliefs about the value of science and the need to address the implementation requirements of the National Curriculum Framework. As Thomas (1980) stated, the perceived ‘worthwhileness’ of teaching science at the primary level.

The next step in the development of the SCIQ item list was to eliminate some of the repetitive statements. Repeating items that were identical or differed in only a word or two were eliminated from the clusters.

As an example:

Item 64. *Teachers at this school are well prepared to adequately teach science.*

And item 124. *Teachers at this school have been adequately prepared to teach science.*

This procedure reduced the number of items on the Item List to 116 items.

The sorting was completed with the intent of eliminating repetitive items, identifying broad categories, and determining how difficult it would be to identify the general

clusters of factors influencing science program delivery. The further elimination of repetitive items; verification of the identification of these groupings; and classification and ranking of items was seen as the next critical stage of the instrument development.

8.3 Focus Group Consultation

The six member Focus Group representing different sectors of the primary education community (science specialist primary teacher, science non-specialist primary teacher, science specialist primary principal, science non-specialist primary principal, science advisor, intermediate specialist science teacher) were initially, given the task of identifying: (1) clusters of items according to patterns and trends in the data; and (2) any gaps in the factors influencing science program delivery (Knight & Meyer, 1996). The Focus Group separated into three pairs and each pair was given the Item List. The List was cut into individual items to assist the focus group members in identifying common groupings of factors. Each pair was also given a Task Completion Sheet (Appendix B-2) that clarified their role as Focus Group members. The Task Sheet also provided the Focus Group with a description of the groupings of factors influencing curriculum delivery identified in Chapter 3 (Professional Knowledge; Professional Adequacy (Self-Efficacy); Professional Attitude/Interest; Resource Adequacy; Professional Support; Time; and School Ethos). Using this information as a guide the Focus Group pairs identified clusters of items according to patterns and trends in the reduced 116-item list. There was little discrepancy amongst the pairs in the items assigned to each cluster. The Focus Group members mentioned that the 'task' was quite easy and attributed this to the 'obviousness' of the categories and the specific guiding remarks made in the Task Completion Sheet. One group sought clarification on the difference between Professional Support and School Leadership and Ethos. The specific difference between these categories was clarified by stating that 'Professional Support' was a hands-on, physical presence working with (a) teacher(s) in some aspect of science delivery whereas School Ethos was a belief system influencing science program delivery about the status or value of science as a curriculum area.

The ranking of the items within the clusters according to how significant they perceived the items were in influencing science programme delivery within their educational context was also regarded as a straightforward task. All groups mentioned that it was hard to prioritise or rank some items, as they were often quite similar in their perspective. The rank order for each of the Focus Groups is provided in Appendix (B-3).

Although the pairs were asked to identify any gaps in the factors influencing science program delivery, the Focus Group pairs were unable to identify any further factors that may be influencing science program delivery within their educational context. The pairs were further asked to provide an alternative 'label' for each category. Some discussion ensued as to whether "Professional Interest" was more appropriately called "Professional Attitude". Members believed both were unique descriptors and that the scale items represented both of these ideas. Thus it was recommended that the scale, by name, or at least in its description clearly acknowledge the two aspects and remain in the form it was presented on the Task Sheet (i.e. Professional Attitude/Interest). All members were satisfied with the labels, as they had been presented.

8.4 Developing the Instrument

Once the items were sorted and ranked, averages of the item rankings were calculated for each category (Appendix B-3). Although I scrutinised this rank order using my own professional judgement, I was confident that the average rank order, as it existed, represented a hierarchy of items that were representative of the major factors influencing science curriculum delivery.

As mentioned in section 5.9, several further considerations were made in the actual development of the Science Curriculum Implementation Questionnaire. The instrument needed to be economical in regards to the amount of time it required for teacher completion and thus ten items for each scale were selected on the basis of the rank order list. Although ten items were selected for the initial scale, this would be reduced, for economic purposes, to seven items in the final instrument. As well, the physical layout followed the format of other learning environment questionnaires and recognised the broad categories identified by Moos (1970).

The SCIQ, in its initial form, thus contained seven, ten-item scales. Table 8.1 lists the seven categories or dimensions contained within the questionnaire, a description of each dimension and an example of one of the ten items from this dimension.

Table 8.1: Scales and Sample Items From the Science Curriculum Implementation Questionnaire

Scale	Description of Scale	Sample Item
Resource Adequacy	Teacher perceptions of the adequacy of equipment, facilities and general resources required for teaching of science.	The school has adequate science equipment necessary for the teaching of science
Time	Teacher perceptions of time availability for preparing and delivering the requirements of science curriculum.	Teachers have enough time to develop their own understanding of the science they are required to teach.
School Ethos	Overall school beliefs towards science as a curriculum area. Status of science as acknowledged by staff, school administration and community.	The school administration recognises the importance of science as a subject in the overall school curriculum.
Professional Support	Teacher perceptions of the support available for teachers from both in school and external sources.	Teachers at this school have the opportunity to receive ongoing science curriculum professional support.
Professional Adequacy	Teacher perceptions of their own ability and competence to teach science.	Teachers at this school are confident science teachers.
Professional Science Knowledge	Teacher perceptions of the knowledge and understandings teachers possess towards science as a curriculum area.	Teachers have a sound understanding of alternative ways of teaching scientific ideas to foster student learning.
Professional Attitude and Interest	Teacher perceptions of the attitudes and interest held towards science and the teaching of science.	Science is a subject at this school that teachers want to teach.

The first four dimensions (Professional Support, Resource Adequacy, Time and School Ethos) are regarded as extrinsic factors influencing science program delivery. The latter three dimensions (Professional Adequacy, Professional Knowledge and Professional Attitude) are regarded as intrinsic factors influencing science program delivery. The initial 70-item SCIQ is included in Appendix C-1.

8.5 Summary

The purpose of this chapter has been to outline the procedures used in the development of the initial Science Curriculum Implementation Questionnaire. It detailed the procedures used in the identification and inclusion of items in the initial instrument and outlined the procedures used in consultation with a focus group in selecting items for and developing the initial instrument. Chapter 9 describes the procedures involved in the validation and modification of the initial SCIQ

Chapter 9 Validation of the SCIQ

9.1 Introduction

The purpose of this chapter is to outline the procedures involved in the validation and refining of the Science Curriculum Implementation Questionnaire. Section 9.2 begins by presenting information on the participating schools. Section 9.3 presents the Cronbach alpha reliability validation statistical analysis data for the initial 10-item scale and the reduced 7-item scale. Section 9.4 investigates the procedures involved in the discriminant validity analysis, refining of the 7-scale instrument and the development of a further, shorter, 5-scale form of the SCIQ based on the merging of the three intrinsic factors scales. Finally, section 9.5 summarises the chapter and introduces the intentions of Chapter 10.

9.2 Information on Participating Schools

The validation process involved 293 teachers from 43 primary, full primary and intermediate schools located within the Central Districts of the North Island of New Zealand. Appendix C-4 presents information on the number of teachers that completed the questionnaire from each of the participating schools. Although the completed returned instruments did not identify the schools participating, the 'Agreement to Participate' form had identified that there was a wide range of school sizes participating in the survey. Several of the schools that participated were either sole charge or two teacher schools, which is quite representative of the rural nature of the Central Districts of the North Island in New Zealand. Only 5 of the 43 schools had a staff participation level of over 15. The largest school to participate involved 22 teachers.

The 'Agreement to Participate' response forms (Appendix C-3) also gave me a clear picture of the types of schools participating in the validation process. Of the 43 schools agreeing to participate, I was familiar with the majority of the schools on a professional advisory capacity. The majority of these schools I would regard as "professionally engaging schools" with a strong endeavour to develop professionally

and deliver quality education programs for children. Many of these schools, I consequently assumed, were not experiencing the difficulty with school science delivery to the same extent as those identified by Garden (1996) in the general New Zealand educational context. The response form provided schools with the opportunity to decide on whether they would like the results of their participation returned to their school. Only seven of the schools did not want the processed information returned. Thus, schools were clearly indicating that their interest in participating was in their best interest as well as mine. This open response to inspection by me, as a researcher, also reiterated the positive school ethos that was likely to exist in those schools intending to participate. From this preliminary response, I predicted that the response perceptions collated in the questionnaire, overall, would be quite positive of the science curriculum delivery process in their schools.

9.3 Validation of the SCIQ Scales - Alpha Reliability

The statistical analysis for the initial validation was performed to determine the internal consistency of each ten-item scale (Cronbach alpha reliability coefficient), mean, and standard deviations. These data are presented for the 10-item scales in Table 9.1. As well, three items were eliminated to reduce the length of the scales and, consequently, improve the economy of the instrument. The new seven-item scale internal consistency is also presented in Table 9.1.

Table 9.1: Alpha Reliability, Mean and Standard Deviation for SCIQ

Scale	Alpha Reliability (10 item scale)	Mean	Standard Deviation	Alpha Reliability (7 item scale)
Professional Attitude	.88	3.53	5.55	.88
Professional Knowledge	.77	3.32	3.76	.77
Professional Adequacy	.91	3.38	5.48	.92
Professional Support	.88	3.60	3.76	.90
Resource Adequacy	.83	3.39	4.01	.83
School Ethos	.86	3.51	3.99	.90
Time	.87	2.78	3.02	.90

9.3.1 Resource Adequacy

The alpha reliability coefficient for Resource Adequacy in the initial 10-item scale was 0.83. This value supports the internal consistency of the scale. Elimination of three items, which were the least correlated to the other items, resulted in the alpha reliability being retained. The seven items retained for this scale are:

1. The school is well resourced for the teaching of science.
2. The school-based system of managing of science resources is well maintained.
3. Teachers at this school have ready access to resources and materials.
4. The facilities at this school promote the teaching of science.
5. The science resources at this school are well organised.
6. The equipment that is necessary to teach science is readily available.
7. The school has adequate science equipment necessary for the teaching of science.

This scale addresses the multidimensional character of resources identified in the Phase One studies. It recognises that 'resources' is a collective term for not only the physical facilities, equipment, and materials necessary to deliver science programs but also the systems of management that make available these resources.

The mean for the 10-item scale over the 43 schools was 3.39. This suggests that teachers, overall, tended to agree only somewhat that their schools were adequately resourced for the delivery of science programs. Of the seven scales addressed within the SCIQ, Resource Adequacy was given the third lowest perception score. Although the Phase One studies identified resources as a critical factor inhibiting science program delivery, the professional commitment evident within these schools suggested they would be making an effort to acquire and manage the resources necessary to foster science programs.

9.3.2 Time

The alpha reliability coefficient for Time in the initial 10-item scale was 0.87. This value supports the internal consistency of the scale. Elimination of three items, which were the least correlated to the other items, resulted in an alpha reliability of 0.90. The seven items retained for this scale are:

1. There is not enough time in the school program to fit science in properly.
2. There is not enough time in the school week to do an adequate job of teaching the requirements of the national science curriculum.
3. The school curriculum is crowded. Science suffers because of this.
4. There is not enough time in the school program to teach science.
5. Teachers believe there is adequate time in the overall school program to teach science.
6. Teachers have the time to prepare for the delivery requirements of the national science curriculum.
7. Lack of time is a major factor inhibiting science program delivery at this school.

This scale addresses some of the time dimensions identified in the Phase One studies. The time dimension most referred to is 'time to teach science' which was repeatedly mentioned in the Phase One studies. Increasing the economy of the scale eliminated one of the two items that referred to time required to prepare for science program delivery. Although this preparation time dimension is explicitly identified in item 6, it is also inherent within item 7. The mean for the 10-item scale over the 43 schools was 2.78. This suggests that teachers, overall, tended to disagree only somewhat that time availability for the delivery of science programs was not a factor influencing science program delivery. Of the seven scales addressed within the SCIQ, Time was given the lowest perception score. This was in agreement with the Phase One studies that consistently testified to time constraints impeding science program delivery at the primary level.

9.3.3 Professional Support

The alpha reliability coefficient for Professional Support in the initial 10-item scale was 0.88. This value supports the internal consistency of the scale. Elimination of three items, which were the least correlated to the other items, resulted in increasing the alpha reliability to 0.90. The items retained for this scale are:

1. Teachers at this school have the opportunity to receive ongoing science curriculum professional support.
2. Collegial support is a positive factor in fostering the implementation of science programs in this school.
3. The collegial support evident in this school is important in fostering capabilities in teachers who find science difficult to teach.
4. Teachers have the opportunity to undertake professional development in science.
5. Teachers at this school are supported in their efforts to teach science.
6. The senior administration actively supports science as a curriculum area.
7. The curriculum leadership in science fosters capabilities in those who require support in teaching science.

Again this scale identifies the multidimensional nature of Professional Support. The scale identifies that the support necessary for effective implementation is not only manifest explicitly within both the school through the collegiality and advocacy of staff and the school administration, but also through other external professional development sources.

The mean for the 10-item scale over the 43 schools was 3.59. This suggests that teachers, overall, tended to agree only somewhat to the adequacy of Professional Support in fostering science program delivery. Of the seven scales addressed within the SCIQ, Professional Support was given the highest perception score. This trend is in line with what I anticipated for the participating schools. The majority of the

schools, as mentioned, would be described as ‘professionally engaging schools’ with a strong collaborative approach to improving the educational experience for their students.

9.3.4 School Ethos

The alpha reliability coefficient for time in the initial 10-item scale was 0.86. This value supports the internal consistency of the scale. Elimination of three items, which were the least correlated to the other items, resulted in an increased alpha reliability of 0.90. The seven items retained in this scale are:

1. The school administration recognises the importance of science as a curriculum area in the overall school curriculum.
2. The school’s ethos positively influences the teaching of science.
3. The school places a strong emphasis on science as a curriculum area.
4. Science has a high profile as a curriculum area at this school.
5. Science has a high status as a curriculum area at this school.
6. Science as a curriculum area is valued at this school.
7. Science is regarded as an important subject in the school’s overall curriculum.

This scale addresses the perceived ‘worthwhileness’ or value of science as a curriculum area within the overall school curriculum as mentioned by Thomas (1980). As Dalin (1993) stated the belief system held by the organisation is strongly influenced by the school administration. This aspect is addressed by item 1 in this scale.

The mean for the original 10-item scale over the 43 schools was 3.51. This suggests that teachers, overall, tended to agree only somewhat that the professional leadership and school ethos fostered the delivery of science programs in their school. Of the seven scales addressed within the SCIQ, School Ethos was given the third highest perception score. This dimension was again characteristic of the schools participating in the validation exercise.

9.3.5 Professional Adequacy

The alpha reliability coefficient for Professional Adequacy in the initial 10-item scale was 0.91. This value supports the internal consistency of the scale. Elimination of three items, which were the least correlated to the other items, resulted in an alpha reliability of 0.92. The seven items retained for the final SCIQ are:

1. Teachers at this school are adequately prepared to teach science.
2. Teachers at this school are confident science teachers.
3. Teachers at this school are competent teachers of science.
4. Teachers at this school possess the personal confidence and skills necessary to teach science effectively.
5. Teachers at this school have positive perceptions of themselves as primary science educators.
6. Teachers at this school are adequately prepared to teach to the requirements of the national science curriculum.
7. Teachers at this school have a positive self-image of themselves as regards their ability to teach science.

The scale addresses the perceptions of teachers' ability to carry out a specific task, in this case the teaching of science. The items in the scale address the many images of self-efficacy, e.g., confidence, self-image, and perception of competence and adequacy of preparation.

The mean for the original 10-item scale over the 43 schools was 3.38. This suggests that teachers, overall, possessed only somewhat positive perceptions of their professional adequacy towards the requirements of the delivery of science programs. Of the seven scales addressed within the SCIQ, Professional Adequacy was given the third lowest perception score. This result is consistent with the trends identified in the Phase One studies. Teachers, in general, did not perceive themselves to be overly confident in their ability to address the requirements of the national science curriculum.

9.3.6 Professional Attitude and Interest

The alpha reliability coefficient for Professional Attitude and Interest in the initial 10-item scale was 0.88. This value supports the internal consistency of the scale. Elimination of three items, which were the least correlated to the other items, retained the alpha reliability of 0.88. The seven items retained for the final instrument are:

1. Teachers have a positive attitude to the teaching of science.
2. Teachers at this school are reluctant to teach science.
3. Teachers have a strong motivation to ensure science is taught at this school.
4. Science is a subject at this school that teachers want to teach.
5. Teachers at this school have a positive attitude to science as an essential learning area.
6. Teachers at this school are motivated to 'make science work' as a curriculum area.
7. Teachers at this school have a positive attitude to science as a subject in the primary school program.

This scale as well addresses the many aspects of personal attitude and interest identified by teachers in the Phase One studies. The items mention that motivation, interest, desire, and reluctance are all attitudinal qualities that influence science program delivery.

The mean for the initial 10-item scale over the 43 schools was 3.53. This suggests that teachers, overall, tended to have only somewhat positive perceptions of their professional attitude and interest towards the delivery of science programs. Of the seven scales addressed within the SCIQ, Professional Attitude and Interest was given the second highest perception score. Again, this result would be anticipated considering the nature of the schools and thus, the individual teachers participating in this validation exercise. It is interesting to note that teachers' perceptions of their

Professional Attitude and Interest were more positive than their perceptions of their own professional adequacy.

9.3.7 Professional Knowledge

The alpha reliability coefficient for Professional Knowledge in the initial 10-item scale was 0.77. This value supports the internal consistency of the scale. Elimination of three items, which were the least correlated to the other items, retained the alpha reliability of 0.77. The seven items retained for the final instrument include:

1. Teachers at this school have a good understanding of the science knowledge, skills, and attitudes they are to promote in their teaching.
2. Teachers at this school have a sound knowledge of strategies known to be effective for the teaching of science.
3. Teachers have a sound understanding of alternative ways of teaching scientific ideas to foster student understanding.
4. Teachers at this school are secure in their knowledge of science concepts pertinent to the primary science curriculum.
5. Teachers at this school possess the necessary science subject knowledge to be a good primary science educator.
6. Teachers at this school have a good background knowledge for teaching science.
7. Teachers possess the necessary knowledge required to effectively teach science.

These items represent the multidimensional nature of professional science knowledge identified by teachers and the literature review. Items 4, and 5 and 3, respectively, explicitly refer to subject matter knowledge and pedagogical content knowledge. Although not explicitly addressed, pedagogical procedural knowledge, curricular knowledge and pedagogical knowledge are implicitly addressed in the remaining four items.

The mean for the original 10-item scale over the 43 schools was 3.32. This suggests that teachers, overall, tended to possess only somewhat positive perceptions of the

professional scientific knowledge necessary for the delivery of science programs. Of the seven scales addressed within the SCIQ, Professional Knowledge was given the second lowest perception score. Considering the results of the Phase One studies and the relatively low perceptions teachers have of their professional science adequacy, it is again not surprising that teachers in this survey suggest that they have lower perceptions of their professional science knowledge.

9.3.8 Summary

The initial validation statistical analysis performed in this section has been completed to determine each ten-item scale's internal consistency (Cronbach alpha reliability coefficient), mean and standard deviation. As well, the analysis has provided the means by which three items could be eliminated to increase the economy of the instrument. The new seven-item scales have been determined. On the basis of this analysis a modified, seven scale, seven-item Science Curriculum Implementation Questionnaire has been developed (Appendix C-6). Although the alpha reliability coefficients confirmed that there was high internal consistency in each scale, it was necessary to determine if the scales overlapped and differentiated between schools. These aspects became the focus of the validation analysis discussed in the next section.

9.4 Discriminant Validity

The discriminant validity described as the mean correlation of a scale with the other six scales for the reduced 7-item scale is given in Table 9.2.

**Table 9.2: Science Curriculum Implementation Questionnaire:
Mean Correlations of 7-item Scale with Other Six Scales**

Scale	Discriminant Validity 7-item scales
Professional Knowledge	.60
Professional Attitude and Interest	.60
Professional Adequacy	.48
Professional Support	.53
School Ethos	.58
Resource Adequacy	.41
Time	.31

Mean correlations for all scales, in particular the Professional Knowledge, Professional Attitude and Interest, and Professional Leadership, suggest the scales measure somewhat overlapping aspects of teachers' perceptions of factors influencing science program delivery. In order to determine what factors overlapped the most, correlations between all scales were determined. The correlations of each scale with the other six scales are presented in Table 9.3.

Table 9.3: Inter-Scale Correlations for Seven Scale Science Curriculum Implementation Questionnaire

FACTOR	Professional Support	Time	School Ethos	Resource Adequacy	Professional Adequacy	Professional Attitude & Interest	Professional Knowledge
Professional Support	1	.33	.67	.46	.58	.56	.58
Time		1	.35	.22	.29	.33	.33
School Ethos			1	.49	.65	.70	.62
Resource Adequacy				1	.43	.40	.46
Professional Adequacy					1	.82	.87
Professional Attitude & Interest						1	.78
Professional Knowledge							1

The scales that have the highest correlations are Professional Knowledge and Professional Adequacy (.87), Professional Adequacy and Professional Attitude and Interest (.82), and Professional Knowledge and Professional Attitude and Interest (.78). These high correlations would suggest that the scales are not discriminating between each other and are measuring very similar attributes. This is not surprising as the Phase One studies, including the review of the literature, showed that these three personal attribute dimensions are suggested to be closely related. As an example, low self-efficacy towards the teaching of science is commonly associated with poor professional science knowledge (Baker, 1994; Tilgner, 1990).

Although potentially related, they are, individually, of such importance in influencing science program delivery that it is beneficial to retain them as separate categories in the questionnaire. In practical terms, it is also worthwhile considering how a school might address low scores in a scale in which these three personal attributes are combined. The manner in which low professional interest is addressed is likely to be quite different than the strategy used to address low professional knowledge. Similarly, the strategy used to address low perceptions of professional adequacy is likely to be different than those used to address low levels of professional interest. For these reasons, consideration needs to be given to the *purpose* of the development of the Science Curriculum Implementation Questionnaire. It is regarded as a valuable and practical tool to support schools in identifying and addressing the broad and complex factors influencing science program delivery. If scales are merged that address dimensions that are uniquely important and remedied in different ways, the scales need to be retained. Consequently, the seven scales in the Science Curriculum Implementation Questionnaire are retained.

Even so, it needed to be acknowledged that these three scales do overlap. Taking into consideration the three personal attribute scales do overlap significantly, a merging of the scales provides an economic and effective means by which a school might determine whether the factors influencing science program delivery are extrinsic or environmental factors or intrinsic or personal attribute factors. For this reason a further analysis was completed to determine the correlation amongst all personal attribute factors in the initial 70-item questionnaire. Principal component factor analysis resulted in nearly all items in the extrinsic factor scales (Resource Adequacy, Professional Support, School Ethos, and Time) having a factor loading of at least .50 on their *a priori* scale (Table 9.4). Thus, it was evident that these four scales were measuring independent factors. On the other hand, factor loadings for the three intrinsic scales (Professional Adequacy, Professional Knowledge, and Professional Interest and Attitude) overlapped significantly. Although factor loadings for items from these three scales are listed in their *a priori* scale in Table 9.4, the factor analysis identified these items as belonging to a single scale.

Table 9.4: Factor Loadings, Alpha Reliability, and Analysis of Variance Results for SCIQ

Item No	Professional Support	Time	Resource Adequacy	School Ethos	Professional Adequacy	Professional Knowledge	Professional Attitudes
1	.77						
2	.72						
3	.69						
4	.69						
5	.65						
6	.54						
7	.51						
8		.82					
9		.80					
10		.74					
11		.74					
12		.72					
13		.70					
14		.69					
15			.81				
16			.80				
17			.75				
18			.74				
19			.71				
20			.68				
21			.66				
22				.75			
23				.72			
24				.72			
25				.58			
26				.49			
27				.45			
28				.36			
29					.79		
30					.72		
31					.71		
32					.64		
33					.63		
34					.61		
35					.60		
36						.85	
37						.80	
38						.75	
39						.74	
40						.72	
41						.70	
42						.68	
43							.73
44							.72
45							.69
46							.67
47							.65
48							.63
49							.53
Alpha Reliability	.90	.90	.83	.90	.92	.77	.88
eta ² (Schools Categorical)	.056	.005	.006	.046	.047	.040	.085
eta ² (Schools Combined)	.427	.412	.635	.400	.512	.498	.587

Principal component factor analysis loadings for the personal attribute items with the highest correlations are listed in Table 9.5.

Table 9.5: Highest Correlations Amongst the Personal Attribute Items

Item	Correlation
(PA) Teachers at this school have the necessary confidence and skills to teach science effectively.	.85
(PA) Teachers at this school have a positive self-image of themselves as regards to their ability to teach science.	.80
(PA) Teachers at this school are competent teachers of science	.79
(PK) Teachers at this school have a good background knowledge for teaching science.	.75
(PK) Teachers at this school have a sound knowledge of strategies known to be effective for the teaching of science.	.74
(PA & I) Teachers at this school are reluctant to teach science	.73
(PA & I) Science is a subject at this school that teachers want to teach	.72

Interestingly, the highest correlations exist amongst seven items that are representative of each of the three personal attribute scales. The first three items are Professional Adequacy (PA) items, the following two are Professional Knowledge (PK) items and the remaining two are Professional Attitude and Interest (PA & I) items.

These seven items were merged into a Personal Attributes scale and a further discriminant validity analysis was completed to determine if the interscale overlap could be reduced. The results of this analysis are presented in Table 9.6.

Table 9.6: Inter-scale Correlations for Five-Scale SCIQ

	Professional Support	Time	School Ethos	Resource Adequacy	Personal Attributes
Professional Support	1	.24	.67	.43	.54
Time		1	.30	.15	.28
School Ethos			1	.44	.61
Resource Adequacy				1	.45
Personal Attributes					1

Correlations again suggest the scales, to varying extents, now measure independent although somewhat overlapping aspects of teachers' perceptions of factors influencing science program delivery. The greatest overlap occurs between School Ethos and Professional Support and School Ethos and Professional Attributes, aspects that might be expected to overlap. As an example, school ethos pertains to the overall school beliefs towards science as a curriculum area. This belief is a collective perception as acknowledged by staff, school, administration, and community. Professional Support pertains to the perception of the level of support that is available for teachers in science delivery from both in school and external sources. Consequently, it would be expected that a school that acknowledges science as an important subject in the overall school curriculum (School Ethos) would practically display this status by the support provided for teachers (Professional Support). Similarly, if the teachers in the school have a strong interest and motivation towards science and the teaching of science (Professional Attitude and Interest) one might expect the school to, overall, acknowledge science as a key curriculum area in the school curriculum (School Ethos).

Despite the overlaps that do exist, the mean correlations were substantially lower for the 5-scale questionnaire as compared to the 7-item score. This would suggest that the 5-scale questionnaire would also be a valuable instrument to use in an educational

context where the analysis of factors influencing science program delivery is not needed to be as thorough. A 5-scale instrument is included in the Appendix (C-7).

9.5 Interschool Correlations

A further analysis was conducted to determine if the Science Curriculum Implementation Questionnaire differentiated between schools. Initially a multivariate analysis of variance was conducted using SPSS General Linear Model (GLM) procedure. This analysis combined all seven scales as the dependent variable and the factor as the school. Significant results ($p < .01$) were found for the school factor confirming that the SCIQ has the ability to differentiate among the perceptions of teachers at different schools. Following this a one-way analysis of variance (ANOVA) was conducted to determine the ability of each scale of the SCIQ to differentiate between the perceptions of teachers at different schools. The ANOVA results obtained were again significant ($p < .01$) confirming the ability of not only the questionnaire but also each scale's ability to differentiate among schools.

A further eta^2 statistic was calculated to provide an estimate of the strength of association between school membership and the SCIQ. The amount of variance in scores accounted for by school membership is reported in Table 9.4. The high variance results (range: 0.400 - 0.635) suggested that there was a high degree of variability amongst the schools for each factor. This would be anticipated when one considers that 20 of the schools were only one or two teacher schools and that a single individual response that is quite different from the rest could distinguish strongly amongst the schools and result in a higher eta^2 statistic. In order to reduce the influence of individual schools, a further analysis of variance was conducted with the dependent variable being the scale but the factor being school size. Schools were broken down into three categories: small (1-4 teachers), medium (5-9), and large (>10). The eta^2 results for this analysis are presented in Table 9.4 as well. This reduced the variance considerably (range: 0.005 – 0.085). On the basis of the ANOVA results it can be concluded that the SCIQ in its entirety and as discrete scales is able to differentiate between schools.

9.6 Summary of the SCIQ Validation Data.

The purpose of this chapter has been to outline the procedures involved in the validation and refining of the Science Curriculum Implementation Questionnaire. It has presented information pertaining to the participating schools. It has also presented the alpha reliability validation statistical analysis data for the initial 10-item scale and the reduced 7-item scale. It further has explained the procedures involved in the discriminant validity analysis, refining of the 7-scale instrument and the development of a further, shorter, 5-scale form of the SCIQ based on the merging of the three intrinsic factors scales. It further has explained the procedures used in determining whether the SCIQ in its entirety and as discrete scales is able to differentiate between schools. Chapter 10 describes the procedures and outcomes associated with the application of the SCIQ at Intermediate School, the location of the case study analysis described in Chapter 7.

Chapter 10 Application of the Science Curriculum Implementation Questionnaire

10.1 Introduction

The purpose of this chapter is to present the results of the application of the Science Curriculum Implementation Questionnaire at Intermediate School, the school used for the case study analysis detailed in Chapter 7. If the SCIQ is to have any professional value as an information-gathering tool, the data collected and inferences made from this information must parallel the information that would be collected from a more thorough school review. Consequently, this application exercise is a critical process in the authentication of the SCIQ as a school development instrument. The information provided by the case study gave a very thorough understanding of the factors influencing science delivery. As suggested by Stewart & Prebble (1985), if School Development processes are to be effective, they must be based on the gathering of high-quality information. Consequently, the application of the SCIQ in the case study school tests its accuracy and professional value. Can the quantitative data collected by the application of the SCIQ identify the same patterns that were identified in the case study analysis? Does it present sufficient information to assist a school to move on from the data-collection phase to the follow-on phase of selecting and implementing a solution or strategy for change?

The chapter begins by outlining the quantitative results of the application exercise in section 10.2. In section 10.3 the quantitative results are compared to the themes identified in the qualitative analysis. Section 10.4 summarises the chapter and introduces the intent of the Chapter 11, the summarising chapter of this thesis.

10.2 Quantitative Results of the Application Exercise

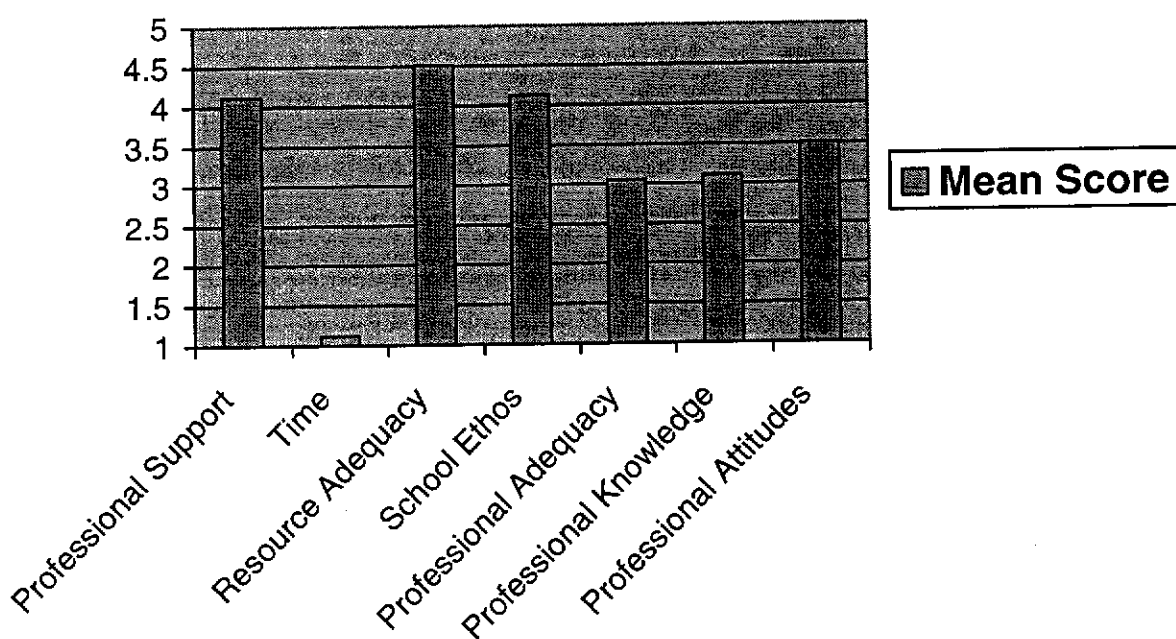
The validated 7-scale, 49-item Science Curriculum Implementation Questionnaire was administered at Intermediate School, the context for the case study reported in Chapter 7. Although the entire staff had been invited to participate in the questionnaire component of the case study, only a selected sample of five teachers (including the Deputy Principal who still performs classroom duties) was included in

the interview phase. Since the themes had been identified primarily through the responses of these five participants it was decided to include only these five participants in the application exercise. A further condition that had pre-empted the use of only selected teachers was the expressed concern by several staff as to the amount they were overloaded by a variety of professional demands during the term in which the application exercise was to be completed. All five teachers were contacted and requested to complete the validated Science Curriculum Implementation Questionnaire (Appendix C- 8). The mean scores and standard deviations from the completed five questionnaires were determined. Mean score and standard deviations for the SCIQ are presented in Table 10.1. Mean scores are also graphically presented in Figure 10.1.

Table 10.1: Science Curriculum Implementation Profiles for Intermediate Normal

Scale	Mean Score	Standard Deviation
Professional Support	4.12	0.50
Time	1.12	0.25
Resource Adequacy	4.51	0.20
School Ethos	4.13	0.74
Professional Adequacy	3.05	0.31
Professional Knowledge	3.11	0.24
Professional Attitudes	3.51	0.76

Figure 10.1: Science Curriculum Implementation Profiles for Intermediate School



10.3 Comparison of SCIQ Data with Intermediate School Case Study Data

Data collected from the SCIQ application confirmed that teachers perceived that Intermediate School is a well-resourced school for science program delivery (mean score – 4.51). Standard deviation results (0.20) affirmed that there is a consistent perception that the school is adequately resourced for teaching the requirements of the national science curriculum. This consistent perception was evident in the data collected from the card-sort exercise and the interviews. The case study had identified there was some concern in the area of the availability of resources because of the demands on equipment and facilities because of overlap in classes completing similar topics. The SCIQ results did not identify this concern.

The SCIQ results further confirmed that time availability was perceived to be a critical factor impeding science program delivery at Intermediate School (mean score – 0.72). Time was consistently identified as the major factor inhibiting science program delivery in the case study card-sort exercise and the interviews. The SCIQ results re-emphasised the consistent degree to which time availability was perceived to be a major factor influencing science curriculum implementation (standard deviation – 0.25). Although the case study interviews identified the multidimensional nature of time constraints, the SCIQ results did not.

The SCIQ further suggested that perceptions of teachers' professional science knowledge (mean score – 3.05) and professional adequacy (mean score - 3.11) were neither strong nor weak. In the case study teachers identified professional knowledge and professional adequacy as critical factors influencing science program delivery. Although time was seen as the major factor impeding effective science program delivery, these two personal attributes were also seen as important factors. Standard deviation results (0.24 & 0.31 respectively) suggested that teachers were quite consistent in their perceptions that teachers collectively did not have either a strong or weak perception of their own professional adequacy or knowledge.

Similarly, teachers viewed their personal interest and motivation in science as a curriculum area as being slightly more positive (mean score – 3.51). Again the case

study had identified personal interest and motivation as a factor somewhat influencing science program delivery. The high standard deviation result (0.76) would suggest that amongst the five teachers involved in the application exercise there was a wide range of perceptions of the degree to which the teacher perceptions of the attitudes and interests held towards science and the teaching of science influence science program delivery at Intermediate School. That is, there was wide range of perceptions about teachers' interest and attitude towards science as a curriculum area. Although the mean perception of staff interest and attitude is quite positive, the standard deviation would suggest that this view is not consistent throughout the staff. This is again consistent with the case study analysis. Judy had suggested that staff interest in science as a curriculum was high whereas George had suggested that professional interest in teaching science was the major factor inhibiting science program delivery in his classroom. The SCIQ mean and standard deviation results affirmed the trends identified in the case study.

The SCIQ results suggested that teachers perceive that science has a relatively high status as a curriculum area (mean score – 4.13). The case study identified that teachers agreed that science had had a high status but this status was waning clearly suggesting that all teachers did not hold the same perceptions of the status of science as a learning area within the entire school curriculum. The standard deviation result (0.74) suggests that although the overall perception of the status of science is very high, there is a wide range of perceptions of the overall staff beliefs towards the status of science as a curriculum area.

The SCIQ results similarly suggested that although teachers identify the support availability from both in-school and external sources as being very good (mean score – 4.12), there is considerable variability in this perception (standard deviation – 0.50). Again this perception is consistent with the results of the case study analysis. All teachers recognised the in-school support they received as very good but differed in their perceptions of the availability of external professional development support. As an example, Judy had identified the close working relationship with the local College of Education as a major factor in supporting her in her science curriculum leadership responsibilities whereas several teachers had identified in the card-sort exercise the lack of in-service opportunities as a factor influencing science program delivery.

Again, the SCIQ, although able to identify the overall perceived teacher support availability, was unable to differentiate between the two dimensions of professional support inherent within this scale.

10.4 Summary

The purpose of this chapter has been to outline the procedures used in the application of the Science Curriculum Implementation Questionnaire at Intermediate School and to compare the quantitative results of the application exercise with the qualitative themes identified in the case study outlined in Chapter 7. The application exercise reaffirmed that time and, to a lesser degree professional attributes such as professional knowledge, interest and knowledge as well as school ethos were key aspects perceived to be impeding effective science curriculum delivery at Intermediate School. The SCIQ results, as well, affirmed that resource adequacy, school ethos and professional support were factors that foster science program delivery at Intermediate School. The SCIQ data not only reaffirmed the same themes identified in the case study they also, by way of the standard deviation analysis, gave a clear description of the variability in the staff perceptions pertaining to the factors under analysis.

Although the SCIQ quantified these perceptions, it did not differentiate between the multidimensional aspects of some of these factors. Thus, although the case study identified teachers concern with multidimensional aspects of time (e.g., time to become familiar with new materials, time to gather science resources, time to teach science, time to learn the science required to be taught), the SCIQ did not differentiate amongst these dimensions. Although the mean score and standard deviations for each of the items in each scale could be calculated, the usual quantification procedure used in the analysis does not reveal this information. Consequently the information it provided was somewhat superficial in its quality.

As suggested by Prebble and Stewart (1985) the gathering of high-quality information is a critical component of the school development process. These authors describe high-quality data as that which allows the school, through discussion and reflection, to reach an informed decision about a problem and the organisation generally. It prevents the school from embarking on needless and unfocused change. In brief it

provides the school with information by which it can learn about itself and address change where necessary. In the light of these comments, it is evident that the data collected from the SCIQ gives an accurate description of the factors perceived to be influencing science program delivery at Intermediate School. As Prebble and Stewart (1985) further suggested, the use of instruments as a data-collecting method is a more superficial but time effective means by which an analysis of the school can be conducted. The data collected from the SCIQ application exercise would confirm this assertion.

Chapter 11 Conclusions

11.1 Introduction

The purpose of this final chapter is to summarise the intentions and findings of this investigation into the complex and interrelated factors influencing primary science program delivery. As well, it examines the practical outcome of the investigation, the development of a learning environment instrument, the Science Curriculum Implementation Questionnaire, that can assist schools in the diagnosis of the intrinsic and extrinsic factors that may be influencing science program delivery within their school. The chapter begins by reviewing the study in section 11.2. Section 11.3, presents a summarisation of the major findings of the study. Section 11.4 identifies the limitations of the study, and section 11.5 provides recommendations for further research. Section 11.6 follows by identifying the significance of the study. Finally, section 11.7 summarises the study.

11.2 Review of the Study

The catalyst for conducting this study has been to satisfy a professional desire to understand the broad and complex factors influencing science program delivery. It has been a further desire to develop a tool that can be of assistance to schools in providing meaningful information from which schools can implement strategies to effectively improve the effectiveness of its science program delivery en-route to providing more meaningful science learning experiences for its children.

The data collection for this study commenced when the first questionnaire was distributed to 155 teachers in the Central Districts of New Zealand. The study identified several factors both related to the professional capabilities of teachers and the environmental conditions of schools as critical factors influencing science program delivery in New Zealand. Shortly after the completion of this survey, the results of New Zealand's participation in the Third International Mathematics and Science Study were released. It was apparent that in the abbreviated TIMSS analysis of factors influencing the science experience of primary children and delivery of

science programs in general was exposing issues that were evident in the initial questionnaire survey. The TIMSS data provided further impetus to further probe the factors influencing science program delivery in New Zealand.

The data collection exercises that followed endeavoured to investigate the issues influencing science program delivery. A pre-service teacher education survey involving 155 students provided a more comprehensive understanding of the background experience New Zealand teachers bring into the primary teaching profession. A further case study analysis at a large Intermediate School probed more deeply into the multidimensional aspects of the factors influencing science program delivery. The first phase of this study, which has been regarded as an interpretivist study into the factors influencing science program delivery within the New Zealand context, concluded with a conducting a thorough review of the literature pertaining to factors influencing curriculum implementation, especially within the context of science program delivery.

Phase Two of the study focussed on the development of an instrument that would assist schools in identifying the factors science program delivery and, by so doing, provide an information foundation for fostering strategies for curriculum delivery improvement. This phase started with the collation of all the factors identified in the Phase One studies as promoters or impediments to curriculum implementation. Using a Focus Group, these factors were then categorised and ranked and included in a Science Curriculum Implementation Questionnaire. The questionnaire was trialled amongst 293 teachers in 43 schools and then statistically validated and modified on the responses of participating teachers. The validated instrument was finally applied in the case study school and the qualitative data collected from the case study was compared with the quantitative application exercise. Finally, based on this application, the professional merits of the *Science Curriculum Implementation Questionnaire* were discussed.

11.3 Major Findings of the Study

In this section the major findings of this study are addressed within the original intentions of the thesis.

1. What are the factors that New Zealand teachers and school administrators identify as contributors or inhibitors to effective science curriculum implementation at the primary level?

The research gathered in this thesis confirms Fullan's (1992) assertions that the factors influencing curriculum implementation are both specific to: (1) the individuals involved in the implementation process and (2) the environment in which the implementation process is to occur. The responses gathered in the Phase One studies repeatedly emphasised that a broad and complex variety of intrinsic and extrinsic factors are influencing the effectiveness of science program delivery in New Zealand primary, intermediate, and Kura Kaupapa Maori schools. Teacher ability is a critical factor influencing science program delivery in New Zealand schools. This ability is strongly influenced not only by multidimensional aspects of knowledge but also by the teachers' own perceptions of their ability to teach science. Science program delivery is also influenced by teachers' professional interest and attitudes toward science and the teaching of science. Although these three personal attributes are strongly interrelated, they are still individual attributes influencing the delivery of science programs in schools.

These attributes influence and are influenced by aspects of the school environment. Time availability, professional support from within the school, and resource adequacy are identified as aspects of the school environment that influence science delivery. As well, the overall school ethos, which is strongly influenced by the school administration, is another critical factor influencing the effectiveness of program delivery.

2. What does the research literature identify as the critical factors influencing curriculum implementation in general and science curriculum implementation specifically at the primary level?

Although Fullan identified 'teacher ability to deal with the task at hand' as one factor influencing curriculum implementation efforts, this study has identified the paramount

significance of the personal attributes in influencing the effectiveness of science program delivery. The research literature repeatedly addresses the impediments to science program delivery as being related to inadequacies in teacher knowledge and the availability of resources, time, and professional support. Although the broader domain of educational administration and sociology recognises the influence of school culture and leadership on curriculum reform, the background literature on factors influencing science program delivery fails to identify the significant impact school culture has on science delivery. Clearly, as identified in the case study, school culture and leadership significantly impact on the effectiveness of science curriculum implementation efforts.

3. To develop a quantitative assessment instrument to measure those aspects of teacher behaviour and school environment known to influence primary science curriculum implementation.

Using the information gathered from the Phase One studies a quantitative assessment was able to be developed to assist schools in the crucial initiating stage to school development, data gathering. Both a five- and seven-scale Science Curriculum Implementation Questionnaire has been developed with the intent of being an economical and accurate instrument for identifying the factors that may be fostering or impeding science curriculum delivery.

4. To apply the assessment instrument within an educational jurisdiction to ascertain its professional usefulness.

The Science Curriculum Implementation Questionnaire was found to give an accurate but somewhat superficial profile of factors influencing science program delivery. The trends evident in the quantitative data collected from the application of the questionnaire paralleled similar themes evident in the more time-consuming and thorough case study investigation. Standard deviation results obtained from the data analysis were essential in providing insight into the degree of consistency in the perceptions towards factors influencing science program delivery at the case study school.

11.4 Limitations of the Study

Since the purpose of the Phase One studies was to identify the factors influencing the implementation of science programs within the New Zealand context, the process of generalising conclusions from a sample population in the Central Districts potentially influences the external validity of the results. The trends and themes identified are generalised but, at the same time, there is nothing to suggest that the pre-service and practising teachers used in the three data collection exercises in Phase One are unique and not representative of the primary science education community. Many of the teachers that participated in the in-service questionnaire survey were known to be the science leaders for the school. This undoubtedly painted a more positive picture of teacher capability in dealing with the teaching requirements of the science curriculum but still this is not believed to have biased the results in regards to identifying the factors influencing science program delivery. Similarly, although many of the teachers involved in the validation exercise were from schools regarded as being 'professionally engaging', the results again painted a more positive picture of the science program delivery situation in New Zealand schools and were used only for the validation of the instrument.

The Science Curriculum Implementation Questionnaire was only applied in one school and with a small sample size. This is regarded as a limitation of this study. It was essential to apply the instrument where the data collected from the instrument application could be compared to a school in which the factors known to be influencing science program delivery had been identified. Potentially several schools could have been used for case study analysis and subsequently the instrument applied to several schools in order to increase its validity as an assessment tool.

11.5 Recommendations for Further Research

Both phases of this study provide opportunities and recommendations for further research, especially within the New Zealand context.

1. The interrelationships amongst professional adequacy, knowledge and interest are both quite complex and tenuous. Further studies to investigate the interrelationships amongst these attributes within the context of primary science delivery are necessary.
2. The influence school administration has on science program delivery have been identified within this study. As well, the school management changes that have occurred in New Zealand under *Tomorrow's Schools* have potentially removed principals from the role of school leaders, especially in curriculum, to educational managers. To investigate the influence these policy changes have had on science program delivery, as seen at Intermediate School, is worthy of study.
3. The development of the Science Curriculum Implementation Questionnaire provides a research platform for comparative studies in factors influencing science program delivery in both the national and international context.
4. The development of the Science Curriculum Implementation Questionnaire is a valuable addition to the collection of educational instruments that presently exist. The SCIQ is believed to be the first questionnaire that addresses factors influencing curriculum implementation in science and consequently serves as a foundation for the development of instruments relating to the delivery of other curriculum areas.

11.6 Significance of the Study

This study has significance at the regional, national and international level.

This study is completed at a time when New Zealand education is undergoing considerable change. *Science in the New Zealand Curriculum* (1993) was gazetted for implementation at the start of 1995. It was the second national curriculum to be gazetted. Since then all of the Essential Learning Areas have been gazetted for implementation. Teachers in primary schools testify to the 'waves' of implementation that have placed considerable and ongoing pressure on teachers and administrators

over the past seven years. Schools within the region in which the author works as a teacher educator and advisor to schools have made it clear that although some are still preoccupied with some of the new curricula, they are voicing their desire to revisit the science curriculum to identify how effective they have been in implementing the science curriculum. In my contact with schools, the development of my own understanding of factors influencing science program delivery and the Science Curriculum Implementation Questionnaire provides practical support to schools in addressing these needs.

At a national level, the information gathered from this study provides a comprehensive analysis of the factors influencing science program delivery in the New Zealand context. Clearly the Ministerial efforts, although regarded as ambitious, are less than adequate in addressing the existing maladies in science education in New Zealand. I am aware that there is little, if any, school-based research into understanding the factors at work in influencing science program delivery in New Zealand. The information emanating from this study over the past five years has been well received and recognised as significant by policy makers, teacher educators, and others within the professional science education community who are committed to making a difference.

As well, the results of this thesis are of value to the international community. As mentioned throughout this thesis, the factors influencing science program delivery at the primary level are both broad and complex. Science teaching in primary schools is in a parlous state. The research in this thesis has been focused on ‘putting’ a finger on the factors influencing science program delivery and, on the basis of this analysis, developing an instrument that can assist schools in moving forward in their efforts to improve the quality of the science education experience it provides its children.

11.7 Summary

During the time of this study the author has become more critically aware of the complex factors at work influencing curriculum delivery. Even though those exceptional schools where the intended science curriculum has become the actual curriculum are experienced by the author, it is readily evident that several aspects of

the professional attributes of teachers and the school environment play a critical role in impeding the implementation of the science curriculum in many schools. Often schools appear to not have the time or desire to reflect on the science educational experience they offer their children.

Despite this capability or desire, for the duration of this study many schools have looked to the information gathered and identified in this study to assist them to move on in providing positive science experiences for their children. For this reason, this study has been both practical and purposeful. Not only for me, but also for the schools I work with and encourage. I confidently believe that the understanding developed in this study in the area of factors influencing school science curriculum delivery and the Science Curriculum Implementation Questionnaire developed as a practical outcome in this study can be of support for the science education community both nationally and internationally in fostering an improvement in the science experience afforded to its students.

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Appendices

Appendix A: Questionnaires - Phase One

- A-1 Letter of Invitation for In-service Questionnaire Participation.**
- A-2 Letter to Participating Teachers**
- A-3 In-service Questionnaire**
- A-4 Letter of Invitation for Pre-service Questionnaire Participation**
- A-5 Pre-service Questionnaire**
- A-6 Case Study Letter of Invitation**
- A-7 Case Study Questionnaire**
- A-8 Case Study Interview Schedule**

A-1 Letter of Invitation for In-service Questionnaire Participation.

Science Department
Massey University College of Education
Massey University
PALMERSTON NORTH

Dear Sir or Madam

I am conducting a doctorate research exercise for the purpose of determining how we can be improving the quality of our service in the area of pre-service / in-service training and general support in the area of science education.

I would like the opportunity to conduct a questionnaire survey with the teachers responsible for year 4 and year 6 at your school. We assume that this person will be teaching some science as part of their regular programme. The questionnaire focuses on the following question – **What do teachers perceive as the major factors contributing to the implementation of effective science education programmes in schools?** The survey completion time is approximately fifteen minutes. Permission for conducting this survey has been provided through my doctoral supervisor at Curtin University.

When the survey is completed and the results are collated, we will give each school that responds an abbreviated report.

If you wish for your year 4 and 6 teacher(s) to take part in the survey or you have any initial queries please complete the fax form that accompanies this letter and return it to the College by April 1.

May I at this time thank you for your support in this matter.

Faithfully yours

Brian Lewthwaite
HOD Science

Appendix A-2: Letter to Participating Teachers

Dear Sir or Madam

Your school principal may have recently informed you that a letter was forthcoming from the College of Education at Massey University.

The research exercise that I am asking you to participate in is focusing on the factors contributing to the implementation of the green document – *Science in the New Zealand Curriculum* and science education programmes in general. We know that the implementation of any document/programme is evolutionary, but it is probable that for many schools the main part of the implementation process is complete. It is evident that a variety of factors influence the process of curriculum implementation in schools. It is your perceptions of what these factors are that is our interest. For science programmes to be implemented effectively teacher **perceptions** of what promotes successful science curriculum implementation are essential in providing us with a clearer focus on what we should be focussing on in our programmes.

The Science Department, in the area of pre-service training, and the Advisory Service, in the area of in-service training and support, realise that our services are able to be improved by the feedback we receive from you. Although there are many other players in the implementation process we believe that your responses allow us to examine that we do and gain a better understanding of how we can improve our efforts in contributing to the effectiveness of science education in schools.

Your governing body, the Ministry of Education, as well as your principal have been informed that this survey is being conducted. I would hope that you would take the time to complete the questionnaire as accurately and truthfully as possible and return it in the envelope provided within a fortnight. The results will be tabulated and an abbreviated report to all participating schools will be forwarded prior to the end of the school year.

I cannot provide you with any payment for your participation, but we are certain that your responses will bring support to you through potential modifications to the service we provide in our pre-service and in-service programmes.

If you have any concerns in regards to what we are asking of you please contact us at the College.

At this time we would like to thank you for your time and ongoing dedication to children's education in all areas not just science.

Faithfully yours

Brian Lewthwaite
HOD Science
Doctoral Student - Curtin University

Appendix A-3: In-service Questionnaire

QUESTIONNAIRE

Factors Contributing to the Effective Implementation of Science Education Programmes

The purpose of this survey is to investigate the following research question:

What do teachers perceive as the major factors contributing to the effective implementation of Science Education Programmes?

Information provided in this survey is for development purposes in the pre-service and in-service training programmes offered by the Science Department at Massey University College of Education and Science Teacher Support Services.

Participant confidentiality is guaranteed.

Questionnaire has been prepared in consultation with staff of the
Science and Mathematics Education Centre
Curtin University

SECTION A: TEACHER INFORMATION

Administration
use only

1. Class that you are responsible for	Year 2 / Year 6 /Year 8	1 <input type="checkbox"/> <input type="checkbox"/> <input type="checkbox"/>
2. Number of children on class roll	_____	2 <input type="checkbox"/> <input type="checkbox"/>
3. Number of years you have taught at this school	_____	3 <input type="checkbox"/> <input type="checkbox"/>
4. Number of years you have taught	_____	4 <input type="checkbox"/> <input type="checkbox"/>
5. Are you	male / female	5 <input type="checkbox"/>
6. Where did you take your pre-service teacher education?	_____	6 <input type="checkbox"/> <input type="checkbox"/>
	_____	<input type="checkbox"/> <input type="checkbox"/>
	_____	<input type="checkbox"/> <input type="checkbox"/>
7. What academic qualifications do you hold?		7 <input type="checkbox"/>
_____		<input type="checkbox"/>
_____		<input type="checkbox"/>
_____		<input type="checkbox"/>
8. Comment briefly on how your pre-service teacher education has prepared you for teaching science.		8 <input type="checkbox"/>
_____		<input type="checkbox"/>
_____		<input type="checkbox"/>
_____		<input type="checkbox"/>
9. Have you studied science at secondary school level?		9 <input type="checkbox"/>
<input type="checkbox"/> Yes <input type="checkbox"/> No		
10. If so, what science subjects?		10 <input type="checkbox"/>
_____		<input type="checkbox"/>
_____		<input type="checkbox"/>
_____		<input type="checkbox"/>
11. Have you studied any science subjects at university level (biology, chemistry, etc)?		11 <input type="checkbox"/>
<input type="checkbox"/> Yes <input type="checkbox"/> No		
12. If so, what subjects?		12 <input type="checkbox"/>
_____		<input type="checkbox"/>
		<input type="checkbox"/>
		<input type="checkbox"/>

13. Comment briefly on how relevant this study has been to you in teaching science in primary/intermediate school.

13

14. Comment briefly on any further professional development you have undertaken or been involved with in science.

14

15. What learning experiences have you had, either formal or informal, that you believe have contributed significantly to your scientific understanding and ability to teach science in the classroom?

15

16. What parts of the *Science in the New Zealand Curriculum* document do you find easy to teach?

- Living World
- Material World
- Physical World
- Planet Earth and Beyond

16

17. What parts do you find difficult to teach?

- Living World
- Material World
- Physical World
- Planet Earth and Beyond

17

18. In this section we would like you to identify the content areas in which you could benefit from receiving in-service support. It would be best that you identify these areas on the basis of the perceived competence you have in dealing with them as a teacher. Use the following scale in identifying these areas in your self-evaluation.

- 1 Competence not a significant problem
- 2 Competence somewhat of a problem
- 3 Competence a serious problem

	(Circle one on each line)			Administration only
	Not a significant problem	Somewhat of a problem	Serious problem	
Living World:				
diversity of living organisms	90	31	1	19 <input type="checkbox"/>
special features of NZ plants/animals	90	31	1	20 <input type="checkbox"/>
structure/function in living things	94	28	-	21 <input type="checkbox"/>
growth/reproduction in living things	106	16	-	22 <input type="checkbox"/>
interdependence of living things	95	24	3	23 <input type="checkbox"/>
Physical World				
light	79	37	6	24 <input type="checkbox"/>
heat and temperature	90	25	7	25 <input type="checkbox"/>
sound	75	41	6	26 <input type="checkbox"/>
electricity	62	44	15	27 <input type="checkbox"/>
energy	53	56	13	28 <input type="checkbox"/>
magnetism	83	32	7	29 <input type="checkbox"/>
flotation	102	18	2	30 <input type="checkbox"/>
how pieces of everyday objects work	79	37	6	31 <input type="checkbox"/>
Material World				
nature and properties of substances	53	55	6	32 <input type="checkbox"/>
properties of substances and their use	51	58	7	33 <input type="checkbox"/>
how materials undergo change	67	47	2	34 <input type="checkbox"/>
grouping substances according to their similarities	77	36	5	35 <input type="checkbox"/>
how selected materials are manufactured	49	62	4	36 <input type="checkbox"/>
materials and their effect on the environment	67	45	-	37 <input type="checkbox"/>
Planet Earth and Beyond				
composition of Planet Earth	70	43	10	38 <input type="checkbox"/>
processes that shape Planet Earth	72	39	9	39 <input type="checkbox"/>
New Zealand geological history	58	55	13	40 <input type="checkbox"/>
movement of Planet Earth in relationship to other objects in the heavens	68	45	11	41 <input type="checkbox"/>
relevant environmental issues	83	37	4	42 <input type="checkbox"/>
Scientific Skills and Attributes				
promoting investigative activities	70	48	6	43 <input type="checkbox"/>
developing skills associated with investigating	60	56	6	44 <input type="checkbox"/>
The Nature of Science and its Relationship to Technology				
how simple items of technology work	75	39	8	45 <input type="checkbox"/>
how items of technology have developed	68	43	11	46 <input type="checkbox"/>
fair testing	75	37	10	47 <input type="checkbox"/>

SECTION B:

Administration
only

In your opinion, how great a problem is each of the following for teaching science in your school as a whole?

(Circle one on each line)

		Not a significant problem	Somewhat of a problem	serious problem		
a.	Facilities	1	2	3	48	<input type="checkbox"/>
b.	Funds for purchasing equipment and supplies	1	2	3	49	<input type="checkbox"/>
c.	Children's reading abilities	1	2	3	50	<input type="checkbox"/>
d.	Children's interest in science	1	2	3	51	<input type="checkbox"/>
e.	Children's absences	1	2	3	52	<input type="checkbox"/>
f.	Teacher interest in science	1	2	3	53	<input type="checkbox"/>
g.	Teacher confidence to teach science	1	2	3	54	<input type="checkbox"/>
h.	Time available to teach science	1	2	3	55	<input type="checkbox"/>
i.	In-service education opportunities	1	2	3	56	<input type="checkbox"/>
j.	Large classes	1	2	3	57	<input type="checkbox"/>
k.	Maintaining discipline	1	2	3	58	<input type="checkbox"/>
l.	Parental support	1	2	3	59	<input type="checkbox"/>
m.	Availability of Science Curriculum document	1	2	3	60	<input type="checkbox"/>
n.	Understanding of Science Curriculum document	1	2	3	61	<input type="checkbox"/>
o.	Emphasis school programme places on science education	1	2	3	62	<input type="checkbox"/>
p.	Science equipment	1	2	3	63	<input type="checkbox"/>
q.	Supplementary resources (units, kits) that support science education	1	2	3	64	<input type="checkbox"/>

SECTION C:

Administration
only

SUMMARY

1. What do you consider to be the major factors that are contributing to the successful implementation of an effective science education programme in your school/classroom?

2. What do you consider to be the main barriers that are preventing or inhibiting the effective implementation of quality science education programmes in your school/classroom?

3. If the *Science in the New Zealand Curriculum* document was to be effectively implemented in your classroom what would be the major factors that would make this implementation a reality?

4. Are there any further comments you would like to make that address the purpose of this questionnaire, ie *Teacher Perceptions of Factors Influencing the Effective Implementation of Science Education Programmes in Schools?*

That completes the questionnaire.

Thank you for completing the survey. Please return the questionnaire in the self-addressed envelope provided.

Appendix A-4: Letter of Invitation for Pre-service Questionnaire Participation

29 August 1998

Science
Massey University
College of Education
PALMERSTON NORTH

Students in Science Curriculum I and II

I am completing a doctorate degree in Science education and have commenced the research phase of the degree. I am at the point where I have established the research focus of the degree and through preliminary surveys have been advised by my supervisor to conduct an initial survey in my interest area amongst Science teacher trainees at Massey University College of Education. I am interested in looking at intrinsic (personal) factors that influence the implementation of Science programmes and classroom Science teaching.

At this stage, I need to trial a questionnaire and desire to involve three classes of students completing Science Curriculum I and the one Science Curriculum II class in the survey. The questionnaire will take 30 minutes to complete and will be conducted during class time in the last week of your course. The questionnaire has four sections. You will be asked to provide biographical details and answer questions related to your present coursework, the teaching of Science, and your knowledge of Science. The questionnaire is totally anonymous and the data will be used for research purposes only.

Please complete the statement below confirming your availability in participating in this survey. Pass this information sheet on to your course controller after completion.

Thank you for your support in this matter.

Brian Lewthwaite
Science

I _____ do/do not wish to participate in the research exercise.

Appendix A-5: Pre-service Questionnaire

SCIENCE CURRICULUM I: REFLECTION

CIRCLE THE ANSWER THAT BEST REPRESENTS YOUR RESPONSE TO THE FOLLOWING STATEMENTS	STRONGLY AGREE	AGREE	NEITHER AGREE NOR DISAGREE	DISAGREE	STRONGLY DISAGREE
1. I have a strong science background	1	2	3	4	5
2. I was a successful science student at secondary school.	1	2	3	4	5
3. Boys were more successful at science than girls during my school years.	1	2	3	4	5
4. I had a positive science experience at secondary school.	1	2	3	4	5
5. I have found that the hands on experiences I have had in Curriculum Science sessions have developed my confidence in teaching science.	1	2	3	4	5
6. I have found that the opportunity to microteach science lessons on Placement Days has helped me to develop a confidence in my ability to teach science.	1	2	3	4	5
7. I have a good understanding of the Science curriculum document.	1	2	3	4	5
8. I have found that the supportive collegial environment of my Curriculum Studies class has contributed to my confidence development and my ability to teach science.	1	2	3	4	5
9. My attitude towards science has become more positive during this course.	1	2	3	4	5
10. The personal investigation I undertook has improved my confidence in the scientific process.	1	2	3	4	5

	STRONGLY AGREE	AGREE	NEITHER AGREE NOR DISAGREE	DISAGREE	STRONGLY DISAGREE
11. I need to further develop my understanding of scientific phenomena in order to be more effective as a teacher of science.	1	2	3	4	5
12. I feel adequately prepared to teach Year 1 to Year 8 science.	1	2	3	4	5
13. The resource file I have compiled will be valuable to me as a teacher of science.	1	2	3	4	5
14. The Course Readings have developed my understanding of issues relevant to the teaching of science.	1	2	3	4	5
15. Good science teaching methods have been modelled during this course.	1	2	3	4	5
16. I would have liked more emphasis on scientific knowledge during this course.	1	2	3	4	5
17. The Science Curriculum I course is sufficient in preparing me to be a more effective teacher of science. A further course is not necessary in my training.	1	2	3	4	5
18. The Reflection Task Assignment gave me an opportunity to put together the theoretical and practical components of this course.	1	2	3	4	5
19. I am pleased with the overall progress I have made as a teacher of science during this course.	1	2	3	4	5
20. My overall impression of this course is positive in regards to its effectiveness in promoting my ability as a teacher of science.	1	2	3	4	5

Appendix A-6: Case Study Letter of Invitation

Department of Technology, Science and Mathematics Education
Massey University College of Education
Massey University
Palmerston North

The Principal
Palmerston North Intermediate Normal School
Palmerston North

Dear David:

Thankyou for the opportunity to be involved in Intermediate Normal's Science Curriculum Review. As part of my doctoral study I am in the process of developing an assessment 'instrument' that can assist schools in identifying factors that may be inhibiting science curriculum implementation. Similar instruments have been developed in other educational domains but not in specific curriculum areas. The development of such an instrument may be a critical element in assisting the primary science curriculum implementation process both nationally and internationally.

The third stage of the analysis is a case study analysis of a selected school. The initial staff survey that Judy Stableford has recently compiled is a part of this process. The next stage in my research focus is eliciting comments about science curriculum implementation from a selected group of teachers. Their comments will be a critical stage in developing the statements contained within the instrument.

Thus, at this stage I am seeking your support in being able to work with Judy in selecting a group of six teachers at your school that would be willing to be interviewed about science curriculum implementation at Intermediate Normal. The interviews will involve seeking their responses to a variety of tasks and questions. Teachers will be asked to participate in the interviews with full confidence that their responses are for research purposes only and that they can withdraw from the research exercise at any time.

I look forward to your response to this request.

Yours sincerely

Brian Lewthwaite

cc. Judy Stableford

Appendix A-7: Case Study Questionnaire

Palmerston North Intermediate Normal School

School Science Review

Term 3 2000

The purpose of this survey is to identify the school's needs in order to improve our delivery of the science curriculum. All information gathered from this survey will be regarded as confidential and will be used for research and school-wide professional development purposes only.

Please complete this questionnaire within the next working week and place it in Judy's staff box when it is completed

1. On a scale of 1 - 5 (1 = extremely easy, 5 = extremely difficult) how easy is it for you to **teach** the following strands of the Science curriculum document. Your ability may not just be influenced by your knowledge of the subject but also your familiarity with the curriculum document and appropriate learning activities. Put your response in the box alongside each strand.
 - Living World** - diversity of living things, their parts and functions of these parts, how living things change and reproduce and how living things are interdependent and are influenced by their environment.
 - Material World** - how materials in our world (plastics, paper, metals, acids, etc.) are grouped according to properties, how their properties are related to their uses, how materials undergo changes and are formed and how our use of materials is effected by technology and effects our environment.
 - Physical World** - understanding physical science topics such as electricity, sound, light and magnetism and how these ideas are important to everyday life.
 - Planet Earth and Beyond** - understanding earth's place in space and the atmospheric and geological processes that have occurred and are occurring on planet earth - weather, geological history, astronomy.
 - Scientific Skills and Attitudes** - developing observational, measurement and classifying skills, recording information and making sense of collected information, reporting, planning and carrying out investigations.
 - Science and Its Relationship to Technology** - using items of technology to improve our understanding of scientific ideas - telescopes, microscopes; promoting fairtesting skills in children.

2. On a scale of 1 – 5 (1 = very well developed, 5 = very poorly developed) how would you describe your knowledge and understanding of the strands. Put your answer in the box alongside each strand.

Living World – diversity of living things, their parts and functions of these parts, how living things change and reproduce and how living things are interdependent and are influenced by their environment.

Material World – understanding materials in our world (plastics, paper, metals, acids, etc.) are grouped according to properties, how their properties are related to their uses, how materials undergo changes and are formed and how our use of materials is effected by technology and effects our environment.

Physical World - understanding physical science topics such as electricity, sound, light and magnetism and how these ideas are important to everyday life.

Planet Earth and Beyond - understanding earth's place in space and the atmospheric and geological processes that have occurred and are occurring on planet earth - weather, geological history, astronomy.

Scientific Skills and Attitudes - developing observational, measurement and classifying skills, recording information and making sense of collected information, reporting, planning and carrying out investigations.

Science and Its Relationship to Technology - using items of technology to improve our understanding of scientific ideas - e.g. telescopes, microscopes, promoting fairtesting skills.

3. In this section identify the specific content areas in which you could benefit from receiving support. It would be best that you identify these areas on the basis of the **perceived competence you have in dealing with them as a teacher**. Use the following scale in identifying these specific areas in your self evaluation.

(i) **Competence not a significant problem.**

(ii) **Competence somewhat of a problem**

(iii) **Competence a problem.**

(Circle one on each line)

	Not a significant problem	Somewhat of a problem	Serious problem
Living World:			
diversity of living organisms	1	2	3
special features of NZ plants/ animals'	1	2	3
structure/function in living things	1	2	3
growth/reproduction in living things	1	2	3
interdependence of living things	1	2	3
Physical World			
light	1	2	3
heat and temperature	1	2	3
sound	1	2	3
electricity	1	2	3
energy	1	2	3
magnetism	1	2	3
flotation	1	2	3
how pieces of everyday objects work	1	2	3
Material World			
nature and properties of substances	1	2	3
properties of substances and their use	1	2	3
how materials undergo change	1	2	3
grouping substances according to their similarities	1	2	3
how selected materials are manufactured	1	2	3
materials and their effect on the environment	1	2	3
Planet Earth and Beyond			
composition of Planet Earth	1	2	3
processes that shape Planet Earth	1	2	3
New Zealand geological history	1	2	3
movement of Planet Earth in relationship to other objects in the heavens	1	2	3
relevant environmental issues	1	2	3
Scientific Skills and Attributes			
promoting investigative activities	1	2	3
developing skills associated with investigating	1	2	3
The Nature of Science and its Relationship to Technology			
how simple items of technology work	1	2	3
how items of technology have developed	1	2	3
fair testing	1	2	3

3. In your opinion, how great a problem is each of the following, for you as a **teacher of science at the classroom level**.

(Circle one on each line)

	Not a significant problem	Somewhat of a problem	Serious problem
(a) Facilities - classroom and science room suitability	1	2	3
(b) Children's interest in science	1	2	3
(c) My confidence to teach science - subject matter knowledge	1	2	3
(d) My interest in teaching science	1	2	3
(e) Time available to teach science	1	2	3
(f) Science resources - equipment, booklets, etc.	1	2	3
(g) My knowledge of the curriculum - curriculum knowledge.	1	2	3
(h) My knowledge of appropriate activities/teaching strategies.	1	2	3

4. In your opinion, how great a problem is each of the following for us collectively as a **school in terms of teaching science**

(Circle one on each line)

	Not a significant problem	Somewhat of a problem	Serious problem
(a) Facilities	1	2	3
(b) Children's interest in learning science	1	2	3
(c) Our confidence to teach science - subject matter knowledge	1	2	3
(d) Our interest in teaching science	1	2	3
(e) Time available to teach science	1	2	3
(f) Science resources - equipment, booklets, etc.	1	2	3
(g) Our knowledge of the curriculum - curriculum knowledge.	1	2	3
(h) Our knowledge of appropriate science activities and teaching strategies	1	2	3
(i) Curriculum leadership in science at the school level - school scheme, clearly identified coherent programme	1	2	3
(j) Professional Development opportunities	1	2	3
(k) Emphasis we place on science as a curriculum area	1	2	3

9. In the space below, a series of cards are presented. They identify common teacher-based factors known to influence science curriculum implementation. Rank these from 1 – 10 (1 = main factor influencing implementation, 10 = least factor influencing science implementation) on the basis as to how you perceive each is inhibiting curriculum implementation in your classroom. Put the rank number you have chosen in the appropriate box.

Limited interest in teaching science

Limited knowledge of the Science Curriculum and what it's about at the intermediate level

Perception that Science Is not that important of a Curriculum area at Intermediate level

Limiting subject matter knowledge of Science concepts

Limiting knowledge of effective teaching strategies/activities

Perception that science is an awkward subject to teach – gear requirements messy, general classroom management

Limited knowledge of how to develop practical investigation type activities for students

Limited knowledge of how to 'translate' scientific facts and ideas into a meaningful language relevant for children

Time inadequate available to prepare for and teach science

Children's poor interest in science

6. In your opinion what are the major factors inhibiting the effective implementation of a quality science programme at our school?

7. If we were to be able to fully implement the science curriculum at our school what would be the major factors that would have to be addressed to make this a reality?

8. In the space below a series of cards are presented. They identify common school-based factors known to influence science curriculum implementation. **Rank these from 1 – 10 (1 = main factor influencing implementation, 10 = least factor influencing science implementation) on the basis as to how you perceive each is inhibiting curriculum implementation at this school.** Put the rank number you have chosen in the appropriate box.

Inadequate Science Resources	<input type="checkbox"/>
---------------------------------	--------------------------

Poor Science Facilities	<input type="checkbox"/>
----------------------------	--------------------------

Poor Teacher Interest	<input type="checkbox"/>
--------------------------	--------------------------

Time Availability	<input type="checkbox"/>
----------------------	--------------------------

Inadequate Science Curriculum Leadership	<input type="checkbox"/>
---	--------------------------

Inadequate Teacher Knowledge	<input type="checkbox"/>
---------------------------------	--------------------------

Inadequate Professional Development Opportunities	<input type="checkbox"/>
--	--------------------------

Low Priority Placed On Science	<input type="checkbox"/>
-----------------------------------	--------------------------

Children's Interest In Science	<input type="checkbox"/>
-----------------------------------	--------------------------

Poor Teacher Confidence	<input type="checkbox"/>
----------------------------	--------------------------

10. On a scale of 1 – 5 (1 = **fully implemented**, 5 = **very easily implemented**) how well do you perceive we as a school have implemented, (in terms of actual teaching), the science curriculum. Circle the appropriate response.

1 2 3 4 5

11. On a scale of 1 – 5 (1 = **fully implemented**, 5 = **very poorly implemented**) how well do you perceive you as a classroom teacher have implemented, (in terms of actual teaching), the science curriculum. Circle the appropriate response.

1 2 3 4 5

12. Are there any further comments you would like to make that address the purpose of this questionnaire – identifying our school's needs as a starting effort to improve science curriculum implementation.

+++++

Department of Technology, Science and Mathematics Education
Massey University College of Education
Massey University
Palmerston North

Dear

As part of my doctoral study I am in the process of developing an assessment 'instrument' that can assist schools in identifying factors that may be inhibiting science curriculum implementation. Similar instruments have been developed in other educational domains but not in specific curriculum areas. The development of such an instrument may be a critical element in assisting the primary science curriculum implementation process both nationally and internationally.

The third stage of the analysis is a case study analysis of a selected school. The initial staff survey that Judy Stableford has recently compiled is a part of this process. The next stage in my research focus is eliciting comments about science curriculum implementation from a selected group of teachers. Their comments will be a critical stage in developing the statements contained within the instrument.

Thus, at this stage I am seeking your support in being one of those to be interviewed about science curriculum implementation at Intermediate Normal. The interview will involve seeking your responses to a variety of tasks and questions pertaining to science teaching and curriculum implementation. The interview will take about 30 minutes to complete. You can have full confidence that your responses are for research purposes only and that you may withdraw from the research exercise at any time.

If you have any questions in regards to this process please contact me at Massey University College of Education 356-9099 (extn 8850).

I look forward to your response to this request.

Yours sincerely

Brian Lewthwaite

cc. Judy Stableford

Appendix A-8: Case Study Interview Schedule

Palmerston North Intermediate School Selected Interviews - Sequence and Content of Interviews

Section A: School Considerations

1. Card sort - Factors Influencing Implementation - School Level.
2. One of the major factors considered to be influencing science curriculum implementation is teachers having adequate time. What do you think "adequacy of time" means?
3. A further factor identified is inadequacy of knowledge. Considering that there are many different forms of knowledge - knowledge of the subject, knowledge of the curriculum, knowledge of the teaching strategies, etc. What knowledge do you think teachers are identifying as necessary?
4. A further identified major factor is teacher confidence. What do you think teachers mean by teacher "confidence" in regards to science curriculum implementation? In respect to the teaching of science, what things promote teacher confidence?
5. To what extent do you think that teacher confidence in science influences curriculum implementation at this school?
6. To what extent do you think that the emphasis the school places on science influences the implementation of science at this school?
7. In comparison to other schools, how well has this school implemented the science curriculum. What reasons can you give to support this evaluation?
8. How would you describe the overall science 'ethos' or 'culture' at this school?

Section B: Classroom Considerations

1. Card Sort - Factors Influencing Implementation - Classroom Level..
2. To what extent does student interest in science influence your implementation of science? Please justify your response.
3. To what extent does parental/community interest in/perception of science influence your implementation of science? Please justify your response.
4. To what extent do resources - materials, facilities, advisory services, professional support, etc., influence your science curriculum implementation? Please justify your answer.
5. Briefly describe your personal and professional science experience.
6. How has this 'experience' effected your teaching of science?

7. If you had the opportunity to be involved in science professional development, what professional needs would you want the professional development to target?

8. If full science curriculum implementation were to be a reality in your classroom what changes would have to occur? In other words what do you see are the major factors inhibiting implementation?

Section C: Further Comments and Considerations

1 Are there any further comments that you wish to make that relate to the purpose of the interview - science curriculum implementation.

Appendix B: Ranking of Factors Influencing Curriculum Delivery Analysis

B-1 Factors Influencing Science Curriculum Implementation Item List

B-2 Focus Group Task Sheet

B-3 Item Ranking List

**Appendix B-1: Factors Influencing Science Curriculum
Implementation Item List**

1. Teachers have the time to organise activities and resources for science.
2. Science has a high status as a curriculum area at this school.
3. Teachers have a positive attitude to the teaching of science.
4. Teachers are confident in their ability to teach science.
5. Teachers have the necessary knowledge to organise meaningful science activities for students.
6. Teachers are confident in their scientific knowledge.
7. Science has a high profile as a curriculum area at this school.
8. Teachers are confident in their ability to present scientific knowledge in a way that is meaningful and appropriate for their students.
9. Teachers are confident in teaching science
10. Teachers have a personal interest in teaching science
11. Teachers are confident in their ability to assess student performance in science.
12. The equipment that is necessary to teach science is readily available.
13. The facilities at this school promote the teaching of science.
14. Science is regarded as an important subject in the school's overall curriculum.
15. Science has a high profile as a curriculum area at this school.
16. Teachers have the opportunity to undertake science professional development.
17. The senior administration actively supports science as a curriculum area.
18. The senior administration clearly identifies science as an essential learning area.
19. The science resources are well organised.
20. The school is well resourced for the teaching of science.

21. Students at this school enjoy science.
22. There is enough time in the school program to teach science.
23. Teachers at this school have a positive professional interest in science.
24. The school places a strong emphasis on science as a curriculum area.
25. Science is a subject at this school that teachers want to teach.
26. The school-based system of management of science resources is well maintained.
27. Teachers at this school are supported in their efforts to teach science.
28. There is a clear expectation that science is to be regularly taught.
29. Teachers are very in their ability to manage science lessons.
30. Teachers understand the aims and objectives of the national science curriculum.
31. Teachers are knowledgeable about appropriate science teaching strategies.
32. The school is well resourced for the teaching of science.
33. Teachers believe that there is adequate time in the overall school programme to teach science.
34. Teachers are confident in their ability to teach practically based science activities.
35. Teachers are confident in their ability to teach investigative science activities.
36. Teachers are confident in their ability to manage science activities.
37. Teachers regard science as a subject that is more difficult to teach than other curriculum areas.
38. Teachers have a good background content knowledge in science.
39. Teachers are well experienced in the teaching of science.
40. Teachers are personally motivated to teach science.

41. The curriculum leadership in science fosters capabilities in those teachers that may have difficulties in teaching science.
42. Teachers at this school are reluctant to teach science.
43. There is enough time in the school week to do an adequate job of teaching the requirements of the national science curriculum.
44. There is enough time for teachers to develop their own understanding of the science they are required to teach.
45. Teachers have a desire to teach science.
46. Teachers at this school take the time to develop their capabilities in the teaching of science.
47. The school community perception is that science is an important part of this school's curriculum.
48. The community perception of science is a positive factor in promoting the teaching of science at this school.
49. Teacher's personal background positively influences the extent to which science is taught at this school.
50. The school's ethos positively influences the teaching of science.
51. Teachers at this school readily take the opportunity to teach science.
52. Teachers at this school are knowledgeable in teaching science.
53. Teachers at this school are apprehensive about teaching science.
54. Teachers at this school would consider themselves to be effective teachers of science.
55. Teachers feel well qualified to teach science.
56. The school has adequate science equipment necessary for the teaching of science.
57. The administration of the school actively supports the science programme.
58. Teachers at this school have a positive attitude to science as an essential learning area.
59. Teachers at this school feel adequately prepared to teach science.
60. Teachers at this school are not reluctant to teach science.

61. Teachers at this school have had a lot of experience in teaching science.
62. Teachers at this school are secure in their knowledge of science concepts pertinent to the primary science curriculum.
63. Teachers at this school are confident in their knowledge of concepts pertinent to the primary science curriculum.
64. Teachers at this school have a sound science subject knowledge.
65. Teachers are confident in their ability to transform their scientific understandings into purposeful learning experiences for children.
66. Teachers have a very good understanding of key scientific ideas underpinning the school science curriculum.
67. Teachers at this school have a positive attitude towards science.
68. Teachers at this school have a sound knowledge of strategies known to be effective for the teaching of science.
69. Teachers at this school have a good science background.
70. Teachers at this school are adequately prepared to teach the requirements of the national science curriculum.
71. Teachers at this school are interested in teaching the requirements of the national science curriculum.
72. Teachers have a good science subject content knowledge.
73. Teachers have a sound understanding of alternative ways of teaching scientific ideas to foster student learning.
74. Teachers have a good professional knowledge in science.
75. Teachers have a good science subject matter preparation.
76. Teachers at this school are confident in their ability to work with the aims and objectives of the science curriculum.
77. Teachers at this school perceive that they possess the necessary knowledge to teach science.
78. Teachers know what the nature of science is, as defined by the national curriculum.
79. Teachers at this school are able to translate the intentions of the national curriculum into meaningful classroom practice.

80. Teachers at this school are confident in their ability to teach investigative science lessons.
81. Science as a curriculum area is valued at this school.
82. There is an adequate provision of written resources available to assist teachers in the implementation of science programs.
83. Teachers at this school are confident in their knowledge in teaching science.
84. Students at this school are given a balanced allotment of time for instruction in science.
85. Teachers are able to translate the ideals and requirements of the science curriculum into meaningful science practice.
86. Teachers at this school have ready access to science materials and resources.
87. Teachers have well developed understanding of the processes and knowledge appropriate to the national science curriculum.
88. Teachers are competent in their ability to teach science.
89. Teachers are able to teach to the key scientific ideas presented in the national science curriculum.
90. Teachers are proficient in their ability to teach science.
91. Teachers are well grounded in the teaching strategies that are known to promote science development in students.
92. Teachers are able to translate science content through their teaching in a way that effectively fosters student understanding.
93. Teachers at this school have the time to develop science programs.
94. Teachers at this school spend less time teaching science than most other curriculum areas.
95. Teachers have the subject content knowledge and related teaching skills necessary to teach science effectively.
96. Teachers, at the time, have the professional capacity to effectively deliver the requirements of the national science curriculum.
97. Teachers have the time to effectively deliver the requirements of the national science curriculum.

98. Teachers get the in school support necessary to implement the science curriculum.
99. Teachers are able to receive professional in-service support as necessary.
100. Teachers have ready access to science curriculum resources appropriate for supporting their teaching.
101. Teachers at this school have access to advisory service support.
102. Teachers at this school have a clear understanding of what science is to be taught to their students.
103. Teachers at this school understand the science concepts they are to teach.
104. Teachers at this school are confident in their ability to teach science.
105. Teachers at this school possess the scientific knowledge necessary for quality science teaching.
106. Teachers at this school are competent science teachers.
107. Teachers at this school have a clear understanding of the goals and objectives of the national science curriculum
108. Teachers have the professional science knowledge necessary to effectively implement the national science curriculum.
109. Teachers at this school have access to effective science professional development opportunities.
110. Teachers at this school have a good understanding of the fundamental concepts underlying the primary science curriculum.
111. Teachers at this school are confident in their ability to teach science emphasising an investigative approach.
112. Teachers are prepared to teach science effectively.
113. Teachers at this school are confident in their ability to teach science.
114. Teachers at this school are motivated to 'make science work' as a curriculum area.
115. Teachers have a strong motivation to ensure science is taught at this school.
116. Teachers possess the personal confidence, skills and knowledge necessary to teach science competently.

117. Teachers at this school are competent teachers of science.
118. Teachers at this school need to develop their expertise in science and the teaching of science to be effective science educators.
119. Teachers at this school are adequately prepared to teach science.
120. Teachers at this school are personally motivated in their desire to improve their science teaching performance.
121. Teachers ensure that science is an integral part of their classroom curriculum.
122. Teachers at this school are confident in their ability to teach science.
123. Teachers at this school are reluctant to teach science.
124. Teachers at this school are very confident in their ability to teach science.
125. Teachers at this school have very positive self-images of themselves with regards to their ability to teach science.
126. Teachers at this school have a very good science discipline knowledge.
127. Teachers at this school have a sound knowledge of the science they are to teach.
128. A lack of professional scientific knowledge is a problem for teachers at this school.
129. Teachers at this school possess the necessary science subject knowledge to be a good primary science educator.
130. Teachers at this school are confident science teachers.
131. Teachers at this school are competent science teachers.
132. Teachers at this school have a good conceptual understanding of their science subject matter.
133. Teachers at this school have positive perceptions of their teaching skills in science.
134. Teachers at this school have positive perceptions of their competence as primary science educators.
135. Teachers at this school are competent in their ability as science teachers.

136. Teachers at this school are competent teachers of science.
137. Teachers at this school are interested in teaching science.
138. Teachers at this school have a good background knowledge for teaching science.
139. Teachers at this school have a good understanding of the science knowledge, skills and attitude they are to promote in their teaching.
140. Teachers at this school have the confidence to promote an investigative approach to science with their students.
141. The school allocates funds appropriately to ensure the adequate resourcing of science programs.
142. The school is adequately resourced to support the teaching of science.
143. Teachers at this school have a positive attitude towards the teaching of science.
144. The school curriculum is crowded. Science suffers because of this.
145. There is not enough time in the school program to fit science in properly.
146. Teachers at this school have positive perceptions of their competence as primary science educators.
147. Teachers at this school are competent in their ability as science teachers.
148. Teachers at this school are competent teachers of science.
149. Teachers at this school are interested in teaching science.
150. Teachers at this school have a good background knowledge for teaching science.
151. Teachers at this school have a good understanding of the science knowledge, skills and attitude they are to promote in their teaching.
152. Teachers at this school have the confidence to promote an investigative approach to science with their students.
153. The school allocates funds appropriately to ensure the adequate resourcing of science programs.
154. The school is adequately resourced to support the teaching of science.
155. Teachers at this school have a positive attitude towards the teaching of science.

156. The school curriculum is crowded. And therefore there is not enough time to teach science.

157. There is not enough time in the school program to fit science in properly.

158. Teachers at this school have positive perceptions of their competence as primary science educators.

159. Teachers at this school are competent in their ability as science teachers.

160. Teachers at this school are competent teachers of science.

161. Teachers at this school are interested in teaching science.

164. Teachers at this school have a good background knowledge for teaching science.

165. Teachers at this school have a good understanding of the science knowledge, skills and attitude they are to promote in their teaching.

166. Teachers at this school have the confidence to promote an investigative approach to science with their students.

167. The school allocates funds appropriately to ensure the adequate resourcing of science.

168. The school is adequately resourced to support science.

169. Teachers at this school have a positive attitude towards science.

170. The school curriculum is crowded. Science suffers because of a crowded school curriculum.

171. There is not enough time in the school program to fit science in.

172. Teachers at this school have the time to prepare science programs.

173. Teachers at this school have the opportunity to receive science curriculum professional support

174. The school's science program is well defined.

175. Professional development opportunities are available to teachers.

176. Teacher advisors are available to provide professional support.

177. Collegial support is a positive factor in fostering science programmes in this school.

178. The collegial support evident in this school is important in assisting teachers that may find science difficult to teach.
179. Teachers at this school tend to teach to their own and the school's interests.
180. Science is regarded as an important subject in the school's overall curriculum.
181. Science has a high profile as a curriculum area at this school.
182. Teachers have the opportunity to undertake science professional development.
183. The senior administration actively supports science as a curriculum area.
184. The senior administration clearly identifies science as an essential learning area.
185. The science resources are well organised.
186. The school is well resourced for the teaching of science.
189. There is enough time in the school program for science to be taught.
190. Teachers at this school have a very positive professional interest in science.
191. The school places a strong emphasis on science as a learning area.
192. Science is a subject at this school that teachers are committed to teaching.
193. The school-based system of management of science resources is well managed.
194. Teachers at this school are supported professionally in their efforts to teach science.
195. There is a clear expectation that science is to be taught regularly.
196. Teachers are very competent in their ability to manage science lessons.
197. Teachers understand the objectives of the national science curriculum.
198. Teachers are knowledgeable about appropriate science teaching strategies.
199. The school is well resourced for science teaching.

200. Teachers believe that there is adequate time in the school programme to teach science.
201. Teachers are confident in their ability to teach practically based science activities.
202. Teachers are confident in their ability to teach science with an emphasis on investigating.
203. Teachers are confident in their ability to manage and teach science activities.
204. Teachers regard science as a subject that is more difficult to teach than other curriculum areas.
205. Teachers have a good background subject content knowledge in science.
206. Teachers are experienced in the teaching of science.
207. Teachers are motivated to teach science.
208. The curriculum leadership in science fosters capabilities in those teachers that may have difficulties in teaching science.
209. Teachers at this school are not reluctant to teach science.
210. There is enough time in the school week to do an adequate job of teaching the requirements of the science curriculum.
211. There is enough time for teachers to develop their own understanding of the science mentioned in the curriculum that they are required to teach.
213. Teachers have a desire to teach science.
214. Teachers at this school take the time to develop their capability in the teaching of science.
215. The school community perception is that science is an important part of this school's overall curriculum.
216. Community perception of science is a positive factor in promoting the teaching of science.
217. Teacher's personal background positively influences the degree to which science is taught at this school.
218. This school's ethos positively influences the teaching of science.
219. Teachers at this school readily take every opportunity to teach science.

220. Teachers at this school are knowledgeable in their science teaching strategies.

221. Teachers at this school would consider themselves to be effective teachers of science.

222. Teachers feel very qualified to teach science.

223. Teachers at this school are intrinsically interested in teaching science.

Appendix B-2: Focus Group Task Sheet

November 1, 2000

Department of Technology, Science and Mathematics Education
Massey University College of Education
Massey University
Palmerston North

Dear Focus Group members

Thanks for your willingness to participate in this stage of my doctoral study examining factors influencing science curriculum implementation in primary schools.

The envelope I have given you contains 112 items or statements that are identified to influence science curriculum implementation. The items have been 'collected' from a variety of sources – literature review, questionnaire surveys, and personal interviews. When the items are sorted it is evident that there are 7 categories of factors. These include:

1. Professional Adequacy – teacher confidence, capability, self-concept.
2. Professional Interest - teacher motivation, interest and attitude towards science.
3. Professional Leadership - recognition that the school and the school administration give to science as a learning area.
4. Professional Support - in school and external advisory support available for teachers.
5. Time - time for planning, preparation, and actual teaching.
6. Knowledge – teacher knowledge and understanding of science, curriculum, and strategies.
7. Resource Adequacy – support materials, facilities, equipment, and written materials.

I would like you, in pairs, to sort the items into these 7 categories. It may be that some categories have many more items than others. If you feel there are further categories because items do not fit those created, create new categories and name them if you wish. It is not necessary to subdivide these groups.

Once they have been sorted, sequence the items in the list from most significant to least significant according to how 'telling' they are for the educational context in which you presently work. If educators answered these items, they would differentiate between schools. Even though you will notice many of the items are very similar try to sequence them as best you can.

Once you have sequenced the items staple or clip the items into packets so the order is not altered. Put the clipped packets back into the envelope I have given to you and return them to me.

Thanks for your support in this exercise.

Yours truly

Brian Lewthwaite

Appendix B-3: Item Ranking List

Factor Category	Group 1			Group 2			Group 3			Item Rank Average			
Professional Interest	3	79	40	98	112	37	79	53	37	62	(4)	79	(7)
	89	53	42	62	18	42	98	45	42	88	(4.6)	18	(7.3)
	45	98	84	88	79	84	62	86	84	98	(4.6)		
	80	12	86	89	12	87	18	89	87	3	(5.3)		
	88	16		45	16		112	12		80	(5.6)		
	112	22		80	26		88	16		89	(6)		
	62	26		3	22		80	22		45	(6)		
18	37		53	86		3	26		112	(6.6)			
Professional Adequacy	50	78	61	97	78	61	94	60	66	94	(3)	42	(8)
	83	97	65	32	96	82	5	32	25	32	(3.6)	78	(10.6)
	85	96	55	42	65	67	83	90	55	50	(4)	96	(10.6)
	94	5	82	94	85	66	46	61	65	83	(4.3)		
	32	25	67	90	25	87	85	97	67	97	(5)		
	42	66	87	58	46	55	50	78	87	85	(6.6)		
	90	46		50	5		58	42		58	(7)		
58	60		83	60		96	82		90	(7.6)			
Professional Support	106	12		106	52		11	110		106	(3)	12	(7.3)
	110	69		10	110		20	108		11	(3.6)	72	(10)
	111	72		111	69		27	52		111	(3.6)		
	10	76		11	70		70	69		20	(4)		
	20	108		20	109		10	72		10	(6.3)		
	11	109		72	76		12	76		70	(6.6)		
	70			12	108		106	109		27	(6.6)		
27			27			111			110	(7)			
School Culture and Leadership	48	107		2	39		9	39		9	(3)	21	(8)
	41	8		8	41		17	21		2	(3.1)	12	(8.3)
	39	38		48	43		107	48		17	(4.3)		
	9	4		9	12		2	62		48	(5)		
	2	43		107	62		12	4		107	(5.6)		
	17	62		17	4		38	43		41	(6.3)		
	21			21			41	44		8	(6.6)		
12			38			8			39	(7)			
Knowledge	92	113	91	59	93	55	54	81	40	57	(4)	92	(8.6)
	100	75	95	49	74	95	57	92	74	49	(4.6)	100	(10)
	73	54		77	99	40	75	100	91	73	(5)		
	57	55		54	75		73	93		54	(5.3)		
	81	56		56	113		99	95		99	(6.6)		
	49	59		57	91		49	55		81	(7)		
	93	74		81	92		59	77		93	(7.3)		
99	77		73	100		113	56		85	(8.3)			
Time	1	105		1	104		24	36		1	(1.3)	68	(6.7)
	104			105			28			28	(3.3)		
	28			15			1			24	(4)		
	103			24			68			15	(5)		
	36			28			15			104	(5.3)		
	68			36			104			103	(6.3)		
	15			68			103			36	(6.6)		
25			103			105			105	(6.6)			
Resource Adequacy	14	64		71	47		13	71		14	(3.6)	114	(8.3)
	19	114		6	51		19	114		19	(4)	64	(9.3)
	7	102		7	63		51	23		6	(4.3)		
	71	23		14	64		63	102		7	(4.6)		
	13	47		13	101		6	47		71	(4.6)		
	6	101		114	102		14	101		13	(4.6)		
	63			23			64			51	(7)		
51			19			7			63	(7.3)			

**Appendix C: *Science Curriculum Implementation Questionnaire (SCIQ)*
Development**

- C-1 Original 70-item SCIQ**
- C-2 Invitation for Participation in SCIQ Validation**
- C-3 SLIQ Validation Response Form**
- C-4 Participant Information for SCIQ validation**
- C-5 Factor Loadings for SCIQ**
- C-6 SCIQ (Long Form)**
- C-7 SCIQ (Short Form)**
- C-8 Invitation to Participate in SCIQ Application at Intermediate
School**

Appendix C-1: Original 70-item SCIQ

Science Curriculum Implementation Questionnaire (SCIQ)

There are 70 items in this questionnaire. They are statements to be considered in the context of the school in which you work. Think about how well the statements describe the school environment in which you work.

Indicate your answer on the score sheet by circling:

SD if you *strongly disagree* with the statement

N if you *neither agree nor disagree* with the statement or are not sure;

SA if you *strongly agree* with the statement;

D if you *disagree* with the statement;

A if you *agree* with the statement;

If you change your mind about a response, cross out the old answer and circle the new choice.

- | | | | |
|---|-------------|---|-------------|
| 1. Teachers at this school have the opportunity to receive ongoing science curriculum professional support. | SD D N A SA | 36. The senior administration clearly identifies science as an essential learning area to be taught as a regular part of the school curriculum. | SD D N A SA |
| 2. Teachers have the time to organise activities and resources for science lessons. | SD D N A SA | 37. Teachers have enough time to develop their own understanding of the science they are required to teach. | SD D N A SA |
| 3. The school administration recognises the importance of science as a subject in the overall school curriculum. | SD D N A SA | 38. Science has a high profile as a curriculum area at this school. | SD D N A SA |
| 4. Teachers at this school are apprehensive about teaching science. | SD D N A SA | 39. Teachers possess the personal confidence, skills and knowledge necessary to teach science competently. | SD D N A SA |
| 5. The school is well resourced for the teaching of science. | SD D N A SA | 40. The science resources at the school are well organised. | SD D N A SA |
| 6. Teachers have a positive attitude to the teaching of science. | SD D N A SA | 41. Science is a subject at this school that teachers want to teach. | SD D N A SA |
| 7. A lack of professional scientific knowledge is a problem for teachers at this school. | SD D N A SA | 42. Teachers have a sound understanding of alternative ways of teaching scientific ideas to foster student learning. | SD D N A SA |
| 8. Collegial support is a positive factor in fostering the implementation of science programs in this school. | SD D N A SA | 43. Teachers at this school have access to advisory service support. | SD D N A SA |
| 9. There is not enough time in the school program to fit science in properly. | SD D N A SA | 44. There is enough time in the school program to teach science. | SD D N A SA |
| 10. The school's ethos positively influences the teaching of science. | SD D N A SA | 45. Science has a high status as a curriculum area at this school. | SD D N A SA |
| 11. Teachers at this school are adequately prepared to teach science. | SD D N A SA | 46. Teachers at this school have positive perceptions of their competence as primary science educators. | SD D N A SA |
| 12. The school-based system of managing of science resources is well maintained. | SD D N A SA | 47. There is an adequate provision of written resources available to assist teachers in the implementation of science programs. | SD D N A SA |
| 13. Teachers at this school are reluctant to teach science. | SD D N A SA | 48. Teachers at this school tend to teach to their own and the school's interests. Because of this science is not taught as much as it should be. | SD D N A SA |
| 14. Teachers have the professional science knowledge necessary to effectively teach to the requirements of the national science curriculum. | SD D N A SA | 49. Teachers at this school are secure in their knowledge of science concepts pertinent to the primary science curriculum. | SD D N A SA |
| 15. The collegial support evident in this school is important in fostering capabilities in teachers who find science difficult to teach. | SD D N A SA | 50. Teachers are able to receive professional in-service support where necessary. | SD D N A SA |
| 16. There is enough time in the school week to do an adequate job of teaching the requirements of the national science curriculum. | SD D N A SA | 51. Teachers believe that there is adequate time in the overall school program to teach science. | SD D N A SA |
| 17. The community perception of science is a positive factor in promoting the teaching of science at this school. | SD D N A SA | 52. The school community perception is that science is an important part of this school's curriculum. | SD D N A SA |
| 18. Teachers at this school believe they are good teachers of science. | SD D N A SA | 53. Teachers at this school are adequately prepared to teach to the requirements of the national science curriculum. | SD D N A SA |
| 19. Teachers at this school have ready access to science materials and resources. | SD D N A SA | 54. The school's science program is clearly defined in the overall school scheme. | SD D N A SA |
| 20. Teachers at this school are intrinsically interested in teaching science. | SD D N A SA | 55. Teachers at this school have a positive attitude to science as an essential learning area. | SD D N A SA |
| 21. Teachers at this school have a good understanding of the science knowledge, skills and attitudes they are to promote in their teaching. | SD D N A SA | 56. Teachers at this school possess the necessary science subject knowledge to be a good primary science educator. | SD D N A SA |
| 22. Teachers have the opportunity to undertake professional development in science. | SD D N A SA | 57. The senior administration actively supports science as a curriculum area. | SD D N A SA |
| 23. The school curriculum is crowded. Science suffers because of this. | SD D N A SA | 58. Teachers have the time to effectively deliver the requirements of the national science curriculum. | SD D N A SA |
| 24. The school places a strong emphasis on science as a curriculum area. | SD D N A SA | 59. Science as a curriculum area is valued at this school. | SD D N A SA |
| 25. Teachers at this school are confident science teachers. | SD D N A SA | 60. Teachers at this school are confident in their ability to teach science emphasising an investigative approach. | SD D N A SA |
| 26. The facilities at this school promote the teaching of science. | SD D N A SA | 61. The equipment that is necessary to teach science is readily available. | SD D N A SA |
| 27. Teachers have a strong motivation to ensure science is taught at this school. | SD D N A SA | 62. Teachers at this school are motivated to 'make science work' as a curriculum area. | SD D N A SA |
| 28. Teachers at this school have a clear understanding of what science is to be taught to their students. | SD D N A SA | 63. Teachers at this school have a good background knowledge for teaching science. | SD D N A SA |
| 29. Teachers at this school are supported in their efforts to teach science. | SD D N A SA | 64. The curriculum leadership in science fosters capabilities in those who require support in teaching sciences. | SD D N A SA |
| 30. Teachers at this school have the time to learn and prepare science programs. | SD D N A SA | 65. Lack of time is a major factor inhibiting science program delivery at this school. | SD D N A SA |
| 31. There is a clear expectation that science is to be regularly taught at this school. | SD D N A SA | 66. Science is regarded as an important subject in the school's overall curriculum. | SD D N A SA |
| 32. Teachers at this school are competent teachers of science. | SD D N A SA | 67. Teachers at this school have a positive self-image of themselves as regards their ability to teach science. | SD D N A SA |
| 33. Teachers have ready access to science curriculum resources to support their teaching. | SD D N A SA | 68. The school has adequate science equipment necessary for the teaching of science. | SD D N A SA |
| 34. Teachers at this school have a positive attitude to science as a subject in the primary school program. | SD D N A SA | 69. Teachers at this school are interested in teaching science. | SD D N A SA |
| 35. Teachers at this school have a sound knowledge of strategies known to be effective for the teaching of science. | SD D N A SA | 70. Teachers possess the necessary knowledge required to effectively teach science. | SD D N A SA |

Appendix C-2
Invitation for Participation in SCIQ Validation
Science Curriculum Implementation Questionnaire (SCIQ)

Intention to Participate

Please complete the following and fax to the number listed below.

The teachers at _____ (include name of school) will/will not be participating in the science curriculum implementation questionnaire validation exercise.

For those schools that have decided to participate please complete the following section.

How many teachers on your staff will be participating in the validation exercise?

Do you wish to be involved in a formal assessment of your school's science curriculum implementation once the questionnaire is validated? _____

Who is the contact person for this exercise at the school?

If you have any concerns with regards to this research exercise please include them in the space below?

Please fax or mail this form to:

Brian Lewthwaite
Department of Technology, Science and Mathematics Education
Massey University College of Education
Palmerston North

Fax 06 351 3472

Appendix C-3: Validation Response Form

Science Curriculum Implementation Questionnaire (SCIQ)

Intention to Participate

Please complete the following and fax to the number listed below.

The teachers at _____ (include name of school) will/will not be participating in the science curriculum implementation questionnaire validation exercise.

For those schools that have decided to participate please complete the following section.

How many teachers are on your staff will be participating in the validation exercise?

Do you wish to be involved in a formal assessment of your school's science curriculum implementation once the questionnaire is validated? _____

Who is the contact person for this exercise at the school?

If you have any concerns in regards to this research exercise please include them in the space below?

Please fax or mail this form to:

Brian Lewthwaite
Department of Technology, Science and Mathematics Education
Massey University College of Education
Palmerston North

Fax 06 351 3472

Appendix C-4: Participant Information for SCIQ Validation

February 12, 2001
Department of Technology, Science and Mathematics Education
Massey University College of Education
Massey University
Palmerston North

Dear Sir or Madam

Thanks for taking the time to participate in this validation exercise.

Could the copies of the Science Curriculum Questionnaire (SCIQ) enclosed please be distributed to those staff members that have mentioned they will complete the questionnaire. Suggest that the questionnaires should be completed within the next week and returned to you. Teachers do not need to identify themselves on the questionnaire, as the process of validation is entirely an anonymous procedure.

Please return the completed questionnaires in the envelope provided. In Term 3 or 4 (once the validation exercise is completed) I will contact you again to find out if your school is interested in a follow-up survey that would provide valuable information to your school about factors influencing science program delivery. As mentioned in the earlier mail-out, this service would be provided as a 'no cost' independent professional service to your school.

If you have any concerns with regards to this exercise please contact me.

Yours truly

Brian Lewthwaite
Senior Lecturer
Doctoral Student
Massey University
Palmerston North
06-353-6246 (8850)
email: b.e.lewthwaite@massey.

Dr Darrell Fisher
Associate Professor
Research Supervisor
Curtin University of Technology
Perth

Appendix C-5: Factor Loadings for SCIQ

Item No	Professional Support	Time	Resource Adequacy	School Ethos	Professional Adequacy	Professional Knowledge	Professional Attitudes
1	.77						
2	.72						
3	.69						
4	.69						
5	.65						
6	.54						
7	.51						
8		.82					
9		.80					
10		.74					
11		.74					
12		.72					
13		.70					
14		.67					
15			.81				
16			.80				
17			.75				
18			.74				
19			.71				
20			.68				
21			.66				
22				.75			
23				.72			
24				.72			
25				.58			
26				.49			
27				.45			
28				.35			
29					.79		
30					.72		
31					.71		
32					.64		
33					.63		
34					.61		
35					.60		
36						.85	
37						.80	
38						.75	
39						.74	
40						.72	
41						.70	
42						.68	
43							.73
44							.72
45							.69
46							.67
47							.65
48							.63
49							.53
Alpha Reliability	.90	.90	.83	.90	.92	.77	.88
Eta ² (Schools Categorical)	.056	.005	.006	.046	.047	.040	.085
Eta ² (Schools Combined)	.427	.412	.635	.400	.512	.498	.587

Appendix C-6: SCIQ Long Form - Validated 49-item SCIQ

Science Curriculum Implementation Questionnaire (SCIQ)

There are 49 items in this questionnaire. They are statements to be considered in the context of the school in which you work. Think about how well the statements describe the school environment in which you work.

Indicate your answer on the score sheet by circling:

SD if you *strongly disagree* with the statement

N if you *neither agree nor disagree* with the statement or are not sure;

SA if you *strongly agree* with the statement;

D if you *disagree* with the statement;

A if you *agree* with the statement;

If you change your mind about a response, cross out the old answer and circle the new choice.

- | | |
|---|---|
| <p>1. Teachers at this school have a good understanding of the science knowledge, skills and attitudes they are to promote in their teaching. SD D N A SA</p> | <p>25. Teachers possess the personal confidence, skills and knowledge necessary to teach science competently. SD D N A SA</p> |
| <p>2. Teachers have a positive attitude to the teaching of science. SD D N A SA</p> | <p>26. Science has a high profile as a curriculum area at this school. SD D N A SA</p> |
| <p>3. The school is well resourced for the teaching of science. SD D N A SA</p> | <p>27. There is enough time in the school program to teach science. SD D N A SA</p> |
| <p>4. Teachers at this school are adequately prepared to teach science. SD D N A SA</p> | <p>28. Teachers have the opportunity to undertake professional development in science. SD D N A SA</p> |
| <p>5. The school administration recognises the importance of science as a subject in the overall school curriculum. SD D N A SA</p> | <p>29. Teachers at this school possess the necessary science subject knowledge to be a good primary science educator. SD D N A SA</p> |
| <p>6. There is not enough time in the school program to fit science in properly. SD D N A SA</p> | <p>30. Science is a subject at this school that teachers want to teach. SD D N A SA</p> |
| <p>7. Teachers at this school have the opportunity to receive ongoing science curriculum professional support. SD D N A SA</p> | <p>31. The science resources at the school are well organised. SD D N A SA</p> |
| <p>8. Teachers at this school have a sound knowledge of strategies known to be effective for the teaching of science. SD D N A SA</p> | <p>32. Teachers at this school have positive perceptions of their competence as primary science educators. SD D N A SA</p> |
| <p>9. Teachers at this school are reluctant to teach science. SD D N A SA</p> | <p>33. Science has a high status as a curriculum area at this school. SD D N A SA</p> |
| <p>10. The school-based system of managing of science resources is well maintained. SD D N A SA</p> | <p>34. Teachers believe that there is adequate time in the overall school program to teach science. SD D N A SA</p> |
| <p>11. Teachers at this school are confident science teachers. SD D N A SA</p> | <p>35. Teachers at this school are supported in their efforts to teach science. SD D N A SA</p> |
| <p>12. The school's ethos positively influences the teaching of science. SD D N A SA</p> | <p>36. Teachers at this school have a good background knowledge for teaching science. SD D N A SA</p> |
| <p>13. There is enough time in the school week to do an adequate job of teaching the requirements of the national science curriculum. SD D N A SA</p> | <p>37. Teachers at this school have a positive attitude to science as an essential learning area. SD D N A SA</p> |
| <p>14. Collegial support is a positive factor in fostering the implementation of science programs in this school. SD D N A SA</p> | <p>38. The equipment that is necessary to teach science is readily available. SD D N A SA</p> |
| <p>15. Teachers have a sound understanding of alternative ways of teaching scientific ideas to foster student learning. SD D N A SA</p> | <p>39. Teachers at this school are adequately prepared to teach to the requirements of the national science curriculum. SD D N A SA</p> |
| <p>16. Teachers have a strong motivation to ensure science is taught at this school. SD D N A SA</p> | <p>40. Science as a curriculum area is valued at this school. SD D N A SA</p> |
| <p>17. Teachers at this school have ready access to science materials and resources. SD D N A SA</p> | <p>41. Teachers have the time to effectively deliver the requirements of the national science curriculum. SD D N A SA</p> |
| <p>18. Teachers at this school are competent teachers of science. SD D N A SA</p> | <p>42. The senior administration actively supports science as a curriculum area. SD D N A SA</p> |
| <p>19. The school places a strong emphasis on science as a curriculum area. SD D N A SA</p> | <p>43. Teachers possess the necessary knowledge required to effectively teach science. SD D N A SA</p> |
| <p>20. The school curriculum is crowded. Science suffers because of this. SD D N A SA</p> | <p>44. Teachers at this school are motivated to 'make science work' as a curriculum area. SD D N A SA</p> |
| <p>21. The collegial support evident in this school is important in fostering capabilities in teachers who find science difficult to teach. SD D N A SA</p> | <p>45. The school has adequate science equipment necessary for the teaching of science. SD D N A SA</p> |
| <p>22. Teachers at this school are secure in their knowledge of science concepts pertinent to the primary science curriculum. SD D N A SA</p> | <p>46. Teachers at this school have a positive self-image of themselves as regards their ability to teach science. SD D N A SA</p> |
| <p>23. Teachers at this school have a positive attitude to science as a subject in the primary school program. SD D N A SA</p> | <p>47. Science is regarded as an important subject in the school's overall curriculum. SD D N A SA</p> |
| <p>24. The facilities at this school promote the teaching of science. SD D N A SA</p> | <p>48. Lack of time is a major factor inhibiting science program delivery at this school. SD D N A SA</p> |
| | <p>49. The curriculum leadership in science fosters capabilities in those who require support in teaching sciences. SD D N A SA</p> |

Appendix C-7: SCIQ Short Form - Validated 35-item SCIQ

Science Curriculum Implementation Questionnaire (SCIQ)

There are 35 items in this questionnaire. They are statements to be considered in the context of the school in which you work. Think about how well the statements describe the school environment in which you work.

Indicate your answer on the score sheet by circling:

SD if you *strongly disagree* with the statement

D if you *disagree* with the statement;

N if you *neither agree nor disagree* with the statement or are not sure;

A if you *agree* with the statement;

SA if you *strongly agree* with the statement;

If you change your mind about a response, cross out the old answer and circle the new choice.

- | | |
|---|--|
| <p>1. Teachers at this school possess the personal confidence, skills and knowledge necessary to teach science competently. SD D N A SA</p> | <p>18. Science has a high profile as a curriculum area at this school. SD D N A SA</p> |
| <p>2. The school is well resourced for the teaching of science. SD D N A SA</p> | <p>19. There is enough time in the school program to teach science. SD D N A SA</p> |
| <p>3. The school administration recognises the importance of science as a subject in the overall school curriculum. SD D N A SA</p> | <p>20. Teachers have the opportunity to undertake professional development in science. SD D N A SA</p> |
| <p>4. There is not enough time in the school program to fit science in properly. SD D N A SA</p> | <p>21. Teachers at this school have a sound knowledge of strategies known to be effective for the teaching of science. SD D N A SA</p> |
| <p>5. Teachers at this school have the opportunity to receive ongoing science curriculum professional support. SD D N A SA</p> | <p>22. The science resources at the school are well organised. SD D N A SA</p> |
| <p>6. Teachers at this school have a positive self-image of themselves as regards their ability to teach science. SD D N A SA</p> | <p>23. Science has a high status as a curriculum area at this school. SD D N A SA</p> |
| <p>7. The school-based system of managing of science resources is well maintained. SD D N A SA</p> | <p>24. Teachers believe that there is adequate time in the overall school program to teach science. SD D N A SA</p> |
| <p>8. The school's ethos positively influences the teaching of science. SD D N A SA</p> | <p>25. Teachers at this school are supported in their efforts to teach science. SD D N A SA</p> |
| <p>9. There is enough time in the school week to do an adequate job of teaching the requirements of the national science curriculum. SD D N A SA</p> | <p>26. Teachers at this school are reluctant to teach science. SD D N A SA</p> |
| <p>10. Collegial support is a positive factor in fostering the implementation of science programs in this school. SD D N A SA</p> | <p>27. The equipment that is necessary to teach science is readily available. SD D N A SA</p> |
| <p>11. Teachers at this school are competent teachers of science. SD D N A SA</p> | <p>28. Science as a curriculum area is valued at this school. SD D N A SA</p> |
| <p>12. Teachers at this school have ready access to science materials and resources. SD D N A SA</p> | <p>29. Teachers have the time to effectively deliver the requirements of the national science curriculum. SD D N A SA</p> |
| <p>13. The school places a strong emphasis on science as a curriculum area. SD D N A SA</p> | <p>30. The senior administration actively supports science as a curriculum area. SD D N A SA</p> |
| <p>14. The school curriculum is crowded. Science suffers because of this. SD D N A SA</p> | <p>31. Science is a subject at this school that teachers want to teach. SD D N A SA</p> |
| <p>15. The collegial support evident in this school is important in fostering capabilities in teachers who find science difficult to teach. SD D N A SA</p> | <p>32. The school has adequate science equipment necessary for the teaching of science. SD D N A SA</p> |
| <p>16. Teachers at this school have a good background knowledge for teaching science. SD D N A SA</p> | <p>33. Science is regarded as an important subject in the school's overall curriculum. SD D N A SA</p> |
| <p>17. The facilities at this school promote the teaching of science. SD D N A SA</p> | <p>34. Lack of time is a major factor inhibiting science program delivery at this school. SD D N A SA</p> |
| | <p>35. The curriculum leadership in science fosters capabilities in those who require support in teaching sciences. SD D N A SA</p> |

Appendix C-8: Invitation to Participate – SCIQ Application

At Intermediate School

Department of Technology, Science and Mathematics Education
Massey University
Palmerston North

Dear Intermediate Normal Colleagues

I am about to complete the last stage of my doctoral study and need those people that participated in the Intermediate School Science Review to complete a short questionnaire. The *Science Curriculum Implementation Questionnaire* has been developed to assist schools in identifying the factors that may be influencing science program delivery at the school and classroom level.

Can you please complete this questionnaire as honestly and as accurately as you can. Don't be too afraid to be too positive or too critical of your circumstance! The results are not for any other purpose other than research purposes.

Once completed the questionnaire, please return it to me in the self-addressed envelope included.

Can I once again thank you for your support in assisting me to complete my studies. I hope the final outcome is of benefit to New Zealand schools.

Thank you again 

Brian Lewthwaite