Science and Mathematics Education Centre

A Longitudinal Study into Science Learning Environments in Dunedin Secondary Schools

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This thesis is presented for the degree of
Doctor of Philosophy
of
Curtin University of Technology

May 2010

Declaration

To the best of my knowledge and belief this thesis contains no material previously published by any other person except where due acknowledgment has been made.

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university.

Signature: M. B. Thompson ……………………………………………

Date: 29/1/10 ………………………….

ABSTRACT

Science learning environments have been studied in secondary schools around the world. There is a long history of this going back over 30 years. The study presented here is unique in that it observes a single cohort in six schools in one city over a period of three years starting from when the students began high school and following them to their first external assessment.

The students were surveyed using the Science Learning Environment Inventory and a short attitude and self efficacy questionnaire. The surveys were carried out late in the year for the first two years and about mid year in the third year. The students' total credits in NCEA science were also collected as they became available. The total data set was collated so that each student's data set was assigned an identifying number.

The data were analysed using SPSS and comparisons made between each year and the relationships between the variables such as learning environment and NCEA achievement and variation in attitude against year level.

The most striking finding was that year 10 presents as an anomaly and shows result in almost all variables, which do not sit between year 9 and year 11. This does show some correlation with the anecdotal evidence of teachers that this year is the most difficult group to teach but nevertheless warrants much more investigation.

ACKNOWLEDGEMENTS

I wish to express my thanks to my supervisor Professor Darrell Fisher for his invaluable advice and guidance throughout this research. I am also indebted to Dr Rekha Koul for her help with the data processing and the use of SPSS.

I would also like to thank my colleagues in the Science Departments of all the schools involved, their continued support with getting the surveys out to their students and back to me is truly appreciated. To those in my school for supporting me in both completing the surveys and my leave to complete the write up I owe a great deal.

My thanks also go to my wife, Mal, and my family for their on-going support and patience through the whole process.

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CHAPTER 1

INTRODUCTION

> "The tendency in the modern classroom is to regard it as a workroom, a workshop where the tools of learning are for convenience housed for the time being, a room but still part and parcel of the outside world, not a prison for saddened souls, nor a retreat where silence must reign, but a place where pupils and teacher meet to work happily together, a place enlivened by song, by spirited discussion, by freedom of movement….. the school architecture and the school furniture reflect most vividly the educational thought and tendencies of the time" Strong T. B. ,1928, p 147

1.1 INTRODUCTION AND BACKGROUND

The work on classroom climate / learning environment really began with the Harvard Physics Project evaluation (Walberg & Anderson, 1968). This was combined with work done in other institutions such as psychiatric hospitals and correctional facilities to measure social climate (Moos, 1974). Generally, the earliest foundation goes back to Lewin in the 1930s showing that the environment and people in it determine how people behave. In the past 30 years, however, there has been tremendous growth in the field of learning environment research specifically. There are available at least nine commonly used and well-tested instruments for studying learning environments. These vary according to target group (primary, secondary or tertiary institution), and the dimensions they examine.

In a classroom setting the learners are in the best position to assess the environment (Fraser, 1998). They have a wide experience in a large number of different environments. The average 15 year old would have been part of at least 30 different teachers/classroom environments. This means that the average student is not only aware of the tremendous variation that exists in learning environments, as they move from primary to secondary or indeed even from teacher to teacher, but also has a clear understanding of what he or she prefers. There have been three main foci for the research to date:

1. Studying the association between environment and outcome or as a predictor of student attitude and/or academic performance.
2. Investigating whether students achieve better in their preferred environment: (Many of the instruments have an actual environment form and a preferred environment form).
3. Using environment measures as a criterion variable, for example, to evaluate an innovation or to compare differences in student teacher perceptions (Fraser, 1998).

The proliferation of learning environments study over this long period of time has created a wealth of knowledge and data but to date little or no work has looked at longer term factors or effects. For example, does a good science learning environment in the first year of secondary school "set up" a student for the future in school science? There have been very few learning environment studies carried out in New Zealand either so this is largely new territory.

Students in New Zealand start secondary school at age approximately 13 in year 9. This is, for most, the first time they are taught by a specialist scientist in a science laboratory. There is a strong belief among secondary science teachers that science teaching in primary schools is poor and possibly even misleading. This means that most feel a need to "start from scratch" and try to "turn kids on" to the subject. There is also the whole new experience, for the learner, of using "real" scientific equipment. (Most primary schools do not even have the simplest of equipment such as beakers or test-tubes). It is therefore quite possible that this “first impression” may colour a learner’s view of secondary school science. The first three years most likely, will determine the learner’s attitude to Science and determine whether or not the learner will continue to study science into the senior school and beyond. It is difficult to get accurate total numbers of students studying science because of the diverse nature of the courses available in New Zealand schools. A reasonable comparison shows that around 35,000 students entered a chemistry examination at level 1 in 2005, this dropped to just over 10,000 at level 2 in 2006 and only 6,500 at the level 3 equivalent in 2007. This indicates that around 70% of students drop out of science as they transition into the senior school and by the time they finish high school less than 20% are studying science. Although these numbers can only be seen as approximate the trend they demonstrate is alarming especially given the rapid advances that are occurring in science and technology at the present time and the world’s ever increasing demand that its citizens understand science, at least at a basic level.

This study looked at the relationships between, science learning environments in the first three years of secondary school, and attitude to science, academic efficacy and performance in national assessment (at the end of year 11). The regressions and multiple correlations are analysed across three years. Comparisons are also made between actual and preferred learning environment results over the three years.

All the greater Dunedin (New Zealand) schools were approached and six schools completed the three years of the study. The same cohort of students was involved from start to finish. This has made it possible to link the students from year to year and make comparisons at the level of the individual. All statistics are presented as groups but the analysis was done using each learner's data across the three years.

1.2 THE INSTRUMENTS

1.2.1 The Science Learning Environment Inventory (SLEI)

The SLEI was used because the school science laboratory is seen as a unique environment and therefore needs its own questionnaire (Fraser, McRobbie & Giddings, 1993; Fraser, Giddings & McRobbie, 1995; Fraser & McRobbie, 1995). The SLEI has seven items in each of five scales with a five point response, from Almost Never to Very Often. The five scales are:

Student Cohesiveness: This is a measure of how well the students relate to each other.

Open Endedness: This looks at the freedom in class experiments and asks whether the students are doing experiments or just practical work.

Integration: This examines the links between experiment/practical work and the theory studied in class.

Rule Clarity: This focuses on the rules for experiments/practical work especially those involving safety

Material Environment: This is self explanatory and covers both the physical space and equipment available

The use of any instrument to measure learning environments is only useful if that instrument can be validated both by comparing items in the same scale and cross checking with other instruments, using statistical analysis and international comparison. Fraser (1998) presents a comprehensive table showing statistical measures of consistency (alpha reliability scores), discriminant validity (mean correlation between scales) and most ANOVA results for class differences (eta^2). These values are within or close to accepted norms. The validity of the SLEI is clearly reported in paper by Fraser, Giddings, and McRobbie (1992). This makes it most likely that the SLEI will be suitable for use in New Zealand but this study also involves the validation of the SLEI for New Zealand conditions.

There is an intuitive link between the learning environment and outcome. It is logical to think that students will do better if they are comfortable with the environment where the learning is taking place. This association between learning environment and outcome is well documented in the research (eg., Everston, Anderson, Anderson, & Brophy, 1980) The suggestion from their work is that apart from innate ability the single most important predictor of outcome is the learning environment and it's impact on attitude to science and the learners self efficacy. This certainly agrees with the anecdotal evidence from teachers that the confident learners with good attitudes tend to be the most successful.

1.2.2 Attitude and Efficacy Scales

The study of learning environment is most valuable if it can be shown that environment affects outcome. The questions that must be able to be answered include:

- Does learning environment impact on student outcomes?
- Is the outcome for students improved if they learn in their preferred environment?

- Is there a relationship between environment and attitude to science?
- Does a good environment foster academic efficacy?

The attitude and self efficacy scales used in this study were first developed (Aldridge, Fraser, & Fisher 2003), for use with another learning environment instrument, from work done by Jinks and Morgan (1999) for help with curriculum design. This study used two eight-item scales one focusing on attitude to subject and the other on academic self-efficacy. These two scales were selected from a three scale 24 item survey (Aldridge, Fraser, & Fisher 2003). A learner's attitude is obviously personal but one would expect that environment should affect it. For example, a student who finds the environment stifling his or her creativity may well feel less able to achieve in that subject. As with environment the learners themselves are in an ideal position to judge there own efficacy and although this questionnaire asks for opinions it is reasonable to extrapolate the results to a point where they can be seen to represent actual efficacy. The experience of the author and discussion with his colleagues in teaching, make it clear that learners are acutely aware of "where they're at" in their learning and efficacy. The most common situation would be for students to judge themselves more harshly than is the reality. The questions in this scale are designed to minimise this effect. For example: Question 24 "I help my friends with their homework in this subject."

The attitude scale asks, what appear at first glance to be, subjective questions. However, when one realises that what is being asked about is the individual's own attitude the questions can be seen to be, in fact, objective. In this case the learner is the only person capable of assessing his or her own attitude to science.

The link between all four variables, learning environment, attitude, self efficacy and outcome, is well established but what is not so clear is where cause and effect lie. For example, does a good attitude help get a good outcome or does a good outcome foster a good attitude? It does, however, seem most likely that the learning environment is the leading factor as in the main this is teacher determined whereas the other three are student determined. On the other hand, it is legitimate to argue that the learning environment the teacher establishes or attempts to establish is at least in part determined by his or her reaction to the attitude of the learners in the class. Similarly, the teacher would modify the environment depending on his or her opinion of the students' efficacy in the subject.

1.3 CONTEXT OF THE STUDY

This study was carried out in six Dunedin city schools. The size and geography of Dunedin means that most of the students taking part will be from a suburban background with a small number of rural or semi-rural students in some schools. There are five co-educational schools and one single sex school in the study. The Decile ratings range from 5 to 8. The Ministry of Education defines a school Decile rating as "indicating the extent to which it draws on student from low socio-economic backgrounds". Decile 1 schools are the 10% of schools with the highest proportion of students from low socio-economic background and Decile 10 the 10% of schools with the lowest proportion of those students. The sizes of the schools also vary with the largest having around 1050 pupils and the smallest around 550. Four schools are year 9 to 13 and two of the schools are year 7 to 13. This means that, in those two schools, the learners may have had some specialist science teaching prior to joining the survey.

1.4 RESEARCH AIMS

The aim of this research is to identify any correlations that may exist between classroom environments across three years and performance in national assessments. It is also envisaged that it will be possible to look for trends in environmental perceptions across the three years. In most studies the practice has been to assess the actual and preferred environment then make some change and re-assess to determine if the change was effective. This study is unique in that no interventions were planned; in fact the researcher intentionally distanced himself from the study. The aim was to determine if a three year pattern or trend existed and to try to identify any significant correlations across the three years. Variations between schools were also studied. The desire was to produce a comprehensive set of base-line data which could be an invaluable starting point for further work as well.

To meet the aim stated above a set of three questions were developed which then became the focus of the study. These three questions are listed below and again in Chapter Three where some further explanation is given.

The research questions to be answered were:

1) Is the SLEI a reliable and valid instrument for studying science learning environments in NZ?

2) a. Do students' perception of the science learning environment change as they progress from years 9 to 11?

   b. Do students' preferred science learning environment change as they progress from years 9 to 11?

c. Do students' attitude and self efficacy change as they progress from years 9 to 11?

3) Part A

i. Are there associations between students' perceptions of their learning environment at year 9 and their performance in NCEA Level 1?

ii. Are there associations between a students' perception of their learning environment at year 10 and their performance in NCEA Level 1?

iii. Are there associations between students' perceptions of their learning environment at year 11 and their performance in NCEA Level 1?

Part B

i. Are there associations between students' perceptions of their science learning environment at year 9 and their attitude to science and self efficacy at year 9?

ii. Are there associations between students' perceptions of their science learning environment at year 10 and their attitude to science and self-efficacy at year 10?

iii. Are there associations between students' perceptions of their science learning environment at year 11 and their attitude to science and self-efficacy at year 11?

Part C

i. Are there associations between students' attitudes to science and self efficacy at year 9 and their performance in NCEA Level 1?

ii. Are there associations between students' attitudes to science and self efficacy at year 10 and their performance in NCEA Level 1?

iii. Are there associations between students' attitudes to science and self efficacy at year 11 and their performance in NCEA Level 1?

1.5 METHODOLOGY

An approach was made to all the secondary schools in Dunedin. Letters were written to the principals with a copy going to the heads of science outlining the research and asking if they were prepared to allow their school to be part of the study. Initially nine of the thirteen schools approached agreed providing a good balance of decile ratings and school types. Those schools that agreed were then sent details of the process and all nine completed the first year's survey. All year 9 students in the participating schools were surveyed using the Science Laboratory Environment Inventory (SLEI) and an Attitude and Self Efficacy questionnaire. One week later they were asked to repeat the process using the preferred version of the SLEI only. The surveys were carried out late in the school year so that the classroom climate is well and truly established.

The following year the whole process was repeated with the same students in year 10. Unfortunately in this year two of the schools dropped out so seven completed the surveys. In the final year another school was unable to take part leaving six schools completing the process. In this last year of data collection the same surveys were used but it was done nearer the middle of the year. This was to avoid creating difficulties for the participants in examination classes. (New Zealand has a national qualification examination period for years 11, 12 and 13 students in November each year).

Finally, the researcher gathered the students' NCEA Level 1 results by accessing the NZ Qualifications Authority website in January of the following year. Total credits in science, English and mathematics were gathered to provide a comparison of performance. Data analysis was carried out at Curtin University using SPSS.

This study is of major importance in the field of learning environments research. It is unique in three ways. It is the first longitudinal study. A thorough search of the literature has found no long term studies of this type with a single cohort of students over a period of three years. This means that it will provide new insights into how learning environments develop as students grow older. The linking of the data sets of the various individuals makes direct statistical comparison possible. It will also provide a large data set as a base for any further study. Each of the schools that completed the study will also have access to their own data and its analysis which will allow them to make a more informed decision as they plan any changes as New Zealand implements a new curriculum.

Secondly, this is the first study conducted in New Zealand schools. This broadens the learning environments research field to a new country and although this study involves a group of schools that have many similarities, and arguably represent only a small section of New Zealand's secondary school population, this is still a major addition to the current position. New Zealand has some unique educational features; it is a country with a small population with a long history of national curricula and national assessment systems. This gives the learning environment variations a greater significance in terms of student outcomes. Dunedin in particular is a comparatively homogeneous population as can be seen by the fairly narrow range of Decile ratings among the studied schools in fact in the whole of Dunedin there are 75 primary and secondary schools with only 28% Decile 5 or below. (By definition there are 50% in this category nationally) This indicates that Dunedin population is statistically skewed up in terms of socio-economic status. This is bound to reflect in the school learning environments. This apparently narrow selection does have the advantage, however that the participants from school to school will be more consistent and therefore any variation found in learning environment more significant.

Lastly the size of the data set is large. Many studies have involved larger numbers of students across a much more diverse group but this study stands alone in having gathered over 250 item responses from each learner as well as their personal data. The results in external qualifications for Science, English and Mathematics were also gathered giving close to 300 data points for each participant. This makes it possible to carry out a wide range of analyses and comparisons.

1.6 SIGNIFICANCE

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1.7 OVERVIEW OF THESIS

There are five chapters following this introductory chapter.

Chapter 2 looks at the current literature relevant to this thesis. There is a section looking at what has happened in terms of the science curriculum in

New Zealand as we look to implement our third version of the national curriculum in less than 30 years. There will also be a brief explanation of how our current assessment system, (National Certificate of Educational Achievement, NCEA) works. The history of learning environments research will be demonstrated along with the development of the SLEI instrument and the Attitude and Self Efficacy scales used.

Chapter 3 gives a detailed methodology and explains the limitations of the work. This includes how the data were collected and collated. There is also an explanation of how the analyses of the data were carried out.

Chapter 4 is the results chapter. Here the analysed data are presented. The variations and overlaps between schools and years are shown. The relevant trends and patterns are identified

Chapter 5 reviews the data and analyses presented in Chapter 4. The possible causes of the correlations and discrepancies are discussed. It gives an explanation and interpretation of the trends and patterns identified in Chapter 4.

Chapter 6 draws it all together and relates the findings to the initial research questions. Comparisons with other learning environment research are made. The implications and limitations of the work are reviewed. A "where to from here" section looks at what would be a good next step given what has been learned from this study.

1.8 CHAPTER SUMMARY

This chapter outlines the intent and format of the thesis. It contains a synopsis of the work and gives a brief explanation of its importance. There is also a short explanation of the usefulness of this work and an indication of how the selection of participants was made. It shows that there is a history to this field of work and places it in context. It gives the research questions that are to be answered and some insight as to how they are to be answered

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

This literature review presents an overview of several areas relevant to this thesis. The first section looks at the development of the science curriculum in New Zealand. There has been a marked shift in focus over the past 25 - 30 years from a largely content based statement to one more concerned with outcome. The latest version due for implementation in 2010 is very generalist in its approach with a small number of brief statements for each year level. Alongside this curriculum change there has been a complete shift in qualification and assessment practice from a norm-referenced external examination to a mixed (internal / external) standards based assessment.

The second broad area is that of learning environment research. This can trace its roots back to the mid 1930s when researchers such as Lewin established that the environment and the people in it determine how people behave. It developed with work done in the Harvard Physics Project (Walberg & Anderson, 1968) and in other institutions (Moos, 1974). Since this time there has been a large amount of work done focussing on learning environments specifically, to the point where there is now a dedicated Learning Environments Research Journal.

There is also a section on the *Science Learning Environments Inventory* (SLEI) as this is the actual instrument used in this study. The SLEI was developed (Fraser, Giddings & McRobbie, 1995; Fraser, McRobbie & Giddings, 1993;

Fraser & McRobbie, 1995) because there was seen to be a need for the unique environment of the science teaching laboratory to have its own instrument to measure it.

The next section looks at attitude and self efficacy measures and how these relate to environment. This also includes a look at the relationship between these two, attitude and self efficacy, along with outcome and learning environment. This section examines the evidence that students achieve better in the environment that is closer to their preference.

The fifth section is necessarily brief because it looks at longitudinal studies of which there are very few. It also identifies the space in the current research and demonstrates the uniqueness of this thesis.

2.2 SCIENCE CURRICULA AND ASSESSMENT IN NEW ZEALAND.

2.2.1 Content–Based Curricula

In 1988, the New Zealand government completely changed the way education was organised in the country with a bold new initiative known as "Tomorrow's Schools". This included a redesign of all curricula. The original philosophy had been that all students be given equal opportunity and that those that have the ability will do well while the less able will not. Renwick (1986) noted that as New Zealand society became more diversified this was no longer a satisfactory scenario, if it ever was. The science curriculum, for years 9 and 10 at that stage was a 21 page booklet entitled "Science: syllabus and explanatory notes. Forms III & IV" (Department of Education,1967). There was a second booklet (56 pages) published in 1978 entitled "Science Forms 1-4 Draft Syllabus and Guide" Needless to say there were other small (one or two page) advisory notices put out by the Department of Education from time to time throughout that period. The main thrust of these two documents was to describe the content to be covered although the latter did have a list of "Interests and Attitudes" as well as "Process Skills" and "Knowledge and Concept Development" The bulk of these documents were lists of the content to be covered at each level. (The New Zealand curriculum is divided into eight levels). Years 9 and 10 roughly equate to levels 4 and 5 of the curriculum. A child begins primary school on level 1 and would be expected to be on level 6 by year 11. Levels 7 and 8 are covered in years 12 and 13 most commonly in the separate sciences; Chemistry, Biology and Physics. The aims and objectives stated in the 1978 publication were that the student acquires:

- some knowledge of the empirical world about him;
- a little of the vocabulary and grammar of science;
- an ability to observe objectively;
- an ability to solve problem situations and think scientifically; and
- an awareness of the culture that is science.

The bulk of the document however outlined the content to be covered in each of the four areas (Biology, Chemistry, Physics, Astronomy/Geology). For example under the heading "Nature of Matter" it stated that learners should understand the three states of matter in terms of the particle nature of matter, the particles are in motion and that the motion is related to temperature. The rest of the page gave more explanation but it focused almost exclusively on the content and skills with only three lines about attitude. This page is typical of the entire booklet. In fact, the chapters were headed, for example, "Content: Level 5". The text books of the time truly reflected this attitude to science where the overarching principle was the acquisition by the learners of a reasonably clearly-defined body of knowledge and a set of prescribed skills.

The old qualification (School Certificate) also followed this broad pattern of content knowledge and science skills as the most important features of science learning. It was a norm-referenced qualification based more of less exclusively on a three hour end of year pen and paper examination. It contained mostly short, (one word to one sentence), answer questions. The questions were mainly recall of content or process with a small number of marks available for interpretation or application of knowledge, although it must be said that these more interpretive questions were increasing by the mid to late 1990s.

This slow drift in question type was, at least in part, driven by a growing awareness that the transmission model of science education was flawed and there was a need to change to a constructivist view. Bell (1985) made this clear in her paper and expressed the hope that the curriculum would head in this direction. There was a clear understanding developing in teaching that there was a need to change not necessarily what was being taught but how it was being taught. Teachers at this time were ready for a change and there was a real enthusiasm for change in practice. Unfortunately, the change that did occur in the curriculum did not really build on this vision.

There was in 1984 a major review of the whole school curriculum carried out with the opinions of the whole community, from educational experts to school drop-outs, sought (Bell, 1987). This provided a great deal of information and set the benchmark for this kind of consultation. There was an opportunity for real progress to be made with all sectors of the community feeling that they had input, this was the first time that the needs of Maori (tangata whenua) had been recognised in a major report (Bell, 1987). The need for a non-racist, non-sexist curriculum was promoted. Curriculum was recognised as all that happens in schools not just the imparting of knowledge. The whole community's desire to be involved was accepted and seen as important. Although some of these things made it into the new curriculum framework much of the vision was lost.

2.2.2 The New Curriculum

The New Curriculum Framework for New Zealand has its foundations in the early to mid 1980s when the Department of Education Curriculum Division began to rewrite the curriculum using a constructivist model of teaching and learning (Bell, Jones, & Carr, 1995). At this time, there was a change of government in New Zealand and this continued the right wing drift in policy and brought a free market model in to education in New Zealand (Bell, Jones, & Carr, 1995). Much of the work done by educationalists and teachers at that stage was essentially discarded and the process begun again. An initial draft was then published in 1993. This established the "Attitudes and Values" along with the eight "Essential Skills" that were to be part of all seven learning areas. Development of individual curricula for all subjects was begun about 1990 and the New Science Curriculum first published in 1993 with full implementation by 1995.

This saw a paradigm shift from a curriculum that was designed by teachers for learners to one where the focus was on outcome and assessment (Shearer, c2000). There was minimal input from teachers or researchers into this new curriculum. The political environment of the time meant there was a fear of "provider capture" along with a growing mistrust of professionals in

Education. When it was finally produced there was little comment from those same professionals possibly because they were relieved that it was nowhere near as bad as it could have been (Shearer, c2000). The framework defined the seven learning areas; Language and Languages, Mathematics, Science, Technology, Social Sciences, Health and Physical Well-being and The Arts each of which required its own curriculum document. Eight "Essential Skills" were also determined, namely; Communication Skills, Numeracy Skills, Information Skills, Problem Solving Skills, Self-management and Competitive Skills, Social and Co-operative Skills, Physical Skills and Work and Study Skills. These skills were to be integrated into all teaching and learning. Teachers were told to make the inclusion of these skills part of their planning process.

The "Science in the New Zealand Curriculum" (1993) book covered from level 1 to level 8. (Years 1 – 13). Science was now divided into six strands, gone were the old names; Biology became "Making Sense of the Living World", Chemistry; "Making Sense of the Material World" Physics; "Making Sense of the Physical World", Geology/Astronomy; "Making Sense of the Planet Earth and Beyond". These were called the contextual strands. Two new strands were added; "Making Sense of Science and its Relationship to Technology" and "Developing Scientific Skills and Attitudes" called the integrating strands. The book began with typical, almost cliché, sections such as general aims, enhancing achievement, girls in science, etc and explanations of the format and how the strands link. The majority of the book however was devoted to the learning strands. Each of the first five had a two page spread for each level. On the verso page were three or four "Achievement Objectives" and some "sample learning contexts" and the recto page was spilt into "Possible learning Experiences" and "Assessment Examples". There was a ten page section showing how the last strand, "Developing Scientific Skills and Attitudes" could be integrated into the other five. The clear philosophy coming through was that teaching needs to be done in a context that suits the learner, but the achievement objective is paramount. This curriculum was introduced at a time when there were major new initiatives in how students should be assessed as well. Achievement–based assessment was touted as the answer to all that was wrong with assessment at the time. The two initiatives combined saw in many cases students being grossly over assessed. However, by the early two thousands things had settled down and teachers were doing what teachers all over the world do, working hard to provide good learning and assessment for all their learners as fitted their needs.

2.2.3 The New "New" Curriculum

In 2005, less than 10 years after the adoption of "The New Zealand Curriculum Framework", there was a "new" curriculum being written with draft version out for consultation in 2006. The final version was out early 2008 (Ministry of Education, 2007). The original plan was for full implementation in 2009 but that proved impossible. There is now an expectation that schools will start to use this curriculum in 2010 and by 2012 be using it exclusively. The format has changed now to a single booklet (34 pages) with a fold out (approximately twice A3 size) for each level. The seven learning areas have become eight with English being separated out of Languages to stand alone. The eight essential skills are apparently no longer essential. They have been replaced by five "Key Competencies". The Key Competencies are: managing self, relating to others, participating and contributing, thinking and using language, symbols and text.

The Science strands have also been modified. The four contextual strands, ("Living World", "Material World" "Physical World", "Planet Earth and Beyond") remain but the integrating strands have been amalgamated into one called "Nature of Science". Each strand at each level is now defined solely by a few achievement objectives. These are very brief statements, for example, level 6 Physical World is defined in 33 words. This defines approximately eight weeks work in year 11 science and so means that the statements must be vague and open-ended. This coupled with the National Assessment and Qualification system makes for an assessment driven curriculum. The National Certificate in Educational Achievement (NCEA) begins in year 11 (roughly equivalent to level 6) of the curriculum. It is supposedly a "standards based assessment" operated through a mixture of internal and external standards. In the past the curriculum has been seen as providing the fence for the examiner but because the new curriculum is so vague the examination essentially sets the curriculum at level 6. (The same is true for levels 7 & 8). Level 6 then impacts on what must be taught at level 4 and 5 so the introduction of the new "new" curriculum into New Zealand will essential hand control of the secondary school curriculum over to the New Zealand Qualifications Authority,(NZQA). The idea of an assessment driven curriculum is distasteful to most teaching professionals as it is seen as "putting the cart before the horse". It also means that curriculum development occurs to suit the assessment rather than the educational needs of the learners/nation. Secondly, this is of great concern because it further erodes the ability of a teacher to design a course of study that is individually suited to the learners in his or her care.

2.2.4 The New Zealand Qualification System

The secondary school qualification in New Zealand was essentially based on a three hour pen and paper end of year external examination. This examination at year 11 was called School Certificate. The final marks from this examination were norm-referenced by statistical scaling of the raw scores. The Official Information Act in 1982 saw many students requesting the return of their marked scripts; this led to an outcry as marks on the scripts were different to the official result because of the scaling. The solution was to abolish scaling but the norm-referencing between years was effectively continued by adjusting marking schedules to maintain means and standard deviations.

There were obvious draw backs with such a system; for example, science practical work is not able to be assessed in a pen and paper test. Norm-referencing also means that marks are not necessarily a reflection of knowledge, a mark of say 60% doesn't have to mean the learner knows 60% of the material, it just means he or she did better in that test than the learner who got 59%.

The year 12 Qualification, until 1986, used a similar process and awarded University Entrance. The qualification could be awarded by the individual school without the need for a learner to actually sit the examination; however, there were very tight rules to make sure schools were not awarding it to the wrong students. Alongside University Entrance was a wholly internally assessed qualification known as Sixth Form Certificate. Students were awarded grades from 1 (top) to 9 (bottom) in each of their subjects. In 1987 university entrance was removed from year 12 and integrated into the year 13 qualification so Sixth Form Certificate became the only qualification in year 12. The grades were still norm-referenced however as schools were given a "grade package" based on the cohort's School Certificate results.

The year 13 qualification was Bursary and this ran in much the same way as School Certificate. The stakes here, though, were very high because there was monetary reward for those who did well and went on to university.

In 2002 the National Certificate in Educational Achievement, (NCEA), was introduced at year 11. This is a standards-based assessment with a raft of individual assessments. They ranged in difficulty, style, size and mark range. The two types are unit standards and achievement standards. A unit standard is always internally assessed and has a simple pass/fail criterion. An achievement standard may be internally or externally assessed and has four possible grades; not achieved, achieved, merit or excellent. In both types of standards the number of credits available varies from two to six depending on the amount of material contained and the level of difficulty. (A very small number of standards offer more than six credits but these are in specialist fields and are likely to be phased out with the review, in progress at the time of writing). All the "standards" have a clearly defined set of criteria that must demonstrated by the learner for him or her to achieve a passing grade. This type of assessment/qualification was then progressively introduced to year 12 in 2003 and year 13 in 2004. On face value, this seems like a much better system and in fact there are some real advantages but it too has its drawbacks. Students tend to "credit shop", that is, they choose to put no effort into one or other standard either because they feel they already have enough credits in that subject or because it is too hard, or even just because they cannot be bothered. The external standards are still norm referenced with Profiles of Expected Performance published well before testing. As was the case in the old system, the marking schedules are adjusted so that similar percentages get each grade from year to year. This makes a mockery of standards-based assessment as we would expect that teachers should be able to learn the criteria and therefore be more able to teach the students leading to steadily improving grades over time.

It was originally envisaged that a “full course” would have 24 possible credits although the reality has become that many schools are offering 30 or more in several subjects. A typical science course would have a mixture of unit and internal achievement standards. For example, practical work, research and rock identification would be done internally. Students would also sit pen and paper external assessments covering the theory in chemistry, biology and physics. There is a wide range of possibilities with over 15 possible external papers and countless internal ones so each school is able to tailor a course to suit the needs of their learners. In fact, in many schools there is a range of courses in an effort to suit the needs of the individual learner. This at first sight seems to offer a great deal of flexibility but in many cases a school’s choices are limited because of the enormous workload and administration associated with each standard and the need to prepare students for the following year’s study. This is particularly a problem for smaller schools. There is a further disadvantage for both employers and others wishing to judge performance in that it is difficult to compare the outcome for a set of learners from different schools or even classes in the same school. Gaining say 20 credits in the science domain only has meaning if the actual standards passed are noted. For example compare the two standards below each worth 2 credits (NZQA, 2009):

a. 18986 Select and use basic scientific equipment (Internal)

Elements and Performance Criteria

element 1

Select and use basic scientific equipment.

Range: six items of equipment.

performance criteria

1.1 The equipment selected is appropriate for the task.

1.2 The equipment is operated in a safe and correct manner.

1.3 Measurements are taken with appropriate degrees of accuracy in terms of task and item of equipment.

b. 90192 Describe aspects of Astronomy (External)

This is assessed by an external pen and paper test. In 2008 the students had to:

Explain lunar phases

Explain lunar orbit

Explain NZ seasons

Discuss the causes of solar eclipse

Discuss the challenges of space travel

The second task requires a much higher level of understanding and knowledge of science but the equal number of credits means that on the surface they have the same value. There is also concern about the equality of internal versus external. In an internal assessment the teacher can "teach to the test" also the student can have a multitude of practices before the "real" test. On the other hand, an external assessment is much harder for the teacher or learner to predict and it is a one chance process. In fact, some employers are ignoring internal credits and only looking at external examination results. There has been constant review and modification of NCEA since its inception but these have been seen as fine tuning. There is, at the time of writing, a major review underway which will re-allocate tasks from internal to external or vice versa, change credit allocations for particular tasks, remove overlap between tasks, and change how external examinations are organized.

This new system is seen as cumbersome and unnecessarily complex by the vast majority of the community (Hipkins, 2007; Radio, 2005; Sachdeva, 2008). There is vigorous debate amongst teachers as to whether it is an improvement and whether or not the current review will make it worse. One of the main concerns is the "one size fits all" mentality which suggests that the best system to assess a knowledge-based subject such as mathematics or science should be the same as that used to assess a skills based subject such as history. There is a real need for further consultation and reduction of political rhetoric if there is to be progress. This is an area crying out for real scholarly research to be carried out and used to find a way forward.

The complexities and vagaries of the assessment have impacted on this work. It was very difficult to assess and compare the outcomes for the students in the study as there was little overlap of standards attempted between schools, classes or even individuals. This meant that the comparisons based on outcome in any New Zealand study using NCEA could only be seen as indicative and not definitive.

2.3 LEARNING ENVIRONMENTS

2.3.1 Introduction

Fraser (2001) suggested that, by the time they graduate from university, an average student will have spent around 20,000 hours in an educational institution. This is more than 20% of their waking hours since age five. It is logical, therefore, to assume that the environment in which they spend such a large proportion of their time will impact on their outcomes in terms of academic performance, attitude to learning and psychosocial development.

It is common for teachers to talk about the environment or climate of their classroom/school. This awareness leads many to attempt to set and maintain a particular style of teaching and an interesting physical layout, for example, seating arrangement, posters on the walls and novel pieces of equipment on display. All such activity is valid but is normally based on teacher intuition, rather than good research or evidence. This section looks at that research evidence and how the understanding of the importance of learning environments has developed.

2.3.2 The History of Learning Environments Research

The study of psycho-social environments began in the 1930s with work done by Lewin (1936) when he stated that the environment and people in it determines how people behave and he developed the formula $B = f(P.E)$ where B represents behaviour, P is person (or people) and E is the psycho-social environment. These ideas were developed and added to by other studies (Murray, 1938). Murray (1938) introduced the terms 'alpha press' and 'beta press' where 'alpha press' means 'the environment seen through the eyes of an external observer and 'beta press' describes the same environment as seen by the individuals in that environment. Stern, Stein, and Bloom (1956) took this further to define 'private' beta press as the individual's personal view of the environment and 'consensual' beta press the view shared by the group as a whole. Although these two often overlap, there is also generally some variation. For example, in a classroom context an individual learner may find the work difficult but be aware that others in the class find it straightforward. Pace and Stern (1958) then worked in college settings and examined the environment of a higher education institution as a whole.

The study of actual classroom climate / learning environment was first seen with the Harvard Physics Project evaluation (Walberg & Anderson, 1968). This along with studies done in psychiatric hospitals, correctional facilities and other institutions to measure social climate (Moos, 1974) formed the basis for modern learning environment research.

Walberg (1969) looks at three causes for variance in student performance; medium of instruction which he all but discounts completely, aptitude of the learner and learning environment. There is also the interaction of these three that may have a multiplicative effect. The paper states that the variance in intelligence only accounts for 50% to 60% of the variance in outcome. A further 10% to 37% can be attributed to classroom environment with the remainder due to other factors such as early (first five years) environments.

In the past 30 years, there has been tremendous growth in the field of specifically learning environment research. There are available at least nine commonly used and well-tested instruments for studying learning environments. These vary according to the target group (primary, secondary or tertiary institution) and the dimensions they examine.

Moos (1974) classified three broad dimensions of human environment:

1. Relationship Dimension which describes how the individual within a group interact.
2. Personal Development Dimension which looks at the opportunities or impediments to self expression.

3. System Maintenance / System Change Dimension which looks at how the environment is structured (in learning environments this would normally be institution or teacher determined).

The various instruments then break these dimensions down into a set of scales with a range of items in each to elicit responses from the learners. For example, the instrument Science Laboratory Environment Inventory, SLEI (Fraser, Giddings, & McRobbie, 1995; Fraser & McRobbie, 1995) measures student cohesiveness in the relationship dimensions, open-endedness and integration in the personal development dimension along with rule clarity and material environment in the system maintenance / system change dimension.

The basis of the vast majority of the learning environment studies is the use of one or other of the instruments which essentially ask the learner to assess their own environment. This makes perfect sense since the learners are in the best place to make such an assessment as they are very experienced in a wide range or learning environments.

The research on learning environments has most commonly been in one or more of the following three areas:

- the relationship between learning environment and outcome/attitude/efficacy;
- differences in achievement when a learner is in his or her preferred environment; and
- using the learning environment as a criterion variable to evaluate change, for example, the effect of increased practical work.

There is also a need that each instrument be validated and tested for reliability in each setting. This study does check the validity and reliability of the SLEI in New Zealand as well as looking for the correlations year to year and how an initial science experience relates to outcome three years later.

2.3.3 Learning Environment Instruments

There are nine commonly used instruments for assessing learning environments. These have been developed over 30 years from the late 1960s. There are others, for example, those developed by Dorman, Fraser, and McRobbie (1997) for Catholic schools but those listed below seem the most prevalent in the research.

Learning Environments Inventory (LEI)

Originally developed by Walberg and Anderson (1968) as part of the evaluation of the Harvard Physics Project it was refined by Fraser, Anderson, and Walberg (1982) to an 105 item, 15 scale questionnaire with a four point response; Strongly Agree, Agree ,Disagree, Strongly Disagree.

Individual Classroom Environment Questionnaire (ICEQ)

This was first developed by Rentoul and Fraser (1979) and then finalised by Fraser (1990) to a 50 item, five scale questionnaire with a five point response – Never, Seldom, Sometimes, Often, Always.

Classroom Environments Scale (CES)

This was designed by Moos (1979) based on his work in other institutions. It has 10 items in each of nine scales with a true/false response.

Science Laboratory Environment Inventory (SLEI)

The SLEI was developed because the school science laboratory is seen as a unique environment and therefore needs its own questionnaire (Fraser, Giddings, & McRobbie, 1995; Fraser, McRobbie, & Giddings, 1993; Fraser & McRobbie, 1995). The SLEI has seven items in each of five scales with a five point response, from Almost Never to Very Often.

My Class Inventory (MCI)

This is a simplified version of the LEI for use with younger children (Fisher & Fraser, 1981; Fraser, Anderson, & Walberg, 1982; Fraser & O'Brien, 1985). The simplifications include five instead of 15 scales, simpler wording and a Yes/No response (LEI has a four point response).

Questionnaire on Teacher Interaction (QTI)

This originated in the Netherlands (Créton, Hermans, & Wubbels, 1970; Wubbels, Brekelmans, & Hooymayers, 1991; Wubbels & Levy, 1993) but has been used in several countries. It has 40 items, over eight scales with a five point response from Always to Never.

Constructivist Learning Environment Survey (CLES)

The CLES was written to investigate the constructivist view of the classroom (Taylor, Dawson, & Fraser, 1995; Taylor, Fraser, & Fisher, 1997). It assesses how a classroom's environment fits with the epistemology of constructivism. It has five scales with seven items per scale. The CLES has a five point response from Almost Never to Almost Always.

College and University Classroom Environment Inventory (CUCEI)

Written to fill the gap, at the tertiary level, it is designed to survey small classes (up to 30 students) in universities and other tertiary institutions

(Fraser, 1998). The CUCEI (Fraser & Treagust, 1986; Fraser, Treagust, & Dennis, 1986) has seven items in seven scales with a four point response, Strongly Agree to Strongly Disagree.

What Is Happening In This Class (WIHIC)

This questionnaire is a distillation of other questionnaires. The WIHIC also has a class form and a personal form to overcome the problems of private versus consensual beta press mentioned previously. The final version of the WIHIC (Fraser, Fisher, & McRobbie, 1996) has 56 items in seven scales. Like the CLES it has a five point response choice from Almost Always to Almost Never.

These nine instruments are summarised in the table below. Similar tables can be found in Fraser (1998a, p. 531) and Fraser (1998b, p. 10), giving other details.

Table 2.1

Summary of the Structure of Learning Environment Instruments

Instrument	Total number of items	Items per scale	Response points	Response range
LEI	105	7	4	Strongly Agree to Strongly Disagree
CES	90	10	2	True /False
ICEQ	50	10	5	Always to Never
SLEI	35	7	5	Almost Never to Very Often
MCI	30-45	6-9	2	Yes/No
QTI	40	5	5	Always to Never
CLES	35	7	5	Almost Always to Almost Never
CUCEI	49	7	4	Strongly Agree to Strongly Disagree
WIHIC	56	8	5	Almost Always to Almost Never

Many of the instruments described above have both an actual form (what is the environment of your classroom) and a preferred form (what would you like your classroom environment to be). The wording of both these forms are similar, generally 'is' is replaced with 'would be'. This makes it possible to compare the learning environment of a student with his or her ideal and can help the teacher in developing his or her plans for improvement.

All the instruments are capable of good determination of classroom environment, although each has strengths and weaknesses and would be suited to a particular setting. There is, however, a general weakness when they are used to examine various subgroups within a class, for example male and female (Fraser & Tobin, 1991). This is because when asked, for example, "Does the teacher get angry with the class?", the response may be different to "Does the teacher get angry with you?", so although two groups may see the class the same way, they may or may not see individual environments differently. This led Fraser, Giddings, and McRobbie (1995) to develop a personal form of the SLEI. The use of personal forms made it possible to distinguish between the various subgroups (Fraser, 1998). It is also worth noting at this point that in general the class form of SLEI produces more favourable results overall than the personal form of the SLEI (Fraser, Giddings, & McRobbie, 1995). Several studies have been undertaken to compare boys' perceptions with girls (Byrne, Hattie, & Fraser, 1986; Fisher, Fraser, & Rickards, 1997; Fraser, Giddings, & McRobbie, 1995; Henderson, Fisher, & Fraser, 1995; Owens & Stratton, 1980). These can be summarised in statements such as boys prefer environments that are more competitive and individualistic whereas girls like cooperation and personalisation. Furthermore, girls are generally happier in the classroom than boys.

A note of caution here, that, although it is possible to measure classroom environments very carefully and in detail with each of the instruments described above, there is variation in the description of the environment according to which unit of analysis is used, or whether it is personal or an aggregation of the class (Fraser, 1998).

Finally, it must be remembered that any learning environment is fluid, and that measuring produces a 'snapshot' of the situation. Any teacher on reading the results of such a measure would evaluate and most likely modify their behaviour to improve students' perception of the learning environment. This cyclic nature of the learning environment: teacher impacts on student → student impacts on teacher →teacher impacts on student →etc happens whether or not the environment is being studied (Fisher, Rickards, & Fraser, 1996).

2.3.4 A Selection of Studies 1968 to the Present

This section looks at a selected range of individual studies. These studies were not selected because they necessarily had a major impact on the field although some may have. The selection criteria were that they typify the range of learning environment study over the past 40 years. It was also important that they used a range of instruments and that at least one addressed each of the three most common research foci.

The study by Walberg and Anderson (1968) is seen by many as the first real learning environment study. The original aim was to contribute to the evaluation of the Harvard Physics Project which was a new approach to teaching physics in the USA. Their study used the first version of the LEI which focussed the study on the individual learner as the base rather than whole class, or school, mean as had been the case previously. Correlations were found between achievement in physics and environment as well as science thinking and environment, although the two correlations involved different scales on the environment inventory. The study showed that equality of the class members and the relationships between them were both important predictors of learning success. The study also showed that personal relationship has a stronger correlation with outcome than shared goals.

Everston, Anderson, Anderson, and Brophy (1980) carried out a study that involved using classroom observation as well as questionnaires. The students' entry level academic aptitude was determined based on a standard test score. Classes were studied for one year and comparisons made between students' attitude to the teacher, classroom climate and academic performance. The strongest correlation was between academic aptitude, as demonstrated by the first test, and achievement, but two significant other factors were attitude to teacher and classroom climate as determined from the observations. It is interesting to note that this study found little correlation between aptitude and attitude, in other words, that ability of the student has little effect on how he or she feels about his or her teacher. Students performed better for teachers with the more organised classrooms and fewer behaviour problems. Students in mathematics classes saw academic competence of their teacher as a factor, rating the more competent more highly although the same result was not evident in English classes.

Fisher and Fraser (1981) carried out a major study to validate the MCI. This was the first time that the MCI had been used exclusively in science classrooms. The MCI had been used before but, this was the first study to really test its validity, internal reliability and predictive ability. The study involved a large sample of seventh graders from a wide range of schools. They determined that the internal consistency and discriminate validity were satisfactory. The MCI was not only internally tested and verified but was able in this study to act as a predictor for student outcome, on a standardised test. The study also showed that the MCI was able to discriminate between classes and scores correlated with student attitude. Since this study the MCI has been widely used for work done in junior secondary/upper primary classrooms.

By 1986, there had been over 15 years of work in classroom environments completed and the researchers were well aware of the relationships between classroom environment and attitude, efficacy and outcome. However, by this time little had been done to provide the tools for science teachers to measure and improve their own classroom environment (Fraser & Fisher, 1986). The main reason for this gap in the research was seen to be the unavailability of simple short environment surveys for teachers. Fraser and Fisher (1986) developed short forms of the CES, ICEQ and MCI and provided a hand scoring technique so teachers could easily evaluate their own classroom climates. There was a limitation on these short forms however in that they were really only valid if class means were used. The new short forms of the CES (six scales, four items each) and the ICEQ (five scales, five items each) both covered all three of Moos' (1974) human environment dimensions. The short MCI (five scales, five items each) on the other hand does not cover the system maintenance/system change dimension. This is sensible as it is designed for younger learners.

The basic process outlined in the paper (Fraser & Fisher, 1986) had the class complete both the preferred and actual form of the instrument. The teacher then hand scored the survey and compared results. Where there was a discrepancy that the teacher felt able to address, an innovation was tried for about two months. This was followed by re-surveying using the actual form and looking for changes in the perception of the environment by the learners. The case studies presented in the paper show improvement in environment with this type of intervention. The researcher also used a simple way to present the data graphically for ease of understanding and evaluation.

In their 1996 paper, Fisher, Rickards, and Fraser reported the use of the QTI as a tool for teachers to make comparisons between their actual inter-personal classroom behaviour, what they see as an ideal teacher's inter-personal classroom behaviour and the students' perception of their inter-personal classroom. This work also presents the use of a graphical representation of the results called a sector profile. These diagrams make it easy to see discrepancies between the three (teacher, teacher ideal and student) variants of the QTI. The teacher can then use these diagrams as a straightforward guide as to where to put his or her energies for improvement. The other possible area of use for these sector profiles suggested by the paper was in focussing teacher development activities

Work done by Fisher, Henderson, and Fraser (1995) also used the QTI but in this case the work was done with senior high school biology students. This study clearly demonstrated a link between the learning environment as described by the QTI and student attitude. They found significant and strong correlations between the various QTI scales and attitude, particularly with a teachers "leadership, "helpful/friendly" and "understanding" scores. There was also some correlation between "leadership and examination score although this was a much weaker relationship.

A paper presented at the fifth International Conference on Science Mathematics and Technology Education (Den Brok, Telli, Piyango, Cakiroglo, Taconis, & Terkkeya, 2005) makes use of the WIHIC to come up with six typologies of classrooms. The six groupings were created by a comprehensive analysis of the various scales from the WIHIC instrument. For example, the typology, "high-effective learning environment" had the highest mean score on all scales except Investigation where it scored second. The second part of the study looked at relationships between the typologies and student affective outcomes and report grades. There was a relationship found for student affective outcome but not report grade. It should be noted that although this study covered 52 classes in four schools the relatively small geographic spread and reliance on self reporting means that extrapolation of results to other situations or locales is not necessarily reliable.

2.4 THE SCIENCE LABORATORY ENVIRONMENT INVENTORY

The Science Laboratory Environment Inventory was first developed in 1993 (Fraser, McRobbie, & Giddings) because there was no specific instrument available for the science laboratory. In fact, although a lot of the research on learning environments was being done by science education researchers little had been done in science laboratories (Hegarty-Hazel, 1990). This gap in the research combined with concern at the cost effectiveness (Giddings & Hofstein, 1980; Pickering, 1980) of the use of laboratory teaching meant there was a real need. The development of the SLEI therefore tied in with the other environment work being done at the time but covered the unique aspects of the teaching laboratory environment that include practical and hands-on investigative work. There was also an awareness of the need for investigation using environment as a criterion variable so both the actual and preferred forms of the instrument were developed at the same time.

The guiding principles used in the development of the SLEI by Fraser, McRobbie, and Giddings (1993) were:

- consistency with the literature on science teaching;
- consistency with other environment instruments;
- inclusion of all three Moos (1974) dimensions;
- relevance to science teachers and students; and
- economy

The initial instrument had eight scales but this was quickly reduced to five: Student Cohesiveness, Open-Endedness, Integration, Rule Clarity and Material Environment. The original eight scales with nine items became seven items in five scales giving a total of 35 items making the SLEI one of the shortest instruments. The SLEI has a five point scoring system: Almost Never, Seldom, Sometimes, Often and Very Often. The scoring is reversed on 13 of the items to counteract teenagers' propensity for mischievousness.

The meanings of the five scales are:

> *Student Cohesiveness:* This measures how well the students know, support and relate to each other. Moos (1974) Relationship dimension.
> *Open-Endedness*: This measures how the laboratory practical work is organised and whether or not there is opportunity for real experimentation. Moos (1974) Personal development dimension.

Integration: Surveys the relationship between theory work and practical work in the laboratory. Moos (1974) Personal development dimension.

Rule Clarity: Surveys the use or formal rules to govern behaviour in the laboratory. Moos (1974) System maintenance/System change dimension.

Material Environment: Looks at the physical space and access to practical equipment the students have. Moos (1974) System maintenance/System change dimension.

The instrument was tested across six countries involving 40 schools with a total of 198 classes and 3,727 students. Item analysis was carried out at both the individual and the class level which led to the deletion of 20 of the original 72 items. This was followed by a factor analysis to determine the independence of the scales which lead to the deletion of two scales and left a 34 item five scale instrument. The analysis was carried out on the actual and preferred versions of the SLEI separately. This testing showed good variance between the scales and good consistency between the items in each scale. The clear outcome of all the analysis was that the SLEI was a statistically reliable instrument for measuring the five scales; furthermore the individual items on the instrument were well suited to the study.

The final phase in the establishment of the SLEI was cross validation with a new sample. In this "re-check" 1,594 students in 92 classes and 52 schools in and around Brisbane were surveyed. This again showed internal consistency and reliability along with good discriminant validity. This work (Fraser, McRobbie, & Giddings, 1993) then, established the SLEI as a useful and valuable tool in the study of the laboratory learning environment.

There is also a well tested and validated personal version of the SLEI (Fraser, Giddings, & McRobbie 1995). This, as with the actual and preferred versions, was widely tested in several countries and again was shown to have internal consistency and validity. It was this particular version that was used to survey the students for this thesis (see Appendix 7). The strength of personal forms is it allows researchers to compare the individual's self perception against how he or she sees the class as a whole. Personal versions also make identification of the views of the various subgroups easier to separate out. For example, it is often the case that girls see the environment more positively than boys. The importance of this separation can be seen when we consider items such as "Members of this laboratory class help me" (personal form item11) compared to "Members of this laboratory class help one another" (class form item 11). In this example a student who felt isolated for what ever reason would give a low score on the personal form but his or her response on the class form may be completely different if he or she sees the rest of the class as cohesive. Fraser, Giddings, and McRobbie (1995) found that there was little significant difference between the class actual and the personal actual except for the integration scale. In the preferred versions however there was significant variation in all the scales but Rule Clarity. In all cases, the variation was small but the direction was always the same. The personal form scores were lower than the class form scores. Similarly, they were able to show that although the class forms showed some gender variation, by using both the preferred and actual questionnaires the variation was more pronounced when using the individual forms.

The study (Fraser, Giddings, & McRobbie 1995) went one step further and compared the results from the two (personal & class) SLEI forms with some outcome measures. This produced an overall strong positive correlation between both versions and the outcome measures. There was no statistically significant variation between the correlations with the two versions of the SLEI. There was an apparently anomalous result showing negative correlation between open-endedness and normality of chemists, suggesting that the greater the freedom learners have in their experiments the less "normal" they see chemists. Further testing did show that it was possible to attribute different parts of the correlation; environment to outcome to the different variants of the form adding more weight to the need for a separate personal form. Although there was no significant variation in correlation, there was unique contribution to that correlation from each form of the questionnaire.

2.5 ATTITUDE AND SELF EFFICACY STUDIES

2.5.1 Introduction

Education generally must be about taking learners from where they are to where they know more and feel better about themselves and their understanding of whatever is being taught. This is especially important when it comes to the teaching and learning of science in the 21st century when the future of the planet may be dependant on how well the general populace understands the science of climate change and how they respond to scientists and science ideas as we look for solutions. The understanding of the relationship, then, between the classroom climate and students' attitude along with student self-efficacy and outcome is of extreme importance.

There is a long history of measuring student attitudes going back as far as 1968 (Dainton, 1968) when concerned was expressed about the "swing from science" that was at least in part attributed to student attitude to science. During the 1980s there was a major drop off in students taking optional science courses. The number of students taking sciences at A level (in the UK sample) all but halved. This also was attributed largely to attitude to science. (Osbourne, Simon, & Collins, 2003) One of the first real attempts to measure attitude was the *Test of Science Related Attitudes* (TOSRA) (Fraser, 1981). This was a broad questionnaire that elicited attitude to science and scientists as well as looking at attitude to science process and experiments. In this thesis the focus is narrowed somewhat to eight questions about a learner's attitude to his or her science lessons.

2.5.2 Attitude to Science

The study of attitude was for a long time confounded by a wide range of definitions and lack of clarity as to what was actually being studied (Osbourne, Simon, & Collins, 2003). Gardner (1975) made the distinction between "attitude towards science" and "scientific attitude". The former is what this study is interested in. It is an attempt to objectively measure feelings and beliefs about science. The latter on the other hand can be seen as part of the curriculum and in fact part of what we are trying to measure the attitude towards. The problem is further exacerbated because the attitude demonstrated may not equate to the attitude held (Brown 1976, Potter & Wetherall, 1987). This is because there may well be other motivation for the behaviour. For example, a student may express a negative attitude to science to avoid being seen as a "geek" by his or her peers. Similarly a positive attitude may be genuine or the result of eagerness to please a significant adult in the students life, (teacher or parent). There is also a need to separate attitude to science at school and attitude to science generally as these two may or may not equate. Potter and Wetherall (1987) further pointed out that in most instances we really only scratch the surface in any measuring of attitude, and that much is hidden and context dependant.

There is clear evidence from the research (cited in Osbourne, Simon, & Collins, 2003) that attitude to science drops as students enter and progress through secondary school. It is not clear however what causes this, it is common for primary teachers to blame the lack on their secondary colleagues but this is unfounded in the research. There is also the possibility that this loss of enthusiasm is just a reflection of an adolescents' general rejection of the establishment. There have been several factors studied and classroom environment and teacher factors have frequently been demonstrated as the best way to combat this loss of positivity (Ebenezer & Zoller, 1993; Hayadyna, Olsen, & Shaughnessy, 1982; Simpson & Oliver, 1990). In all these studies it was found that students with the "better" teachers in the "better" learning environments had the "better" attitude. This makes it clear that good teaching does combat poor attitude but in no way shows that the drop off in attitude in adolescents is caused by poor teaching. There are, however, two major implications for education policy makers and researchers.

1. What is it that constitutes better teaching? There has been little work done to find out what the pupils see in the teachers that are capable of having this impact on their attitude. (Osbourne, Simon, & Collins, 2003)
2. Once the teacher type has been identified what is being done to recruit and retain these individuals in the profession. (Osbourne, Simon, & Collins, 2003)

It is also worthy of note here that although there have been few studies there has been no strong relationship found between the general attitude to school and attitude to science. (Morrell & Lederman, 1998) The weak correlation found between the two attitudes can be easily explained by the high overlap in the external factors that affect both. This inevitably leads to the conclusion that there is little point in whole school strategies to fix the problem with attitude to science classes.

Freedman (1997) carried out a study on the impact of experimental work on both attitude and achievement. What is of interest here is that he chose to analyse attitude using an adapted card sorting system. In this, students are asked to sort 50 cards each with a single adjective on it according to how that adjective describes their feelings about science. This is a quite different approach to the usual questionnaire type survey but did elicit a similar set of results. The paper also produces some interesting results showing correlations between attitude and achievement, especially for a group where there was an intervention introducing experimental work.

In a study using the SLEI, the QTI and an eight-item attitude scale adapted from the TOSRA (Fraser 1981) (Henderson, Fisher, & Fraser, 2000), it was shown that there is correlation between the SLEI scales and student attitude. The one exception being open-endedness where there was a suggestion of a negative correlation. The most common explanation for this is that when students are facing an external final examination they become concerned when a task is not seen to be directly associated with the curriculum.

Very recently (Hassan, 2008) research was done that separated out several different factors that impact on attitude. A Likert-type questionnaire with between four and eight items in each of: Enjoyment of Science, Self-concept of Ability, Lack of Anxiety, Ability to Make Choices, Motivation for Science, Usefulness of Science, and Career Interest. The correlations between the various scales made it possible to determine what areas were important for students' enjoyment of/interest in science. For example, those with science career goals and a high view of their own ability view science more positively. This new attitude survey is destined to have a major impact on this field of study.

2.5.3 Student Self-Efficacy In Science

Self–efficacy has been studied for a long time but it is only recently that the importance of a learner's self-efficacy to his or her academic performance has become apparent (Jinks & Morgan, 1997). This correlation is particularly important for science as it is perceived as difficult by many learners and this will impact strongly on their academic self efficacy in science. The literature also suggests that self-efficacy is learned and not the result of some "deeper psychological construct" (Jinks & Morgan, 1997). This makes it doubly important that educators are aware of the correlation and include improving self-efficacy as a goal of their teaching.

Jinks and Morgan (1999) developed a 30-item questionnaire that was unique in that it was designed for use by a lower age group than any of its predecessors and that it was a "stand alone " instrument that focussed solely on self efficacy. The instrument covered three scales; talent, context and effort. All the items were rated on a four point Likert scale again with wording suitable for a wide range of learner age groups. Students were also asked to report on their academic performance based on their latest report grades. The results of this work (Jinks & Morgan, 1999) showed again the clear link between self-efficacy and achievement and go on to suggest that the improvement of students' self-efficacy should become part of the teaching in the same way that schools would work to break down other barriers to achievement such as providing disadvantaged students with breakfast.

There is further research (Joo, Bong, & Choi, 2000) that suggests that the link between self efficacy and outcome is very specific. In this study, self-efficacy was tested in two areas. The students' academic self efficacy in a given subject was assessed as well as the students' internet–use self efficacy. This was done prior to a series of lessons using the internet and computers as an integral part of the teaching. At the end of the lesson series, the students were tested on both their subject knowledge and ability to search the internet. Perhaps not surprisingly their academic self-efficacy only correlated with test performance and their internet search capabilities with their internet-use self-efficacy. This makes it clear that although there may well be some overlap in the learners' self efficacy across a range of subjects or disciplines, any correlation with outcome is only reliable if the instrument used is sufficiently precise to separate as much as possible the various foci of such a study.

Since both academic self efficacy and learning environment are predictors of outcome it makes sense to look for correlations between the two. This at first glance appears to be a self-fulfilling prediction because of the possible overlap in what is being observed/measured; however, this is easily shown to be much more complex a relationship than just a simple coincidence. For example, students are constantly aware of how their classmates are performing both at the individual task level and the larger scale performance on formally assessed activities (Dorman, 2000). This observation constitutes part of their psycho-social environment and will in turn have an effect on their own perception of their academic self efficacy Dorman (2000) found significant but small correlations between all of the 10 WIHIC environment scales and academic self efficacy. However, when multiple correlation was carried out using the class as the unit of analysis his results indicated that classroom environment scales accounted for 52% of the variation in academic self efficacy. This strong correlation combined with the previously mentioned correlation between academic self efficacy and outcome, as well as the fact that self efficacy can be taught, make it imperative that teachers and teacher training focus on maximising all three (environment, self efficacy and outcome) not the more conservative approach that make outcome alone the sole driving force in teaching practice / teacher education.

In a different type of study Carter, Sottile, and Carter (2001) used a pre-test post-test methodology. In this study, students (American grades four to eight) were given a pre-test that covered "light" and "matter" as well as a self efficacy survey. A "road show" type one and a half day lesson was then presented at the school and all the participants re-tested and surveyed. Gains were seen across the board in that not only did the learners' achievement improve significantly but so did their self efficacy. Students also were more interested in pursuing science careers after the experience. With this type of "high powered" one-off lesson coming into a school, one would expect a "spike" in the students' self efficacy and enthusiasm for science; however it should not be dismissed as a "flash in the pan". The implication is clear that it is possible to improve both enthusiasm and self efficacy and what teachers and educators must do is continually strive to find ways to sustain both in the learners in their care.

There has very recently been a new instrument developed, *Self-Efficacy and Metacognition Learning Inventory* – Science, SEMLI-S, (Thomas, Anderson, & Nashon, 2008). This is an instrument that recognises there is close association between metacognition, with all it dimensions and definitions, and a students' ability to learn, and that metacognition also has a major impact on his or her self efficacy. The researchers (Thomas et al., 2008) make the point (p. 1702) that there is no simple answer and that no one construct can explain how students learn. There is in fact a recognition that any characteristic of the students' metacognition / self efficacy will vary with time and situation.

2.5.4 Validation of the Attitude and Efficacy Scales Used

The attitude and efficacy scales used in this study are the same as those used by Aldridge, Fraser, and Fisher (2003) in their investigation into a technology rich learning environment. Their study also included an attitude to computer scale not used in the present study. The analysis of all three scales showed excellent factorial validity, internal consistency reliability and discriminant validity (p. 172). Their study involved the development of a new instrument, the *Technology-Rich Outcomes-Focussed Learning Environment Inventory*, (TROFLEI) and they looked for correlations with attitude and self efficacy scales. They found positive correlations between environment, attitude and self efficacy as had many other researchers before them. This adds more weight to support the inevitable conclusion that there is a link between the three facets of a students' psyche.

2.6 LONGITUDINAL STUDIES

What is presented in this section is a review of four studies that had a longitudinal component. The small number of studies reviewed is because there is a paucity of this type of research in the field of learning environments, attitude and efficacy. One, of the four, looks at the changing attitudes to, and involvement in science over time and compares the differences between the genders (Kelly, 1986). Two look at the effect over time of a special programme or intervention (Doppelt, 2006; Gibson & Chase, 2002). In the fourth, (Zvoch & Stevens, 2006) the students were studied over a three-year period to ascertain the effect of school on achievement and development.

The long term effect of the attitude to science developed at secondary school may well be more important and long lasting than any titbits of science knowledge learned at the same time (Kelly, 1986). In this study (Kelly, 1986), students were surveyed twice with the first in their first year of secondary school and the second two and a half years later at age 13-14. The results showed that as the students got older their attitude to science became less positive. This reflected earlier studies (Ormerod & Duckworth, 1975). What was of greater interest here, was that on a scale called "LIKESCI" which measured how much the students liked science, there was a marked decrease as expected over time, but what was unexpected was that this was much greater for girls than boys. Some of the schools studied had an intervention programme designed to encourage girls' interest in science. These schools did show better results than the schools without the intervention but the improvement was similar for both boys and girls and was only a small effect compared to the overall loss of interest that occurred with age. In another comparison made in this study (Kelly, 1986) it was noted that students with higher IQ's retained a greater interest in science especially the physical sciences. This effect was shown to be much greater for girls than boys. It is also worthy of note that the attitude to human biology improved over the period of the study and while the reasons for this are not examined it may well be a reflection of the age of the participants and their natural increase in interest in their own bodies. Finally, some schools out-performed others in that they showed a much better retention of student interest in science and this does offer some optimism for the future.

The Gibson and Chase (2002) study compared the changing attitude of three different groups of students. One group had taken part in a special summer science programme designed to stimulate interest in science. The second group was selected from among those who had applied to go on the programme but had not been selected, and the third was selected from students in the same year group who had no involvement in the special programme. Information was gathered using two standard surveys administered in both 1993-1994 and 1996-1997 as well as from some students who were interviewed. The two surveys covered attitude to science and interest in science careers. As would be expected, those that showed interest in the programme had significantly higher interest than their peer group in science at the start of the study; however, what is of most interest is after three years, although all had lost interest there were startling differences. The group who had participated in the special programme were markedly more interested in science than either of the other two groups, and secondly, the group that applied for but were not accepted in to the programme were now showing approximately the same level of interest as the group that were not involved at all. The qualitative work done in this study (Gibson & Chase, 2002) suggests that one of the reasons for this was the loss of open-endedness in the courses as students progressed through their schooling.

A study designed to measure the impact of long term teacher in-service training on learning environment was done by Doppelt (2006) in Israel. In this study 22 teachers were given 224 hours of training in each of the three years of the study. Their classroom learning environments were evaluated using the *Science-Technology Learning Environments Questionnaire* (STLEQ) administered to both the teachers and their pupils. The results were compared to a similar group of 19 teachers, who although not part of the programme described above, were given another programme over the same period to help them integrate the science and technology components of their teaching. The results showed that the research group and their pupils had a much better view of their learning environment than the control. Furthermore it demonstrated that a collaborative long term intervention programme for (science-technology) teachers has a positive spin-off for the pupils in their charge. This group showed an enhanced attitude and interest in science when compared to the control group.

In their 2006 study, Zvoch and Stevens (2006) began with a discussion about the difficulties associated with cross-sectional studies that try to compare schools. These types of studies have produced varied and often contradictory results because of the huge difficulty caused by the non-random nature of school selection. This can be partly addressed using modern statistical methods but sampling issues still make the validity and transferability of any results dubious. Their solution was to study a single cohort as they moved through a range of schools and look at "value–added" rather than at absolute performance measures. The study measured performance using a state-wide standardised norm-referenced assessment. Zvoch and Stevens, (2006) found that student background was a far more accurate predictor of student achievement but that school characteristic was a more significant factor in mean student growth. Similarly, teacher education background and curricula were not important in predicting absolute achievement but did have significant effects on student improvement. This study then emphasises the need to follow individuals through rather than look at unrelated cohorts. This study was carried out using mathematics classes and teachers but it is almost certain that their findings can be extrapolated to include science teaching and learning.

2.6.1 Where This Study Fits in the Research

Although this work stands on the shoulders of many great researchers in the field there are some gaps in the research that this thesis covers. There has been very little testing and validation of the instruments done in New Zealand and none at all in Dunedin. This thesis, therefore, will expand the geographic range of environment research and provide a set of baseline data for the SLEI in New Zealand. Secondly, although it is not the first longitudinal study of learning environments, attitude and self efficacy it has a unique methodology and setting. The study presented here is a first attempt to look at the drift in all three parameters (environment, attitude and self efficacy) across a three year period using such straight forward instruments.

2.7 CHAPTER SUMMARY

This chapter has shown that there have been two major redesigns of the New Zealand curriculum in the past 10 – 15 years and that these have had an impact on the teaching and learning of science. There has been a change from a "learn the facts" kind of approach to an outcomes-based, open-ended, qualifications driven curriculum. This has led teachers to change not only what they teach but how they teach it. The changes were in part based on research but as is unfortunately often the case much of it was based on political ideology. However, teachers are more than capable of making sure that their learners get the best deal possible if they are provided with the information and given the scope to do their job.

Along with the curriculum changes in New Zealand there has been a complete re-write of the qualifications system, with the deletion of the old norm-referenced system that had a different and separate qualification at each level and the adoption of a new, apparently, standards based qualification (NCEA) available at three levels. This has added a wide array of assessment both internal and external. This has the advantage of giving individual learners more opportunities but the disadvantage of being cumbersome and often confusing.

Learning environment research has a 40 year history with roots going back over 70 years. It is a large field of research with a diverse range of instruments and study types. Through all this diversity it has been shown time and again that the environment in which a student learns is a vital factor in the quality of his or her learning. All the research shows clear correlations between a wide range of environment scales and student outcomes, be they attitude, self efficacy or performance in an end of learning assessment. The correlation between the SLEI scales and attitude and self efficacy have likewise been clearly demonstrated (Henderson, Fraser, & Fisher, 2000). The attitude and self efficacy scales are also well tested and their validity must now be considered beyond question.

Longitudinal studies have a comparatively small history so research of this type has less well understood processes and implications. However, the use of the well tested instruments adds some confidence to the results. There is still a great deal of scope for research in this area.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

This chapter presents the research method. There is a presentation of the research questions and an explanation of why they were chosen. This chapter, also, explains what was done to collect the data and gives the rationale behind the decisions made about how data were collected and who was involved in the study. The process began in 2006 when it was noticed that there were very few studies that looked at learning environments over a time frame of more than a few months to a year at most. Similarly, very few New Zealand studies were in the journals. These two omissions presented an opening for this thesis.

All the secondary schools in Dunedin, New Zealand, were contacted and asked if they wished to be part of the study. Initially, nine of the 12 schools contacted agreed to join the study. Unfortunately, three dropped out over the study time for a variety of reasons. The year 9, 2006, cohort was surveyed in each of the three years (2006, 2007 & 2008) and data were collected on their achievement in NCEA (November 2008) Level 1. Students were surveyed on their learning environment, preferred learning environment and their attitude to science as well as their self efficacy. The data collected were entered into an *Excel* spreadsheet and transferred into SPSS for analysis. This allowed for several comparisons to be made involving differences and/or similarities between schools, years, classes and student preferences. It was also possible to analyse the validity and internal consistency of the instruments used within a New Zealand setting.

3.2 RESEARCH QUESTIONS

This section presents each of the questions asked and explains the rationale behind the choice of each question

3.2.1 Question One

Is the SLEI a reliable and valid instrument for studying science learning environments in NZ?

The use of this as a first question is self explanatory; the whole project is only as good as the instrument used.

The SLEI was chosen initially for three main reasons: firstly, that it focused on the science learning environment, secondly, that it had both an actual and preferred form and thirdly, because it was a short and easy to score instrument.

It was seen as important that there be a specific science focus to the surveys as such a large number of science teachers and schools were to be involved and to have an obvious science focus would be of greater relevance to them. It was envisaged that they would be more willing to take part when they could so easily see that the survey focused, at least in part, on the areas that were unique to science.

The importance of having two forms of the instrument is apparent when the following research questions are read. There was a desire to be able to compare the actual and preferred situations so a comparison could be made regarding the effect of satisfaction/dissatisfaction on attitude, self efficacy and achievement.

The need for a short questionnaire was driven by a simple fact of numbers, since each student was, in effect, going to be completing six questionnaires plus the attitude and efficacy instrument three times, there was a need to keep the surveys short.

3.2.2 Question Two

a. *Does students' perception of the science learning environment change as they progress from years 9 to 11?*
b. *Does students' preferred science learning environment change as they progress from years 9 to 11?*
c. *Do students' attitude and self efficacy change as they progress from years 9 to 11?*

The anecdotal experience of the writer and his colleagues is that students arrive at high school full of enthusiasm and eager to learn, especially in science, as it is for many their first experience of this type of learning environment. This enthusiasm is then, unfortunately, seen to wane over the three years until at the end of year 11 most "drop out" of science all together. The purpose of this question is to try to quantify the apparent loss of enthusiasm and identify, if possible, which areas of the learning environment teachers should focus on to curb the decline.

3.2.3 Question Three

Part A

1. *Are there associations between students' perceptions of their learning environment at year 9 and their performance in NCEA Level 1?*
2. *Are there associations between a students' perception of their learning environment at year 10 and their performance in NCEA Level 1?*
3. *Are there associations between students' perceptions of their learning environment at year 11 and their performance in NCEA Level 1?*

Part B

1. *Are there associations between students' perceptions of their science learning environment at year 9 and their attitude to science and self efficacy at year 9?*
2. *Are there associations between students' perceptions of their science learning environment at year 10 and their attitude to science and self- efficacy at year 10?*
3. *Are there associations between students' perceptions of their science learning environment at year 11 and their attitude to science and self- efficacy at year 11?*

Part C

1. *Are there associations between students' attitudes to science and self efficacy at year 9 and their performance in NCEA Level 1?*
2. *Are there associations between students' attitudes to science and self efficacy at year 10 and their performance in NCEA Level 1?*
3. *Are there associations between students' attitudes to science and self efficacy at year 11 and their performance in NCEA Level 1?*

This set of questions is an attempt to determine the effect of a changing learning environment. For example, is it the case that having a "good" learning environment in year 9, when the learner first comes into a science laboratory setting, carries through for the three years until year 11 or is it in fact irrelevant and the only thing that matters is that the year 11 environment suits the learner. Another possible scenario is that it is only important that one of the three years' environments be "good" for the learner to do well.

It is also possible that in fact the correlation remains relatively consistent throughout the three years and this would have some interesting implications in terms of the relationships between environment and outcome.

3.3 SELECTION OF INSTRUMENTS

3.3.1 Learning Environment Instrument

There is a multitude of learning environment instruments available (see Chapter 2) but this study required a relatively short, easy to score and well tested instrument suitable for testing science learning environments. An instrument with an actual and preferred version was also a prerequisite. The Science Laboratory Environment Inventory (SLEI) (Fraser, McRobbie, & Giddings, 1993) was seen as the most suitable for this study. It is a 35-item five scale questionnaire; it covers all of Moos' (1974) three human environment dimensions and it is specifically designed for use in a school science laboratory setting. There are three forms of the questionnaire: an actual class form, an actual personal form and a preferred (personal) form. In this study the actual personal form and the preferred form were used. Using these versions made it possible to compare a broader range of variables as the personal form makes it easier to separate out subgroups and the use of a preferred form allows for comparison with the students' perception of what constitutes an ideal environment.

Table 3.1

Comparison of Actual and Preferred Forms of SLEI

Scale	Question	Sample Question Actual	Sample Question Preferred
Student Cohesiveness	11	Members of this class help me	Members of this class would help me
Open Endedness	32	I decide the best way to proceed during laboratory experiments	I would decide the best way to proceed during laboratory experiments
Integration	13	My regular class work is integrated with laboratory activities	My regular class work would integrated with laboratory activities
Rule Clarity	4	My laboratory class has clear rules to guide my activities	My laboratory class would have clear rules to guide my activities
Material Environment	15	I would be ashamed of the appearance of this laboratory	I am ashamed of the appearance of this laboratory

As previously noted, a major consideration when choosing an instrument was the desire to keep it short, as it was going to be used by several schools, teachers and classes over a long period of time. The teachers involved were being asked to give up a part of their teaching time and students asked to complete surveys that were seen as being of little benefit to themselves or their respective schools. This is at least in part because, as previously mentioned, the importance of understanding learning environments has little or no time devoted to it in teacher training or professional development in New Zealand. It was, therefore seen as important that the instrument be no more than a single page.

3.3.2 Attitude and Self Efficacy Scales.

The requirements were again the need for a short simple survey that could be used to give an insight into how the learners felt about science as a school subject and how they saw their own efficacy. Although it would be an interesting point for further study, there was no need in this study to get fine details about either attitude or self efficacy. Here the need was for some evidence of the students' position on the two scales so these could be used as a point of comparison with the various learning environment scales.

The scales chosen were taken from those used by Aldridge, Fraser, and Fisher (2003). They provided a 24-item questionnaire that covered, attitude to science, attitude to computer use and science self efficacy. This was seen as an ideal instrument as it had been used successfully in the past (Aldrige, Fraser, & Fisher, 2003) it was short simple and gave an overview of the two areas. Again with the large number of teachers administering the survey in a range of schools simplicity was paramount. The results from the computer use section were not used as these became largely irrelevant due to the wide variation in availability of computers between schools and even in some cases classes. This left an instrument with two eight-item scales. (These two scales have some items reverse scored in the same way as the SLEI to improve accuracy and counter the students who do not take the survey seriously.) This instrument, like the SLEI, has only a small number of items (eight) per scale but has been validated and checked for internal consistency in other studies so was seen as an acceptable solution for this study. The 2006 data testing did validate it for a New Zealand setting.

This was also a one-page questionnaire that had the added advantage of the same five point response system as the SLEI so was able to be copied on to the back of the actual SLEI form. Although the formatting was slightly different the students were able to follow the same set of instructions for both surveys which made the process much easier. This was especially important in the first year dealing with the younger students.

3.4 SCHOOLS IN DUNEDIN

3.4.1 Overall Demographics

Dunedin city has a population of around 120,000 and 12 secondary schools. There are two state boys' schools, two state girls' schools and four state coeducational schools. The other four are integrated schools, these are schools that were privately run but have gone through a legal process and integrated into the state system. Integrated schools are funded the same way as normal state schools but are allowed to maintain certain policies and practices designed to keep the schools "special character", for example, religious instruction. They are also allowed to charge fees whereas ordinary state schools are only allowed to ask parents for a voluntary donation. There is one integrated (Presbyterian) boys' school and one integrated (Anglican) girls' school along with an integrated (Presbyterian) area school, (area schools have pupils from year 1 to year 13), that is coeducational to year 6 and girls only from year 7 to 13. The other is an integrated (Roman Catholic) coeducational school. These 12 schools are spread across the city with a range of locations from central city to suburban to semi-rural.

New Zealand schools are given a decile rating based on the socio-economic background of their catchment area. Decile 1 schools are in the poorest, most disadvantaged areas whereas decile 10 implies comparative affluence. The decile range in Dunedin is from 5 to 10. This indicates that on a New Zealand wide basis Dunedin schools are in the upper half of this scale meaning that all of the schools are and most of pupils are at least not seriously disadvantaged. The number of pupils in Dunedin secondary schools range from just over 500 to nearly 1,100.

3.4.2 Schools in This Study

Six schools completed the study; this included all five coeducational schools and one of the boys' schools. The decile range was 5 to 9; given that this is a very broad measure it is to be expected that there would be some overlap in the background of the learners. For example, the most well-off students in a decile 5 school are almost certainly better off than the least privileged in a decile 9 school. This breadth along with the method of determining decile rating makes comparison between deciles in the context of this study of little value. However, being aware of the range is important when comparing schools.

The size range of the schools in this study is similar to that for the whole of Dunedin, with the smallest close to 550 and the largest just under 1,100. This is again advantageous to the study as it avoids the variation being caused by vastly different size schools. (Although this may seem to be a large size variation it should be noted that the national range is from fewer than 100 to over 3,000 pupils in a secondary school). Also, the smallest school had at least four classes in the cohort so it is to be expected that the students would be unaware of what was going on in all classes in their respective schools. This makes it reasonable to assume that students would be responding about their own class specifically and not be influenced by their friends' opinions from another class, or at least any cross over would not be greater in one school because it's small size meant that all pupils knew each other. All the schools are similarly structured with science being taught by specialist science teachers from year 9. The schools are also bound by the national science curriculum so although order of treatment may vary between schools there is an expectation that approximately the same content will be covered by all schools and teachers. It is also worth noting that the science teaching community in Dunedin is relatively small and nearly all of the teachers involved were known to the researcher before the start of the study. There is an informal but good relationship between the teachers and this makes for a good sharing of ideas and practice.

3.5 DATA GATHERING

3.5.1 Ethics Approval

The first step in any research of this type is to gain ethics approval from an appropriate authority. For this study it was deemed appropriate that approval be gained from both the supervising university and the local college of education. Both institutions have similar requirements but wherever there was discrepancy the decision was made to work to the higher level.

The basic requirements could be summarised under five main headings:

Informed Consent
Initial contact was made through the heads of science at each school involved and the researcher explained the nature of the research and answered any questions. This initial contact was followed up with a letter to both the Head of Department and the Principal along with copies of the instruments to be used, consent forms and explanatory notes (see Appendices). All those

involved were made aware of the details and their right to withdraw at any time.

Anonymity

This was guaranteed to all those involved and names were removed from the data as soon as practicable. No individuals or institutions were identified in the study and the raw data with the names were only available to the researcher and his supervisor.

Consideration

The completion of the surveys should only take around 15 minutes and schools were asked to do this at a time convenient to them. The majority of the surveys were done in the last two weeks of the school year, a time when there is normally less curriculum pressure on teachers and students.

Feedback

All schools involved were given access to the results of the study. They were also able to access any de-identified data during the study on request.

Data Storage

The completed forms were stored with the researcher until they were converted to an electronic form when they were destroyed using a commercial document destruction company. The electronic data will be stored on removable storage in the supervisor's office at Curtin for a period of five years.

3.5.2 Initial Contact with Schools

The 12 Dunedin schools were all contacted initially by a telephone call to the Head of Science this was followed up by a letter sent to the Principal with a copy going to the Head of the Science Department (see Appendix 1). The letter asked for the school to take part in the study and outlined the basic process for the data collection. The schools were informed at this stage of their right to withdraw without consequence at anytime. They were also given basic information about data storage, use and confidentiality. The last paragraph in the letter stated that the researcher would contact them one week later to confirm their involvement. They were also given contact details for both the researcher and his supervisor.

The heads of the science departments were then contacted, again, by telephone one week later. This phone call resulted in all the schools being sent copies of the questionnaires involved and they were again contacted by telephone after they had had time to peruse the surveys. Two decided not to take part and a third although initially interested was unable to finally join due to their board of trustees' concern around ethics issues, despite the research gaining ethics approval from both Curtin University and the Dunedin College of Education. The nine schools that did agree all had only one major concern and that was the copying requirement with around 1,000 pages required per school. They were assured that they would be sent enough copies for their entire year 9. The numbers for each school were ascertained via email and the appropriate number of surveys copied for each school along with instruction sheet and consent forms.

The initial contact happened in early October with the aim of having the students surveyed in mid November. This timing was chosen as it meant that the classroom climate/learning environment was fully established. There is a danger with year 9s in that the early excitement of being in a science laboratory for the first time at the start of the year (February) would colour their response on the surveys. However, by the end of the year the survey should hopefully find a more stable and considered response. This time of year has the added advantage that for most teachers there is less curriculum pressure and they are more likely to be able to find the time to have their students complete a survey of this type.

3.5.3 Year One (2006) Data Collection

A few days after final agreement to take part, all nine schools were sent enough copies of the surveys for their year 9 classes based on the numbers they had indicated during the telephone conversations. There were several sets of instructions for supervising teachers (see Appendix 4) included in the package. The bulk of the package sent to schools was the two sets of papers for each pupil (see Appendices 5 - 9). The first had a consent form stapled on the front followed by the instructions to participants backed with the standard instructions on how to complete the SLEI. The last two pages, again backed, were the questionnaires, the actual personal version of the SLEI on the front and the Attitude and Self-Efficacy instrument on the back. The second was a single double sided sheet for the preferred version of the SLEI with the instructions and a participant details space on one side and the questionnaire on the other.

Heads of science departments were asked to pass the actual surveys out to their science teachers, who were in turn, asked to give the surveys to their students in class at a time that suited them. The instructions to teachers gave a brief and simple outline of the process to be followed. There was no strict timing here; it was considered important to allow the teacher to choose the exact time as suited their particular class. For example, in one school there is a school cultural event that involves a large number of the pupils and it was hoped that the teachers could avoid times when they had many students absent. There was also no mention of how long the students were to be given to complete the survey. In informal discussions with some of the teachers involved, it became clear that the less able students needed a great deal of time and support to complete the surveys, whereas the able students were finished within 15 minutes. The next step was to have the students complete the preferred questionnaire approximately one week later. Again teachers were told that the timing was not critical and that they should do it to suit their programme. The heads of department were asked to gather in all the completed surveys, preferably in class lots, and put them in a box. They then contacted the researcher by email to arrange a pick up.

The completed forms were kept in school groups and the data entered into an *Excel* spreadsheet. The data were entered exactly as the student had replied, no reversal was done at this stage. The data included the name of the individual and his or her teacher's name. The school and class identifier were also recorded as well as gender, although as this was not specifically asked for, in some cases it was unknown or uncertain based on student first name.

This first year's set of data were analysed initially to test the internal consistency and validity for use of the three instruments in New Zealand (Table 4.1, Chapter 4).

3.5.4 Year Two (2007) Data Collection

This was essentially a repeat of the year one process. The heads of department were this time contacted by email in late October and asked if they were able to continue. Unfortunately, two schools were unable to remain in the study. Those that agreed were sent an equivalent package of material as in the previous year. The teachers were asked to go through the same process only this time with their year 10 classes (the same students as the year before). The data were handled in exactly the same way, although this time it was seen as unnecessary to repeat the internal reliability and validity analysis. After collection, the data were entered into a spreadsheet and set up for further analysis. It was noticed in this set that there were more mischievous answers, for example some students gave each item a score of three, or there was a simple pattern to their answers such as one, two, three, four, five, one, two, three…….. This was most likely just an expression of the well known tendency of year 10 students to be difficult. These obviously roguish answers were again removed from the data set. Similarly, any students who had only completed the preferred survey and not the actual were removed. This was done because it was thought they may well skew the results. The data were then combined with the data from the first year. This was done carefully to make sure there was student matching between the years.

3.5.5 Year Three (2008) Data Collection

The third year was problematic in that the group being surveyed was now in an important year of their study. Year 11 is when students in New Zealand enter into their first national assessment/qualification, NCEA Level 1. The external examination part of this assessment occurs in late November and so it was seen as unwise to ask teachers to survey their students then. The schools were contacted in the middle of term two (late May) via email and asked to remain in the survey for the last year. The consensus amongst the heads of department was that they thought the surveys should be done early in term three, late July or early August. The researcher agreed as this was late enough in the year to assume that the classroom climate was well established but early enough to not interfere with examination preparation. Again the teachers were asked to survey their own classes with the actual SLEI and attitude and self-efficacy questionnaires followed by the preferred SLEI one week later.

The actual process, therefore, was much the same as the previous two years. There was, however, a need for a slight change to the consent form. Another space was added as the date of birth of each participant was needed (see Appendix 6). This added piece of information was required for the researcher to access their NCEA results. It was made clear on the form that these extra data were being gathered and why, and that they were under no obligation to take part if they did not wish to. Again these data were entered into a spreadsheet at the time and mischievous or incomplete sets removed.

3.5.6 Year Three (2008) Outcome Data Collection

The final set of data was gathered from the New Zealand Qualifications Authority (NZQA) website by the researcher. Each student's total credits in science, English and mathematics were added to the third year's data. In New Zealand, it is compulsory for all students up to year 11 to take English or Te Reo Maori; for those students with no English grade their grade total for Te Reo Maori was substituted. This gave an indication as to academic outcome although it has some limitations. The English and mathematics grades were gathered as a reference only. It was hoped that these could be used to gain an insight into the intellectual ability of the participants.

It was envisaged that it would be possible to find a common set of data for each student. Initially, all the grades in the external standards were collected with the intention that students' outcomes could be compared using not only total credits gained but also a measure of level of performance with an achieved grade being scored as 1, merit as 2 and excellent as 3. This was found to be impractical, however, as it soon became apparent that schools did not enter their students in a standard set of external examinations. In some cases, this was obviously related to ability. For example, one school had a group of students take a range of external examinations selected from the individual sciences (biology, chemistry and physics) domains; judging by their performances in English and mathematics, this was the schools most able group. In another example, students in one class had not sat any external examinations; again judging by their English and mathematics scores and a brief look at some of the standards attempted, this was a group with a much lower ability.

The only real solution was to count total credits in any science domain, and as pointed out in Chapter 2, this has some limitations as to how accurately it reflects the actual achievement of the learner. However in the context of this study it could be argued that the choice of standards that the learners were entered into was a reflection of their ability and that the actual number gained was therefore determined largely by their learning environment.

3.6 DATA SORTING AND ANALYSIS

3.6.1 Year One Reliability and Validation

The first year's data were analysed as a separate set to test the validity and reliability of the various instruments used. This was seen as a very necessary first step as it would have been pointless to continue if the instruments could not be shown to be reliable and valid in a New Zealand setting. The analysis was carried out using SPSS software. The Cronbach's alpha scores for the actual SLEI scales ranged from 0.55 to 0.67, for the preferred scales from 0.61 to 0.77 and for the attitude and efficacy scales 0.93 and 0.83 respectively (see Table 4.1 Chapter 4, page 82).

There was also some informal discussions held with teachers and heads of department who found that although the more able year 9 students found the instruments straight forward, the less able found some items difficult due mainly to literacy issues. Further discussion in the following two years indicated that this issue was less of a problem for the students as they got older, although a brief look through the various survey forms indicates that some students may have had difficulty in interpreting the various items.

3.6.2 Correlation of Three Years Data

The first step in correlating the data involved going through the third year's data set and removing all students whose NCEA data was unavailable. This could have many causes; for example, students who fail to pay the NZQA fee have their results made inaccessible by the authority, or a simple error in the data set such as a student using his or her second name on the consent form made it impossible for the researcher to access his or her records. It was seen as necessary to remove these students as a major thrust of the thesis was to compare the three years' learning environments with final outcome. This left a total sample of 539 students from six schools and 26 classes. Each of these students, schools and classes were then assigned a unique number. The previous two years' data were then matched so that the student number remained consistent from year to year. The classes and in some cases the school changed between years. For example, student 25 was in school 1 for all three years but in class 3 in year 9, class 2 in year 10 and class 1 in year 11. The year to year movement of students' class setting made it impossible to do any real analysis by class so all analysis was done at the individual level. It should also be noted here that gender was recorded in the data but not used in this study.

This produced a data set that had 539 students in the year 11 set but only 408 in years 9 and 10. This discrepancy was caused by the need for overlap. The year 11 data were used as the primary set and only 408 of these had a year 10 match. The same number of matches for year 9 was purely coincidental. To remain in the study a student needed to have completed the year 11 actual form, have a set of NCEA data and have completed the surveys in either year 9 or year 10. This left approximately half the original sample size but was still big enough to be statistically valid. (The original sample included the three schools that failed to complete the three years of the study). The total number of students that completed the questionnaire in year 11 (third year) was 583. The 2007 data set had 769 students (these were from seven schools) and 2006 had 1,017 students (this figure is the return from the original nine school study group). In both the first two years all data were included, although these numbers suggest a large loss, many of the students purged from the final set were those who had not completed the questionnaires or only been present for one of the two surveys in a particular year.

The data for all three years were then combined onto a single spreadsheet using SPSS and analysed for associations between the various factors using accepted statistical methods.

3.7 OVERVIEW AND EXPLANATION

Dunedin was used as the study centre for convenience (it is the researcher's home town) but also because it has some unique features that make it ideal for this study. It is a university town and its residents see it as an education hub. This predisposes them to view any research favourably and they are generally relaxed about being involved. The schools in the town like schools anywhere have their strengths and weaknesses but they are all seen as basically good schools and although they are not totally homogeneous they have more in common with each other than would be the case in most cities in New Zealand. For example, it is the only city of its size in New Zealand without a private secondary school. The comparatively small range of decile ratings similarly indicates that the schools are not vastly different.

The basic approach throughout the data gathering phase was "hands-off". This was done for three reasons. First, it was seen that the best way to study an individual teacher's/class's learning environment was to have a situation where the teacher was working with his or her own class. In other words, there was a desire to minimise any outside influence coming into the class and impacting on the responses to the various surveys. Secondly, it was felt that many of the schools and teachers involved would see it as an unnecessary and unwanted imposition, the decision was made to give them as much control of the process as was possible. This has the obvious disadvantage, however, that there is a real chance that the survey will be administered poorly and that much of the data will be incomplete with students missing one of the two surveys and not being followed up. This proved to be only a small issue as the number of complete data sets was well over 75% of the final number involved. The third reason for this style of approach was that the researcher is on the staff at one of the schools involved and there was a slight danger that some of the students at other schools may be prejudiced by this and respond unfavourably to him or be less inclined to take the study seriously.

The original sample did contain as broad a range of schools as possible for Dunedin but by the last year the spread had decreased. The final six schools included only one of the single sex schools and one of the integrated schools. This has both advantages and disadvantages for this study. The one school of each type does give a point of comparison with the other schools. This means that if a particular feature is really a point of difference, as many would claim, we should see this with either or both the single sex school and the integrated school showing out as different on one or other of the measures. The loss of three single sex schools, one of which was also an integrated school, did increase the homogeneity of the remaining schools. The main disadvantage is a simple loss of numbers of participants in any study of people in situ, that requires statistical analysis, the greater the number of individuals being tested the more reliable the results. The data analysis, however, makes it clear that there were enough students with full data sets in the finish to produce worthwhile results.

The decision to use a three year time frame was in part determined by the basic operational structure of the New Zealand education system. Students begin secondary school in most cases in year 9 so this made year 9 the appropriate starting point for the study. Science is compulsory to year 10 only but most schools insist that students continue studying some science in year 11. Year 11 is also when the first national assessment occurs and having some sort of standard measure for outcome was also important to the study, hence year 11 was seen as the ideal end point. Three years are also suitable for this type of study as anything longer is likely to have a higher attrition rate and so there would be a need to add some form of more complex tracking of participants to maintain an acceptable sample size.

The main reasons for choosing the SLEI as the primary instrument have already been outlined but it does have another advantage as well. Three of the five scales have some relevance to the debate about school type. It is often said that boys' schools are more competitive and less cooperative and that there is an increase in bullying in this type of school, if that were the case we would expect it to show up in the student cohesiveness comparison. Similarly boys' schools are supposedly stricter that their co-educational counterparts this, likewise, should show in rule clarity. There is also a belief that integrated schools are wealthier and have better resources than the ordinary state schools; if this were the case we would expect that the integrated school would be able to provide a better material environment.

3.8 CHAPTER SUMMARY

This chapter began with the research questions and an explanation as to how they were chosen. It shows how these questions relate to the methodology that followed and how this fits into teaching practice in New Zealand. The three questions cover the range of the study. Question one asks about the validity of the instrument, question two covers the changes in student perceptions over the period of the study and the last question is about the relationship between perceptions and outcome.

This chapter also presented the methodology and noted the reasons why the data were collected in the way that they were. It explained the size of the data set and why the final year's data were about half the size of the 2006 set. The type and range of schools are identified and explained and how this may impact on the results is noted. It contains information about the variation between years and the timings of the data collection.

The ethics requirements are explained and the gaining of ethics approval noted.

The limitations of outcome data are explained along with some explanation of how it is all but impossible to directly compare student performance using NCEA as a tool. This creates real difficulties for the results presented in the following chapter(s) although there is a note above that the shortcomings of NCEA in one sense may in fact enhance the accuracy of the results.

The final section gives an overview and explains much of the rationale behind the work. There is information about the schools involved and how this may affect the analysis.

CHAPTER 4

PRESENTATION OF RESULTS

4.1 INTRODUCTION

This chapter presents the results of the research after the collected data had been processed using SPSS. An explanation of what the results in each table mean is provided in the relevant section. The main intent of the presented results is to answer the research questions. The implications of the results are covered in the following chapters.

The second section looks at the validity and reliability of the SLEI in a New Zealand setting. It details the results from traditional standard statistical techniques used to measure the internal consistency of the seven items in each of the five SLEI scales. It also covers the discriminant validity for each of the scales.

Section three reports on how the students' perception of their learning environment changes over time. The data presented in this section are in two parts. The first table shows how the gross means for each scale of the actual SLEI compared across the three years of the study. The second set of tables gives a comparison between actual and preferred learning environment measures for each year.

There is also a section describing how the preferred learning environment changes over time. Here results are presented that compare the student responses to the preferred form of the SLEI for each of the three years of the study.

The next section covers the correlations between the learning environment scales and outcomes. Results are provided for each year with correlations between each of the five SLEI scales and attitude to science, academic self-efficacy, as well as, year 11 NCEA achievement. The multiple correlations are also detailed and provide a more conservative analysis of the results.

The last set of results presented gives a comparison between the six schools. This does not relate directly to any of the original research questions but is relevant as it gives an indication of the homogeneity of the schools. This has implications as to the value of the other results as the greater the diversity of the sample the less reliable the statistic can be expected to be.

The final section summarises the information presented. Additionally, brief answers to the research questions are given in this section.

4.2 INTERNAL CONSISTENCY AND DISCRIMINANT VALIDITY

The internal consistency and discriminant validity of any psychosocial measurement instrument must be established in the setting that it is used before any other results can be trusted. The initial analysis of the SLEI carried out by Fraser, McRobbie, and Giddings (1993) in six countries established it as a reliable instrument for the study of the science laboratory learning environment so what is presented here is a confirmation of those results in a New Zealand setting. The attitude to science and the self efficacy results are also analysed for internal consistency. These are a less well tested set of items but as can be seen they have very good Cronbach alpha scores.

The Cronbach alpha scores for Rule Clarity (actual), Open Endedness (actual) and Student Cohesiveness (actual) are at the low end of the conventionally accepted range but are still satisfactory. (DeVellis, 1991, Nunnally, 1978) Similarly, the other reliability scores are less than those reported in the original study (Fraser, McRobbie, & Giddings, 1993) but are high enough to assure the validity of the instrument for New Zealand conditions. There have been other studies (Quek, Wong, & Fraser, 2005; Wong & Fraser, 1995) that have had low values for some of the alpha scores particularly in the Open-Endedness scale.

Table 4.1
Analysis of Internal Consistency (Cronbach's Alpha Coefficients) and Discriminant Validity (Mean Correlation with Other Scales) (2006 Data)

Scale	Mean value		Standard deviation		Cronbach's Alpha Coefficients		Mean Correlation with Other Scales	
	Actual	Preferred	Actual	Preferred	Actual	Preferred	Actual	Preferred
Student Cohesiveness	3.80	3.86	0.63	0.64	0.60	0.69	0.29	0.37
Open Endedness	2.49	3.13	0.59	0.62	0.56	0.67	0.09	0.22
Integration	3.64	3.56	0.64	0.74	0.66	0.64	0.30	0.24
Rule Clarity	3.82	3.55	0.65	0.66	0.55	0.75	0.28	0.25
Material Environment	3.59	3.89	0.67	0.76	0.67	0.77	0.33	0.34
Attitude to Science	2.82		0.45		0.93			
Academic Self-Efficacy	2.83		0.68		0.83			

The mean correlations with other scales are all lower than those reported by Fraser, McRobbie, and Giddings (1993) with the exception of Open Endedness (preferred) which is slightly higher. This indicates that the various scales are measuring distinct but slightly overlapping aspects of the laboratory environment which is to be expected. Again, this makes it reasonable to conclude that the instrument has performed satisfactorily in New Zealand and more particularly for this group of students.

4.3 VARIATION OF LEARNING ENVIRONMENT YEAR TO YEAR.

This section presents two analyses of data. The first is a comparison of how the students' perception of their actual learning environment varies as they progressed through the three years of the study. This was done by using a one-way ANOVA, with year of study as the main effect, to generate an F-value. This same sort of analysis was also carried out on the preferred data set to determine if student preference changes as they mature.

The second analysis compared the actual and preferred learning environment results for each year. The aim in this case was to analyse how the differences between the two measures (actual and preferred) may have varied as the students changed from their first experience of science in a laboratory, through to the year 10 student who sees him/herself as an "old hand", and finally to the learner facing their first external qualification. Common sense suggests that the style of learning environment preferred by each of these groups would vary.

4.3.1 Comparison of Perceptions of Actual Learning Environment.

The variation in both age and circumstance for the learners as they progress through their first three years of secondary school would logically suggest that their perception of the learning environment would change. For example, a year 9 student is much more likely to be impressed by a piece of equipment, such as a van der Graaf generator, when he/she sees it for the first time than when in year 10 it is brought out again. This would most likely impact on the learner's perception of the material environment. Similarly, the pressure of an end of year external examination in year 11 would be expected to affect how the student felt about integration and open endedness.

Table 4.2
Variation in Actual Learning Environment, Attitude and Self Efficacy Scales Between Years (Whole Sample)

Scale	Year 9 (2006)		Year 10 (2007)		Year 11 (2008)		F Value	Post hoc tests
	Mean n=385	Standard deviation	Mean n=369	Standard deviation	Mean n=540	Standard deviation		
Student Cohesiveness	3.86	0.67	3.69	0.55	3.77	0.67	5.99**	9>10**
Open Endedness	2.48	0.48	3.50	0.63	2.59	0.54	402.75***	10>9*** 11>9** 10>11***
Integration	3.72	0.64	3.76	0.63	3.46	0.52	34.53***	9>11*** 10>11***
Rule Clarity	3.80	0.59	2.63	0.52	3.62	0.58	472.24***	9>10*** 9>11*** 11>10***
Material Environment	3.66	0.65	3.32	0.39	3.51	0.69	29.92***	9>10*** 9>11*** 11>10***
Attitude to Science	3.22	.97	3.29	.92	3.17	.91	11.13***	10>9*** 10>11***
Academic Self Efficacy	2.88	.74	2.91	.68	2.82	.74	38.40***	10>9*** 10>11***

*$p \leq 0.05$ **$p \leq 0.01$ ***$p \leq 0.001$

The F value being significant for all the scales shows that there is non-random variation with respect to year for the students as they progress through the study. The post hoc results then show where the variation occurs.

Table 4.2 shows that Student Cohesiveness is greater in year 9 classes than in year 10; is this a case of "familiarity breeding contempt"? Open Endedness is by far greatest in year 10 and lowest in year 9 with the year 11 result between these, although it is much closer to year 9. The Integration results appear, at least in part, to contradict the Open Endedness results with the least Integration at year 11 when it would be expected that teachers were most focused on preparing students for a clearly defined set of achievement standards and therefore making every effort to integrate the theory and practical work so the students are best equipped for their external examinations. The rules are clearest in year 9 and least clear in year 10 by a large margin, with year 11 having the middle result although again it is much closer to year 9 than year 10. The material environment is perceived as best in year 9 which is for most of the students the first year they are able to use any scientific equipment and so it is not surprising they view the laboratories as well equipped. What is most interesting in this result is that the year 11s perceived the material environment as better than they did in year 10.

The student's attitude to science is likewise greatest in year 10 with no significant difference between years 9 and 11. This is most interesting as the research suggests that the normal pattern is for attitude to decrease with age (Gibson & Chase, 2002; Osborne, Simon, & Collins, 2003). What is also worthy of note here is the large standard deviations suggesting that there is a much broader spread in students' attitude than with any of the other measurements. The self efficacy results follow the same pattern as attitude. This is to be expected based on the research which suggests the two measures are related in most cases. (Hackett & Betz, 1989, Liu, Hsieh, Cho, & Schallert, 2006)

Table 4.2 also highlights a most interesting factor; in that in three of the SLEI scales as well as the attitude and self-efficacy, the middle result is different and not between the other two values. In the other two SLEI scales the pattern is the same, although not statistically significant, and may well, therefore, just be a random variation. This does not follow the trend expected. It is logical to assume that any variable would either decrease or increase with time; however, here values increase between years 9 and 10, then decrease between years 10 and 11. Likewise those variables that go down as students go from year 9 to year 10, then go up as the students transition from year 10 to year 11. This lack of consistent direction of change with respect to time is an indication that the situation is not simple and that there are at least two factors causing the changes we see. There must be at least one cause for increase and one for decrease for both effects to appear.

4.3.2 Comparison of Preferred Learning Environment over Three Years.

The factors mentioned above that impact on a student's perception of his/her learning environment such as age and experience will also, most likely, impact on his/her preferred learning environment. The expectation, therefore, would be a similar pattern of variation to that shown with the actual SLEI.

Table 4.3
Variation in Preferred Learning Environment Between Years (Whole Sample)

Scale	Year 9 (2006)		Year 10 (2007)		Year11(2008)		F Value	Post hoc tests
	Mean n=385	Standard deviation	Mean n=369	Standard deviation	Mean n=540	Standard deviation		
Student Cohesiveness	3.96	0.63	3.50	0.60	3.81	0.84	33.08***	9>10*** 9>11*** 11>10***
Open Endedness	3.15	0.61	3.97	0.81	3.03	0.69	162.26***	10>9*** 10>11***
Integration	3.53	0.69	3.67	0.58	3.60	0.93	2.48	
Rule Clarity	3.44	0.56	2.87	0.61	3.46	0.66	91.06***	9>10*** 11>10***
Material Environment	4.08	0.76	3.59	0.52	3.82	0.89	32.05***	9>10*** 9>11*** 11>10***

*$p \leq 0.05$ **$p \leq 0.01$ ***$p \leq 0.001$

Although there are differences in which variations, between years, are significant for the two different (actual and preferred) sets of SLEI results, none of the significant variants disagree between the two sets of results. In other words, the significant variations in the actual data are all in the same direction as the significant variations in the preferred data.

The result for the middle year (year 10) is, again, the odd one out. In four of the five scales the year 10 results are significantly ($p \leq 0.001$) different from the other two and in all five cases this result is not between the other two as would be expected. (The Integration result shows no statistically significant variation and may well just be a random result).

The students most wanted cohesiveness in year 9, by year 10 this desire had decreased significantly. In year 11, there was a significant increase but not to the same level as year 9. This suggests that in year 10 the students' desire to “get on” with each other is at its lowest. It must be noted, however, that the mean here is 3.50 with a standard deviation of 0.6 suggesting (assuming a normal distribution) that around 80% of students scored above three on the Likert scale response.

The year 10 students wanted the most open-endedness with no significant difference between years 9 and 11. This may be the result of year 9’s hesitancy when faced with a lower level of direction and the year 11’s desire for clear guidance in an external assessment course. The year 10 mean is nearly four (sd = 0.81) which indicates that around 85% or more of students at this age desire open-endedness in their experimental work.

The preferred level of integration shows no significant variation between years.

The results for the Rule Clarity scale show that when in year 10 the students want significantly less than in years 9 and 11. The reasons here may well be similar to those for open-endedness.

The Material Environment results again show year 10 as the lowest. However, as before, the year 10 results do not show the students are happy with the environment, the mean and standard deviation suggest that there is room for real improvement.

4.3.3 Comparison of Preferred with Actual Learning Environment over Three Years

The relationship between preferred and actual learning environment is fluid as there may be changes in both over time. The most obvious factor is the change in teachers as students go from one year to the next; this will impact not only on the actual learning environment but also on the student preference. This change in preference could, for example, be changed as the student experiences a different style of teaching and hence learning environment and he or she realises that they do or do not enjoy a particular aspect.

Table 4.4
Comparison of Preferred with Actual Learning Environment Year 9 (2006)
(n = 270)

Scale	Mean		Standard deviation		Difference (Preferred – Actual)	t Value
	Actual	Preferred	Actual	Preferred		
Student Cohesiveness	3.88	3.97	0.70	0.63	0.09	2.24*
Open Endedness	2.50	3.16	0.49	0.62	0.66	15.00***
Integration	3.75	3.54	0.65	0.75	-0.21	4.21***
Rule Clarity	3.83	3.46	0.59	0.55	-0.37	9.85***
Material Environment	3.69	4.10	0.66	0.75	0.41	7.94***

*$p \leq 0.05$ **$p \leq 0.01$ ***$p \leq 0.001$

Table 4.4 suggests that the learners in year 9 find the level of student cohesiveness less than what they would prefer. They would like more open ended practicals, greater freedom and for more and/or better equipment to be available.

Table 4.5
Comparison of Preferred with Actual Learning Environment Year 10 (2007)
(n = 270)

Scale	Mean value		Standard deviation		Difference Preferred - Actual	t Value
	Actual	Preferred	Actual	Preferred		
Student Cohesiveness	3.85	3.97	0.59	0.64	0.12	3.63***
Open Endedness	2.58	3.08	0.52	0.64	0.50	11.57***
Integration	3.52	3.53	0.48	0.53	0.01	0.26
Rule Clarity	3.69	3.51	0.55	0.59	-0.18	5.30***
Material Environment	3.49	4.01	0.65	0.75	0.52	11.34***

*$p \leq 0.05$ **$p \leq 0.01$ ***$p \leq 0.001$

The trend here continues from year 9 with the results showing a similar pattern. The students want greater cohesiveness and more open-ended practical work. The level of integration was seen by the students in year 10 as about right. They wanted the rules to be less clear and a better material environment.

Table 4.6
Comparison of Preferred with Actual Learning Environment Year 11 (2008)
(n = 346)

Scale	Mean		Standard deviation		Difference (Preferred – Actual)	t Value
	Actual	Preferred	Actual	Preferred		
Student Cohesiveness	3.79	3.79	0.65	0.80	0.00	0.13
Open Endedness	2.54	3.03	0.54	0.66	0.49	12.12***
Integration	3.48	3.53	0.51	0.87	0.05	1.08
Rule Clarity	3.62	3.41	0.54	0.58	-0.21	6.52***
Material Environment	3.50	3.83	0.66	0.85	0.33	6.51***

*$p \leq 0.05$ **$p \leq 0.01$ ***$p \leq 0.001$

Table 4.6 shows how the year 11 students feel about their learning environments. It shows that they are once again satisfied with the level of student cohesiveness and integration, likewise, shows little difference between actual and preferred results. However, the students would still prefer to have more freedom to experiment. The dissatisfaction with the classes being seen as too strict and lacking in equipment (quality) carries forward from the previous two years.

4.3.4 Summary of Comparisons of Preferred with Actual Learning Environment Over Three Years

The actual environment measure of student cohesiveness matched the preferred measure in year 11 and was least like the preferred value in year 10, whereas year 9 showed some separation but less than in year 10. The reasons for this are not able to be determined but may relate to the changing maturity of the students and/or the change in focus of the learning as students progress through the first three years of their secondary schooling. In most cases, student class groupings would remain close to the same as they move from year 9 into year 10 but there would be a complete rearrangement as they move from year 10 into year 11.

The actual open-endedness of the classrooms is consistently much lower than what the students would prefer it to be suggesting that students in science in New Zealand would like to have greater freedom in their laboratory sessions. The most common type of practical work has students following a set procedure to gain expected results. This study suggests that the learners would prefer to have a more investigative structure where they would be given a broader set of parameters and allowed to develop their own methodology.

The level of integration between theoretical and experimental work in years 10 and 11 matches the students' preference. In year 9, however, the students would like to see less integration of theory and practical. These results combined with the Open-Endedness results suggest that students in year 10 and 11 at least like to see a relationship between what they are learning in class-work and their experiments but would like to have more opportunity to test the ideas in their own way.

It is not surprising to see that the results suggest that teenagers would like to have fewer rules. The variation is greater in year 9 but very similar to years 10 and 11. The reasons for this are unknown but may be due to teachers being more cautious with the year 9 students because of their lack of laboratory experience.

The material environment falls short of what the students prefer across all three years. This is a complaint common to all science and scientists at any level: there is always a desire for more equipment and a better physical working environment. The everyday demands on the average science teacher in New Zealand make the maintenance of a tidy and well ordered laboratory a difficult task and this may also, in part, explain this set of results.

4.4 REGRESSIONS AND MULTIPLE CORRELATIONS WITH ATTITUDE, SELF-EFFICACY AND YEAR 11 ACHIEVEMENT

4.4.1 Relationship Between SLEI Scales and Outcome Measures

The main purpose of education must be to improve the learner. The definition of improvement is broad and somewhat indeterminate. In the context of this study, three outcomes were measured, namely, attitude to science, self efficacy and achievement at the end of year 11 in NCEA. The variation in attitude to science and self efficacy over the three years is presented in section 4.2. What is presented below is the relationship between these three variables and the learning environment scales of the SLEI for each of the three years. The simple and multiple correlations between the SLEI scales and attitude to science are for the stated year's results. For example, the simple correlation (*r*) of 0.34 for Student Cohesiveness (year 9) with Attitude to Science is for that year only. The results for Academic Self-Efficacy are calculated the same way. The results for year 11 achievement are based on a comparison between the stated year's results and the learner's performance in his or her external qualification in year 11 (2008). For example, the simple correlation (*r*) for year 9 Student Cohesiveness of 0.19 compares the year 9 (2006) SLEI result with the year 11 achievement in NCEA (2008)

Table 4.7

Simple and Multiple Correlations Between the SLEI Scales and Attitude to Science, Academic Efficacy and Final Year Achievement, Year 9 (2006)

Scale	Attitude to Science		Academic Efficacy		Year 11 Achievement	
	r	*β*	*r*	*β*	*r*	*β*
Student Cohesiveness	0.34**		0.26**	0.10*	0.19**	0.17**
Open Endedness	0.29*	0.11*	0.21**	0.20***	-0.02	
Integration	0.44**	0.27**	0.37**	0.33***	0.21**	0.22***
Rule Clarity	0.35**		0.13**		0.05	
Material Environment	0.47**		0.19**		0.03	
Multiple Correlations (R)	0.61***		0.43***		0.27***	
R^2	0.36		0.19		0.07	

(n = 376) *$p \leq 0.05$ **$p \leq 0.01$ ***$p \leq 0.001$

Table 4.7 shows there is an association between all the SLEI scales and Attitude to Science. Interestingly, the strongest associations are 0.47 and 0.44 with Material Environment and Integration, respectively. The other three simple correlations, Student Cohesiveness (0.34), Open Endedness (0.29) and Rule Clarity (0.35), are all significant. For the multiple correlations the beta values suggest there is some predictability of attitude based on the Open-Endedness and Integration scales. The multiple correlation show a quite strong association between the learning environment overall and Attitude to Science. The R^2 value indicates that 36% of the variance in the students' attitude can be attributed to their perceptions of their learning environment.

The association between Academic Self-Efficacy and the SLEI scales are less strong. In this case the strongest associations, in terms of simple correlations, are with Integration (0.37) (as with attitude) and Student Cohesiveness (0.26). This result suggests that there is a need for teachers to be aware of the interactions between students. Again, the multiple correlation shows a reasonably strong association of R=0.43 between the SLEI scales and Academic Self-Efficacy. Or in other words, 19% of the variance in students' self-efficacy can be attributed to their perception of their learning environment. The beta values suggest that integration of theory with practice has the strongest effect on students' feelings of self efficacy.

The relationship between the learning environment and NCEA achievement is much weaker than the others but this is to be expected when the comparison are of data that are three years apart. The most noteworthy result here is the R^2 value of 0.7. The observation that there is a seven percent variance is significant for teaching and there needs to be awareness amongst teachers that there is a relationship even at this early stage. The mere fact that there is some correlation is surprising considering how much young people change as they move from year 9 to year 11.

Table 4.8
Simple and Multiple Correlations Between the SLEI Scales and Attitude to Science, Academic Efficacy and Final Year Achievement, Year 10 (2007)

Scale	Attitude to Science		Academic Efficacy		Year 11 Achievement	
	r	*β*	*r*	*β*	*r*	*β*
Student Cohesiveness	0.32**		0.09		0.20**	
Open Endedness	0.21**	0.27***	0.08	0.12*	-0.13*	-0.10*
Integration	0.41**		0.18*	0.21***	0.23**	0.18**
Rule Clarity	0.34**	0.12*	0.12*		0.15**	
Material Environment	0.44**	0.12*	0.02		0.06	
Multiple Correlations (R)	0.56***		0.23***		0.28***	
R^2	0.31		0.05		0.08	

(n = 374) **p*≤0.05 ***p*≤0.01 ****p*≤0.001

Again in year 10, as presented in Table 4.8, there is a relatively strong correlation between the SLEI scales and Attitude to Science although the individual *r* values and the overall correlation have decreased slightly. The strongest associations are still with Material Environment (0.44) and Integration (0.41). The results for Student Cohesiveness and Rule Clarity, 0.32 and 0.34, respectively, likewise have gone down slightly, but are still quite significant. The value for Open Endedness (0.21) is much lower and the beta coefficient is again significant.

The multiple correlation shows that there is still a strong association between the SLEI scales and Attitude to Science with 31% of the variance in attitude attributable to the students' perception of their environment.

The association between the SLEI scales and Academic Efficacy in year 10 is quite weak with only Integration (0.18) and Rule Clarity (0.12) having statistically significant *r* values. The multiple correlation gives a R^2 value of just 0.05 suggesting that environment has only a small, but significant, influence on how students in year 10 view their efficacy. This is a surprising result especially in the light of the year to year variation above that shows that both attitude to science and self efficacy are better in year 10 than year 9 and Jinks and Morgan's (1997) work that suggests self-efficacy is learned. The implication then is that students are somehow gaining confidence in their own ability and feeling better about science generally despite being less satisfied with their learning environment.

The Year 11 Achievement column gives some surprising results. Four of the five SLEI scales do show significant simple correlations. Three of these Student Cohesiveness (0.20), Integration (0.23) and Rule Clarity (0.15) have small positive associations but Open Endedness (-0.13) shows a negative correlation suggesting that the greater the perceived open endedness in experimental work the poorer the student performance, in the following years NCEA assessment, will be. The multiple correlation result, R^2=0.08 means that 8% of the variance in NCEA science is attributable to the year 10 learning environment which has implications for teachers and how they think about their year 10 classes.

Table 4.9
Simple and Multiple Correlations Between the SLEI Scales and Attitude to Science, Academic Efficacy and Final Year Achievement, Year 11 (2008)
(n = 530)

Scale	Attitude to Science		Academic Efficacy		Year 11 Achievement	
	r	*β*	*r*	*β*	*r*	*β*
Student Cohesiveness	0.32^{**}	0.11^{*}	0.11^{*}		0.11^{**}	
Open Endedness	0.19^{**}	0.27^{***}	0.17^{**}	0.24^{***}	-0.01	
Integration	0.37^{**}	0.23^{***}	0.23^{**}	0.23^{***}	0.26^{**}	0.27^{***}
Rule Clarity	0.24^{*}		0.09^{*}		0.10^{*}	
Material Environment	0.38^{**}		0.11^{**}		0.04	
Multiple Correlations (R)	0.51^{***}		0.29^{***}		0.36^{***}	
R^2	0.25		0.08		0.13	

$^{*}p \leq 0.05$ $^{**}p \leq 0.01$ $^{***}p \leq 0.001$

Table 4.9 shows that the interrelationship between the SLEI scales and attitude have continued to weaken although again the decrease in both the simple and multiple correlations are small. The overall pattern is similar with Material Environment and Integration showing the strongest associations and Open Endedness the weakest. Interestingly, Rule Clarity now has a stronger association than Open Endedness. The multiple correlations shows that 25% of the variance in attitude is attributable to the students perception of their environment in year 11. Student Cohesiveness, Open Endedness and Integration retain their significance in the multiple correlation.

The results for self-efficacy show that the values have increased slightly, from year 10 with the exception of Rule Clarity. Although, it must be noted, that all the results are still well below the year 9 (2006) levels. This is most interesting because the comparisons presented in Table 4.2 show that the students' academic self efficacy was greatest in year 10. This begs the question; how is it that the year with the poorest associations between the other scales and self efficacy is also the year with the strongest self-efficacy?

There is a similar issue with the NCEA achievement data. The individual regressions are stronger in year 10 with the exception of Integration yet the multiple correlation is strongest in year 11 with an R^2 value of 0.13. This, also, has implication for teachers and teaching with such a strong association between achievement and environment. This strong correlation with year 11 is not surprising as this is the year when the actual assessments are attempted by the students.

4.4.2 Relationship of Attitude and Self Efficacy with Achievement.

Table 4.10 presents the simple and multiple correlations for each year's attitude and self efficacy compared with achievement in the end of year 11 national assessment. It shows quite clearly that there is a strong relationship between self-efficacy and achievement. The associations are constant for the first two years with 5% of the variance in achievement at year 11 being attributable to the students' self efficacy in years 9 and 10. This is interesting given that the self efficacy results for year 10 are much higher than in year 9. The year 11 result of R = 0.30 demonstrates the importance of students self-efficacy when they are facing assessment.

Table 4.10
Simple and Multiple Correlations of Attitude and Efficacy with Achievement in NCEA

Scale	2006 Year 9		2007 Year 10		2008 Year 11	
	r	*β*	*r*	*β*	*r*	*β*
Attitude to Science	0.10^{*}				0.16^{***}	
Self Efficacy	0.22^{***}	0.21^{***}	0.21^{***}	0.21^{***}	0.30^{***}	0.29^{***}
Multiple Correlations (R)	0.22^{***}		0.21^{***}		0.30^{***}	
R^2	0.05		0.05		0.09	

$^{*}p \leq 0.05$ $^{**}p \leq 0.01$ $^{***}p \leq 0.001$

The link between attitude to science and achievement is less clear with an *r* value of 0.1 in year 9. The year 11 result is slightly higher but still just over half the efficacy result of 0.30 at 0.16. There is no significant correlation between the attitude to science the students held in year 10 and their final achievement in the external assessments in year 11.

4.5 COMPARISONS BETWEEN SCHOOLS BY YEAR

Although not asked in the original research questions it was seen as valuable to look at the variations between the schools involved. The differences between each school's data could have an impact on the validity of the whole data. If, for example, students (or their parents) chose their school based on a belief that a particular school was stricter or had more resources this could easily have an impact on the students' perception of Rule Clarity or Material Environment. Similarly, if students went to a particular school because they thought it had an excellent science department we would expect that school to score more highly in attitude and possibly self-efficacy.

The size of Dunedin city (approximately 120,000) means that there is a certain amount of overlap between the schools, with many teachers over a period of a few years moving from one school to another within the city. This natural movement of staff between schools means there must be overlap of ideas and teaching styles but does the school "culture" dictate the learning environment in the individual classrooms? Another possibility is that individuals chose a school because it suited their personality and so their expectations will colour their responses to the surveys. In other words, for example, if a student chooses a single sex boy's school because he expects the greatest rule clarity, does that mean that he would score the rule clarity items more "harshly" than his counterpart who chose the liberal co-educational school for its perceived more relaxed rules structure? The testing for variation between schools then is to allow for assumptions to be made about the homogeneity or otherwise of the cohort under investigation in this study.

Table 4.11

Variation Between Schools (2006)

School / Scale	1 Mean	1 Standard Deviation	2 Mean	2 Standard Deviation	3 Mean	3 Standard Deviation	4 Mean	4 Standard Deviation	5 Mean	5 Standard Deviation	6 Mean	6 Standard Deviation	F value	Post hoc tests
Student Cohesiveness	3.91	0.61	3.73	0.59	3.82	0.68	3.85	0.53	3.67	0.56	4.08	0.89	3.14	6>5* 6>2*
Open Endedness	2.55	0.56	2.45	0.42	2.53	0.53	2.39	0.50	2.47	0.44	2.49	0.43	0.98	
Integration	3.91	0.58	3.67	0.61	3.75	0.68	3.68	0.60	3.55	0.72	3.77	0.64	1.94	
Rule Clarity	3.90	0.58	3.89	0.57	3.72	0.61	3.78	0.51	3.55	0.70	3.89	0.53	3.26	1>5* 2>5* 6>5*
Material Environment	4.28	0.65	3.86	0.75	4.07	0.83	3.81	0.79	4.15	0.81	4.16	0.68	4.01	6>2* 6>3* 6>5***
Attitude to Science	3.61	0.82	3.09	1.05	3.06	1.16	2.94	1.05	3.18	.71	3.45.	0.79	1.96	
Academic Efficacy	3	.66	2.69	.81	3.04	.8	2.86	.82	2.84	.75	2.87	.57	1.02	

(n = 377) *$p \leq 0.05$ **$p \leq 0.01$ ***$p \leq 0.001$

Table 4.12

Variation Between Schools (2007)

School / Scale	1 Mean	1 Standard Deviation	2 Mean	2 Standard Deviation	3 Mean	3 Standard Deviation	4 Mean	4 Standard Deviation	5 Mean	5 Standard Deviation	6 Mean	6 Standard Deviation	F value	Post hoc tests
Student Cohesiveness	3.57	0.55	3.47	0.54	3.51	0.50	3.49	0.50	3.35	0.54	3.70	1.26	2.93	6>2*
Open Endedness	2.73	0.48	2.57	0.59	2.65	0.46	2.53	0.51	2.48	0.54	2.45	0.50	1.96	
Integration	3.54	0.47	3.48	0.46	3.44	0.46	3.57	0.53	3.61	0.62	3.55	0.45	0.59	
Rule Clarity	3.82	0.53	3.75	0.51	3.69	0.48	3.71	0.62	3.73	0.60	3.52	0.48	1.88	
Material Environment	3.69	0.62	3.38	0.58	3.58	0.57	3.46	0.68	3.60	0.65	3.48	0.64	1.49	
Attitude to Science	3.59	.91	3.11	.88	3.13	.79	3.35	.86	3.38	.93	3.23	1.02	2.00	
Academic Efficacy	3.15	.64	2.95	.8	2.83	.72	2.92	.6	2.7	.66	2.93	.67	0.91	

(n = 286) $*p \leq 0.05$ $**p \leq 0.01$ $***p \leq 0.001$

Table 4.13

Variation Between Schools (2008)

School	1		2		3		4		5		6		F value	Post hoc tests
Scale	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation	Mean	Standard Deviation		
Student Cohesiveness	3.85	0.57	3.78	0.63	3.87	0.71	3.86	0.71	3.74	0.63	3.82	0.61	0.40	
Open Endedness	2.69	0.55	2.50	0.49	2.66	0.51	2.63	0.51	2.49	0.52	2.42	0.54	3.01	1>6*
Integration	3.50	0.42	3.47	0.54	3.57	0.62	3.48	0.57	3.60	0.50	3.46	0.46	0.73	
Rule Clarity	3.75	0.50	3.76	0.48	3.53	0.50	3.53	0.50	3.64	0.49	3.48	0.61	3.71	1>6* 2>6*
Material Environment	3.62	0.54	3.40	0.69	3.45	0.76	3.54	0.69	3.60	0.71	3.35	0.67	1.82	
Attitude to Science	3.41	.91	3.14	1.04	3.22	1.04	3.19	.83	3.12	.75	3.08	.88	0.47	
Academic Efficacy	2.73	.81	2.67	.73	3	.9	2.91	.73	2.83	.57	2.94	.75	1.86	

(n = 539) *$p \le 0.05$ **$p \le 0.01$ ***$p \le 0.001$

Table 4.14

Summary of Significant Variations Between School

Scale	2006 (Year9)	2007 (Year10)	2008 (Year 11)
Student Cohesiveness	5<6* 2<6*	2<6*	
Open Endedness			6<1*
Integration			
Rule Clarity	5<1* 5<2* 5<6*		6<1* 6<2*
Material Environment	2<6* 3<6* 5<6***		
Attitude to Science			
Academic Self-Efficacy			

*$p \leq 0.05$ **$p \leq 0.01$ ***$p \leq 0.001$

Tables 4.11 to 4.14 highlight the similarity between the schools. There are no significant variations in the students' attitude to science or their academic self-efficacy. Likewise, Integration results show no variation across the three years. Those variants that do occur in any one year are not repeated in other years. This adds considerable weight to the idea that the schools in Dunedin are essentially homogeneous in terms of science learning environments and students' attitude and self-efficacy. The variation that does occur does not fit any traditional pattern where one would expect the rule clarity to be higher in an all-boys school than a liberal coeducational one, or the expectation that a higher decile school would have the better material environment. The reality is that in some cases the variation is the exact opposite.

The apparent homogeneousness of the schools makes the other data more significant as any variations, trends or patterns shown are less likely to be caused by systemic school differences.

4.6 CHAPTER SUMMARY

The results presented in this chapter show that the SLEI and Attitude to Science and Self-Efficacy scales are suitable instruments for use in New Zealand. The tests for internal consistency and discriminant validity are all within internationally accepted guidelines. These results make it possible to use the data from the surveys to make observations and comparisons of the various subgroups (for example, years and schools) within the study.

The variation in their perception of their learning environment for students does seem to vary with time. The most curious result here seems to be that the middle year is the odd one out. In all cases, the year 10 (2007) results are either the highest or the lowest of the three. There seems to be a "year 10 anomaly" in that the data for year 10 do not appear to sit between the year 9 and year 11 data. This poses some interesting questions that will need to be considered in the next chapter.

The relationship between outcome and environment is also shown with significant simple and multiple correlations for the various SLEI scales with attitude and NCEA performance. The link to academic self-efficacy is less clear especially for the year 10 data set. The strength of correlation with NCEA does show an expected trend with the link becoming stronger as the students get closer to the time when they are actually involved in the assessment process.

The six schools in the study cover a range of decile ratings and types with integrated schools, coeducational schools and single sex schools. Despite this apparent variation the differences in perception of learning environments between the schools are quite small with few significant differences found. There is certainly no school or schools that show a consistent difference from the others in any of the SLEI scales over the three years. The fact that there are no significant variants in attitude and self-efficacy in any of the three years is in itself a strong indicator that the students in Dunedin are a fairly homogeneous group independent of the school they attend. Similarly, the small variation in their perceptions of learning environments suggests that the teachers offer a fairly consistent learning environment regardless of the school they find themselves teaching at.

The answer to all the research questions at the simplest level is yes. This shows the importance of learning environment to student performance, attitude and efficacy. There is and interesting anomaly in the year 10 results with this almost universally out of kilter with the other two years.

CHAPTER 5

INTERPRETATION AND DISCUSSION

5.1 INTRODUCTION

This chapter further examines the results presented in Chapter 4 and provides explanations. There is an attempt to explain any differences between what has been found in this study and previous research in similar areas. There is also a section looking at the implications of each of the research question answers and how they may impact on schools and teachers.

5.2 VALIDATION OF INSTRUMENTS FOR NEW ZEALAND

5.2.1 Validation of the SLEI

The results for the validity and reliability of the SLEI for this group of students are based solely on the first year's data. These results show that the internal consistency of the SLEI is slightly below the expected values when compared with what has been previously reported (Fraser, McRobbie, & Giddings 1993). There are three possible causes for this lower result: the students involved were younger than those in the other study (Fraser, McRobbie, & Giddings, 1993). The students used in this study were all first year secondary while the students used in the original work were upper secondary. Many teachers commented that some students found the language of the SLEI difficult in some items. For example, some items are phrased negatively which means the student must select the “almost never” or “seldom” response to indicate a positive answer. The double negative was confusing for some and may have led to them responding the wrong way or simply picking the neutral “sometimes” response. This would drive the means toward three and therefore decrease the discrimination of the various scales. Secondly, this lack of understanding of some of the statements on the SLEI may well have increased the tendency for the students to “guess” their responses and therefore not reflect their true perceptions. Similarly, the younger students may have found the length of the questionnaire an issue and not answered the final questions as thoughtfully as they should have; again this could affect the overall result.

The final results, however, are still within accepted ranges and so it is safe to conclude that the SLEI is a valid instrument for use in New Zealand.

5.2.2 Validation of the Attitude and Self Efficacy Scales

The internal consistency (Cronbach’s alpha) scores for these two scales are both well above even the conservative value of 0.7 meaning that they are internally consistent. This makes it legitimate to use these two scales and draw conclusions based on their results. The high value for the internal consistency also points to the idea that this is a good measure as poor items in such a survey would affect the alpha scores detrimentally because they would not match the pattern of the others. This means that the Attitude and Self Efficacy scales used are also satisfactory for a New Zealand setting.

5.3 VARIATION BETWEEN YEARS

Logic suggests there are three possible scenarios for what could happen, to a cohort's learning environment perception, as it moves through the first three years of secondary school:

1. The learning environment could improve. This could be a factor of student maturation and an accompanying improvement in relationships with both the teachers' and the learners' peers. This could also be a result of increasing complexity of the work leading to a more stimulating and interesting environment. The tendency for teachers to use more elaborate equipment and develop more challenging experiments as the students get older would also, most likely, improve the way the students feel about their learning environment.
2. The quality of the learning environment could decline. This would happen if, as the students continued, they found themselves getting "sick of school". They may also find the more complex work too difficult and, therefore, lose enjoyment. Similarly, the pressure of external qualifications may mean that they find school more of a chore, and therefore, find that the perceived quality environment suffers. The initial thrill of being in high school may well have gone by the third year.
3. The variation may be random and the quality of the environment may be dependent on only short term factors such as who the teacher is. If this was the case it would be expected that as the various scales were compared year to year there should be some randomisation of the results for the individual scales.

However, none of these are the case, 2007 is the extreme result in all variables of the SLEI and, in all but Integration, year 11 (2008) is the middle result. Similarly, the attitude and self efficacy data show a matching pattern, again with 2007 as the extreme result.

5.3.1 Variation in the Perception of the Actual Learning Environment

The fact that none of these propositions match the actual result means that the system is more complex and there are at least two factors coming into play, at different times, to affect the way students perceive their environment. The simplest explanation is that there is one factor that leads to an improved perception of the environment and another that leads to a worsening perception and that these two factors have a greater or lesser effect at different stages as the learner moves through the three years of the study.

The pattern of the year 10 (2007) result being the outlier is consistent throughout all the SLEI scales but in some cases it has the largest value and in others the smallest, for this reason each of the scales will be looked at separately.

Student Cohesiveness

The results here show a decline between year 9 (2006) and year 10 (2007) with year 11 (2008) in between, although not significantly different from either. This may well be because, in the main, the classes remain essentially unchanged as the learners go through their first two years of secondary school and are then completely rearranged for the third year. The unchanged classes from year 9 to year 10 could lead to the students developing strong links with some members of the class and a separation between the groups within the class, this combined with the contrary nature of an adolescent could make responses to statements in the SLEI like "I get on well with students in this laboratory class" more negative, and thus, a lower score. The change in class composition and the increased motivation of an external assessment in year 11 are possible reasons why the student cohesiveness result is not significantly different from either of the other two years.

Open-Endedness

The year 10 (2007) result is significantly higher than both year 9 (2006) and year 11 (2008). Also year 11 (2008) is significantly higher than year 9 (2006). The low value for year 9 (2006) can be explained most simply as a result of teacher caution with students in their first year of secondary school combined with the young age of the students. These two factors combined mean the teachers would be less inclined to give the students as much leeway in practical sessions on the grounds of safety.

The year 11 (2008) result being lower than the year 10 (2007) result is probably again a factor of the external assessment. This makes teachers feel constrained and limits how far they allow their students to experiment outside the tasks directly relating to the assessment.

Integration

The Integration results show that year 9 (2006) and year 10 (2007) are both significantly greater than year 11 (2008) but not significantly different from each other. This seems at first glance to disagree with the results for Open-Endedness. However this is more a reflection of the amount of practical/experimental work carried out at year 11, where, as previously noted, the major focus is on an external qualification and so the teacher tends to concentrate on the theory and spends less time on practical work. This lack of practical work would mean the students see it as less relevant. The opposite applies at year 10, where the largest amount of experimental work is traditionally done, allowing the students to perceive high degrees of both integration and open-endedness.

Rule Clarity

The explanations for the results in Rule Clarity reflect those for Open-Endedness. Year 9 (2006) has the highest Rule Clarity because this is the first year the students do laboratory based practical/experimental work and so for safety reasons teachers tend to operate with the tightest rule structure at this level. In year 10, the experience of the students makes it easier for a teacher to be more relaxed about the rules in his or her classroom. The lower result for year 11 (2008) is again the need to prepare the students for external assessment in practical work and so a teacher sets up very strict guidelines so the students complete the task according to the assessment schedules.

Material Environment

The highest score for year 9 (2006) is not at all surprising as this is when students first get to work in a laboratory and so they would tend to see all equipment as new and exciting. The significant drop in year 10 (2007) is also a reflection of this as now the students are used to having access to much of the equipment and so are more inclined to notice its shortcomings. The improved result going into year 11 has three possible causes: first, the students will see experimental work as more of a means to an end and so have a more utilitarian view of the quality of the equipment; secondly, they will often get better equipment provided for the assessed practical; and thirdly, in many cases the classes preparing for external assessment are kept smaller.

5.3.2 Variation in Attitude to Science and Self Efficacy

These two show the same pattern of variation across the three years with year 10 (2007) being significantly higher than the other two. The year 9 (2006) and year 11 (2008) results do not show a significant difference.

Attitude to Science

The normal pattern is for the learners' attitude to science to become more negative with time. (Doherty & Dawe, 1985; Kelly, 1986; Osbourne, Simon, & Collins, 2003) The results here suggest that this is not necessarily always true; in fact, there has been a significant improvement from year 9 to year 10. The reasons for this are difficult to fathom but there are a number of possible explanations.

It could be that this is a uniquely New Zealand phenomena or even as localised as Dunedin. The way the curriculum is structured could have an impact on how students feel about science and it may be that the year 10 programme in some way enthuses learners about science. This again may simply relate to the structure where year 9 is the first year of "real science" and so is a little daunting for the students yet by year 10 they have grown in confidence and so have a more positive attitude. The decrease in year 11 fits with the expected pattern and may well again be related to the external assessment.

The result maybe unique to this cohort and there may have been some outside influence that occurred in 2007 that produced the result. For example, there was a major local news story about the discovery of a colossal squid in the southern ocean in 2007. This, or some other event, may have had a short term impact on the cohorts' attitude to science and produced an unusually high result.

A third possibility is that this is a more common situation than is currently believed. It may be that a group's attitude to science while generally trending downward does have times when it is higher. This would need a great deal of further work to establish.

The possibility that this is a case of "better" teaching occurring is discounted. This is simply because, in most cases, the study involved the same teachers. The individual students would have in most cases changed teachers between years 9 and 10 but the same teachers were involved in all three years of the study.

It is also important to note here that the mean values for all three years are above three. On a five-point Likert scale three can be thought of as the neutral grade and so, the means remaining above three indicates that the students have an essentially positive attitude to science.

Academic Self-Efficacy

This follows the same pattern as attitude to science with the results showing that year 10 (2007) is significantly better than both year 9 (2006) and year 11 (2008) and that these two are not significantly different from each other.

The explanation for these results is much more straightforward. The low value at year 9 can be explained as apprehension in the face of something new. Jinks and Morgan (1997) noted that self-efficacy was learned; therefore, it is not surprising that in the first year of learning something new, students' self efficacy is slightly low. The increase into year 10 may well be simply a reflection of the students' increased confidence with age and science experience. The decline going into year 11 is again a factor of lack of confidence as the students face the nerve-racking prospect of external assessment.

The obvious overlap in the results for attitude and self efficacy is also an important observation and needs to be shared with the teaching profession especially given the correlations between these two and performance outcomes.

It is disappointing to note that the means for self efficacy are all below three. As stated above, this indicates that the general result is a slightly negative self efficacy. This is of concern, as research (Jinks & Morgan, 1997) suggests that there is a strong link between efficacy and performance.

5.3.3 Variation in the Preferred Learning Environment

The results for the preferred learning environments show a remarkably similar pattern, with the year 10 result appearing to be independent of the results on either side. This same pattern occurring in the preferred results would seem to suggest that it is a student dependant effect rather than a teacher or school effect. The explanation should therefore focus more on the learners than on systemic issues.

Student Cohesiveness

The results here show year 9 students wanted the greatest level of cohesiveness followed by year 11, with year 10 significantly below both. This may be explained by students in year 9 feeling a greater need to work with their peers in a new and unfamiliar environment. Similarly, year 11 students want the support of their colleagues while facing stressful external assessments but are comfortable with less than in year 9 due to greater maturity. The year 10 students have more maturity than when they were in year 9 and do not yet have the pressure of external qualifications. The anecdotal evidence from teachers also suggests that, although there is a great deal of interaction amongst 14 year olds, it is in year 10 when students are most enthusiastic about their independence and this may be the cause of the lowest preferred student cohesiveness.

Open-Endedness

The results here show that year 10 students wanted significantly more open-endedness than when they were in years 9 or 11. This again may be about their desire for independence and a wish to discover for themselves the mysteries of science. The lower value at year 9 is most likely to be a result of their tentativeness in a laboratory situation. Year 11 will, almost certainly, be a factor of the students wanting to "stick" to the curriculum when they are preparing for external assessment.

Integration

There is no significant variation of preferred integration with time. This implies that the students do see the need for practical work that re-enforces their theory work and that they see this reasonably consistently through their first three years of high school science.

Rule Clarity

The results for Rule Clarity mirror those of Open Endedness with the year 10 result significantly lower than the other two. The reasons the students prefer a lower level of Open Endedness are very likely to be the same as why they would want a high level of Rule Clarity and vice versa. For example, a student in year 9 who found the practical work to have a high perceived risk would want minimal freedom of experimentation and very clear rules for behaviour. The year 10 student is more comfortable in the laboratory environment and so wants more freedom. When that same student gets to year 11, he or she wants very clear guidance while attempting a practical exercise that is assessed as part of the national qualification.

Material Environment

The year 9 value here is very high indicating that the students would like a very high quality physical environment with good quality gear. This may in part be a result of when the survey was done which was the end of the year. The students will have had a broad range of experience with a great deal of different equipment in various states of repair. This would mean that they may well be coming to understand what is available generally but have also seen some better quality or more sophisticated items. This would make them want the 'good stuff" all the time. The next survey being done late in year 10 may mean that by now the students are resigned to the fact that although the school is doing its best there is a limited amount of scope within a budget. Once in year 11 the students are again looking for the best possible opportunity to succeed in the external assessment. However, even at this level, the results for Material Environment have not returned to the levels of year 9.

Summary

In summary, the year 10 students wanted the most open-endedness with no significant difference between years 9 and 11. This may be the result of the year 9's hesitancy when faced with a lower level of direction and the year 11's desire for clear guidance in an external assessment course. The year 10s, on the other hand, have experience and no real assessment concerns and so may well be eager to try out their own ideas. The results for Rule Clarity show that when in year 10 the students want significantly less than in years 9 and 11. The reasons here may well be similar to those for Open-Endedness with year 9 nervousness and year 11 assessment pressures driving the results. Year 10s, conversely, have none of these concerns. The material environment results again show year 10 as the lowest. This is possibly because the year 9 students experience this type of environment for the first time and just want more. The year 11s want the best they can have so they have the best chance in their external assessment, whereas the year 10s have accepted the reality of the situation and understand that the school is doing the best it can. However, as before, the year 10 results do not show the students happy with the environment, the mean and standard deviation suggest that there is room for real improvement.

5.3.4 Comparisons Between Actual and Preferred Learning Environment

There were in total 15 learning environment scales measured. (Five scales in each of three years). Twelve of these 15 did show a difference between the actual learning environment as perceived by the learners and their preferred learning environment. The three that showed a match were: year 10 (2007) Integration, year 11 (2008) both Integration and Student Cohesiveness, apart from these three the amount of difference year to year was relatively consistent.

The students wanted more cohesiveness. This is not surprising as teenagers are the group in society most concerned about their peer relationships. It is exceptionally important for adolescents to feel a sense of belonging and so they strive for a cohesive classroom environment. The most interesting result was that the students were happy with the level of cohesiveness in year 11 in as much as the actual and preferred means were the same at 3.79 which indicates quite high cohesiveness.

There was a desire for more open-ended experimentation in all three years. This is at least in part the result of a natural curiosity among the students. Anecdotal evidence from teachers indicates that questions such as; "What will happen if I mix these two chemicals?" are common from students. There is a clear desire to discover by doing. Most teachers would agree that this is the best, but not always the most practical option.

When they were in year 9 the students wanted less integration. This is almost certainly due to the teacher making his or her first year class more narrowly focussed as the students discover the trials and tribulations of working in a science laboratory. The interesting result is that the students felt that the level of integration was about right in year 10. This may be linked to the reason for their improved attitude mentioned above and may indeed indicate a general satisfaction with the curriculum.

The fact that this group of teenagers wanted less rule clarity will come as no surprise to anyone who has worked with this age group. Adolescence is epitomised by a desire to rebel and the preference for less structure in laboratory sessions is just one facet of this. What is of interest, however, is how high the means are for Rule Clarity. These indicate that students do see the need for a safe controlled environment in laboratories.

Everyone who works in science wants better equipment and more of it, the students in this study are no different. This is shown by the comparison which shows the preferred Material Environment result is significantly above the actual result for all three years.

5.4 CORRELATIONS BETWEEN SLEI, ATTITUDE, SELF EFFICACY AND NCEA RESULT

The simple and multiple correlations of the SLEI scales with attitude to science all show a significant relationship for all three years, although, these are quite weak at year 10. This agrees with the research and really just adds weight to the importance of good teaching, in a good classroom environment (Ebenezer & Zoller, 1993; Hayadyna, Olsen, & Shaughnessy, 1982; Simpson & Oliver, 1990)

The relationships with self efficacy are also strong in year 9 (2006) with a final R^2 value of 0.19, by year 10, however, this has dropped to just 0.05. It does increase again slightly for year 11 to 0.08. The weakest correlation occurring at year 10 is most interesting especially in the light of the high measured value for Academic Self-Efficacy occurring in the same year. This may be just another expression of the "middle year", between starting secondary school and sitting external qualifications, phenomena. Anecdotal evidence from teachers is that year 10 is the toughest year to teach so it may well be that their adolescent rebellion and arrogance simply cause a high Academic Self-Efficacy and a poor correlation with the environment scales.

The most interesting result is that there is a significant ($p \leq 0.01$) association between both Student Cohesiveness and Integration in year 9 (2006) and NCEA results in 2008 (year 11), as well as, a multiple correlation with the SLEI scales (2006) to NCEA (2008) with R at 0.27. It is well known that correlation is not the same as cause and effect; it is, however, noteworthy that 7% of the variance in student achievement in an external qualification two to three years later can be attributed to the year 9 learning environment. Part of this correlation may be explained by the more able students who are generally the better adjusted having a more positive view of their environment and doing well in assessments. However, it is also possible that a good learning environment in science in a student's first year sets him or her up to do well in future science classes. There may well be some long term benefit for students who have a positive first experience of science teaching and learning.

The year 10 (2007) regressions show that all the SLEI scales except Material Environment have a significant relationship to the following years NCEA results. The variance in achievement has also increased slightly to 8%. This again will be, at least, in part due to able students having a positive view of their environment and doing well in NCEA. There is still, however, the other explanation that having a "good" environment in the previous year provides real benefit in terms of improved performance in the external qualification.

The year 11 (2008) results, not surprisingly, show the greatest amount of variance in the NCEA results attributable to the SLEI scales (R^2 = 0.13). What is of interest here is that the greatest simple correlation value (r = 0.26) is for Integration with Student Cohesiveness and Rule Clarity the only other two showing significant results with r values of less than half that for Integration. Keeping in mind that correlation is not the same as cause and effect it still seems to suggest that teachers need to make sure that their class is harmonious with clear rules and most importantly that the experiments/practical tasks are closely related to the theory. This should give the students the best chance to achieve well in NCEA.

5.5 VARIATION BETWEEN SCHOOLS

The most general conclusion about the variation between schools in the study is, that in the main, there is very little at all. Seven scales (SLEI, Attitude and Self Efficacy) were measured over three years in six schools. This means that there were over 300 different comparisons made. Out of this large number only 12 significant differences were found and all but one of these were only at the $p \leq 0.05$ level. There was no variation found in Integration, Attitude or Self Efficacy and these were the three most associated with achievement.

While it has to be realised that not all schools are the same and, when it comes to choosing a school for a particular child, there will almost certainly be schools more suited to his or her personality. It must also be said that the variations are subtle. In other words, the schools in the study may not be equal but they are equivalent. It also needs to be recognised that in some cases the variation shown in this study is in complete contradiction with what is traditionally assumed.

For example, when it comes to which type of school will have the best equipment or the clearest rules.

5.6 CHAPTER SUMMARY

There are four clear conclusions that can be made from the results in Chapter 4 and what is presented above. The learning environment is an important factor in student performance. There is something different about the average year 10 student/class. The relationships between environment, attitude and efficacy are not as simple as they may seem. There is a real need for further long term studies.

The relationship between learning environment and performance is shown in this study. There are correlations between the SLEI scales and outcomes for all three years. The strength of these correlations are variable but are also significant. This makes it relevant to focus on the learning environment to improve performance at all stages of the student's school career. Teachers need to be encouraged to believe that they can make a difference by doing things as simple as having clear rules in the laboratory.

The year 10 results were consistently outside the line between year 9 and year 11. This agrees with the anecdotal evidence of teachers and gives real data to support their intuitive statements. This "middle year anomaly" should be an important consideration for teachers and heads of department as they plan courses of work so that maximum advantage can be taken of, for example, the high self-efficacy.

The relationship between the learning environment and attitude to science was strong but the results for self-efficacy were less clear cut. There is again the odd result at year 10. This combined with the research that suggests self-efficacy is learned (Jinks & Morgan, 1997) has implications again for teacher planning and preparation. The actual delivery and teacher-learner relationship are likewise important variables.

The overwhelming simple conclusion is that it is extremely important for teachers to be aware of their classroom environment, students' attitude and students self efficacy. This would be most likely to happen in a class where the teacher and the student have a positive and affirming relationship so that teachers are able to modify their practice to best suit the known needs of the learners in front of them.

CHAPTER 6

THESIS SUMMARY AND THE FUTURE

6.1 INTRODUCTION

This chapter presents a summary of the thesis. There are sections reviewing the preceding chapters as well as a section describing what needs to be done in the future in light of what has been learned from this study. It has a section providing answers to the research questions. This is followed with sections on the limitations and significance of the work. The main intent is to tie it all together and present an overview without concern for detail. This chapter provides a simple synopsis of what has gone before and allows the reader to quickly come to terms with the study.

6.2 CHAPTER REVIEW

6.2.1 The New Zealand Education System

The New Zealand education system has undergone major change in the past 25 years. There has been a complete systemic change in how schools are administered. The curriculum has changed from one based around a body of knowledge to be taught and learned to one where outcomes are the main focus. As part of this change attitudes and skills have become much more prominent features both in the government documentation and in the philosophy of teaching.

The system of qualification has also changed. Up until 2002, there was a range of norm-referenced qualifications almost wholly based on end of year pen and paper examinations, since then a new standards-based qualification has been used based on a range of assessment types. This has completely changed how science is assessed and also has impacted strongly on teaching and learning particularly the approach to practical work.

6.2.2 Learning Environments Research

There is an enormous amount of work that has been done in the field of learning environments over the past 30 or more years. This has created a wealth of literature and many varied kinds of studies. The overwhelming conclusion from all this work is that the learning environment does impact on student outcomes. The basic implication is that the better the perceived environment the better the students attitude, self-efficacy and educational achievement. There have, however, been very few longitudinal studies done to observe the effects of learning environment over time frames greater than a few months. This presented the opportunity for this study.

There has been a multitude of instruments developed for use in a wide range of settings and student ages. For example, these two; My Class Inventory (Fisher & Fraser, 1981; Fraser, Anderson, & Walberg, 1982; Fraser & O'Brien, 1985) designed for younger learners and the College and University Classroom Environment Inventory (Fraser & Treagust, 1986; Fraser, Treagust & Dennis, 1986) designed for small tertiary classes, are for each end of the student age spectrum.

The SLEI (Fraser, Giddings & McRobbie, 1995; Fraser, McRobbie & Giddings, 1993; Fraser & McRobbie, 1995) used in this study was designed specifically for science laboratory classes. The science teaching laboratory was seen as a unique environment and so required its own instrument. This instrument covers all three of Moos' dimensions (Moos, 1974), with many of the various items related directly to the practical/experimental nature of the science classroom.

The attitude and efficacy scales (Aldridge, Fraser, & Fisher 2003) are short reliable instruments that give good insight into how the students feel about science and their own ability.

6.2.3 Methodology

The basics of the method were quite simple. All schools in Dunedin were approached and asked to take part in a study of learning environments in their science classes. Those that agreed were sent details and asked to have their year 9s complete the surveys in the last few weeks of the 2006 academic year.

The schools involved were then approached again in late 2007 and asked to repeat the surveys with the same cohort of students. Finally, in the middle of 2008 the students, now in year 11, were surveyed for the final time.

The total number of NCEA credits gained in science by each learner was added to the data set once the results were available. This gave a total of around 300 data points for each learner. These were entered into a spread sheet and analysed using SPSS.

6.3 ANSWERS TO RESEARCH QUESTIONS

This section provides answers to the research questions that were proposed in Chapter One

6.3.1 Question One

Is the SLEI a reliable and valid instrument for studying science learning environments in NZ?

Yes. The data show that the SLEI, the Attitude to Science and the Academic Self-Efficacy questionnaires are valid instruments for this setting. The Cronbach's alpha scores and the discriminant validity testing all show results within the accepted range. There are some small discrepancies between the results in this study and those of the original research. (Fraser, McRobbie, & Giddings, 1993). However, it is safe to conclude that the SLEI questionnaire and the short Attitude to Subject and Academic Self-Efficacy scales are valid and useful instruments for New Zealand.

6.3.2 Question Two

a. *Do students' perception of the learning environment change as they progress from years 9 to 11?*

Yes. The issue here is not that it changes but rather how it changes. In all scales, the middle (year 10) was the "odd one out" although this difference was not always at the $p \leq 0.05$ significance level it was always present. This has produced a very odd conundrum in that the perception definitely changes as the student moves through the three years but the change is in both directions with the middle year being different from the other two.

The only conclusion then is that, in New Zealand at least, the second year of secondary school is unique and, although it sits chronologically in the middle, the students' behaviour is not between the first and third years. There has long been anecdotal evidence from teachers that this year (year 10) is problematic in its behaviour and that these students are the most difficult to manage. The results presented above seem to bear this out and add considerable weight to the idea.

b. *Do students' perceptions of preferred learning environment change as they progress from years 9 to 11?*

Yes. Here again the year 10 results stand out as being different from the other two. The conclusion here is similar to conclusions above in that preference definitely does change but there is no straight forward pattern in a single direction. The year 10 anomaly remains. These results do, however, point to the reasons being student centred rather than teacher caused or systemic.

c. *Do students' attitude to science and self efficacy change as they progress from years 9 to 11?*

Yes. The variation here mirrors the SLEI results with year 10 being greater than the other two. This again shows year 10 as the "odd one out" but what is most interesting is that both attitude and self-efficacy are best at this stage. This result is most surprising given the anecdotal evidence mentioned earlier. These two facts together lead to the conclusion that it may well be that students in this age group are growing in self-confidence and self-belief and are therefore "acting out" against what they see as "the system". Regardless of the underlying causes this does present an opportunity for teachers to really get the students involved in their own learning and not see year 10 as unimportant.

These three answers are especially interesting when viewed in the light of some of the past research discussed in Chapter 2. For example, Doppelt (2006) showed that an enhanced environment created as a result of teacher training gave long term advantages for students in both attitude and performance. In another study (Gibson & Chase, 2002), it was shown that a special programme in science can have long term benefits for the students involved. It is not a large extrapolation from this to suggest that good environments early in schooling could lead to enhanced outcomes.

6.3.3 Question Three

Part A

i. Are there associations between students' perceptions of their learning environment at year 9 and their performance in NCEA Level 1?

Yes. Although the simple correlations and beta values suggest this association is small it is noteworthy. Similarly, the multiple correlations suggest that 7% variance in NCEA results are attributable to the year 9 learning environment.

ii. *Are there associations between a students' perception of their learning environment at year 10 and their performance in NCEA Level 1?*

Yes. The simple correlations are now significant for more of the scales (than in year 9) Again, however, these simple correlations are small. The multiple correlations show a slightly greater (8%) variance associated with the year 10 SLEI results than year 9.

iii. *Are there associations between students' perceptions of their learning environment at year 11 and their performance in NCEA Level 1?*

Yes. The individual simple correlations have remained small. The multiple correlations, however, have increased to show that now 13% of the variance in NCEA results are associated with the SLEI scales.

The evidence is clear here in that there is an association between the SLEI and NCEA achievement in all three years although it is strongest in year 11. This means that it is important that teachers work to provide the best possible learning environment from the start of secondary school (or possibly even earlier) if they want their students to have the best opportunity to do well in NCEA.

These results are not unexpected as, far back as the original work by Walberg and Anderson (1968), correlations between environment and outcome were found (See chapter 2). What is new here is that these effects can been seen back over at least three years

The reasons for the association of learning environment with NCEA achievement are not able to be determined from this study, however, some reasonable explanations may include: the students that find the environment the best would be more inclined to focus and therefore achieve in class; the year 9 and 10 classes particularly, are in most schools in the study streamed according to ability; and the more able groups tend to have the better environments and thus would be expected to achieve the best results.

Part B

i. *Are there associations between students' perceptions of their science learning environment at year 9 and their attitude to science and self efficacy at year 9?*

Yes. The simple correlations for all five SLEI scales show significant association with both attitude and self efficacy. There are, likewise, strong multiple correlations with attitude and self efficacy.

ii. *Are there associations between students' perceptions of their science learning environment at year 10 and their attitude to science and self- efficacy at year 10?*

Yes. The simple correlations at this level with attitude remain significant although all are slightly weaker than in year 9. The multiple correlations between the SLEI scales and attitude likewise remain high. The relationship to self efficacy however is much weaker than in year 9

iii. *Are there associations between students' perceptions of their science learning environment at year 11 and their attitude to science and self- efficacy at year 11?*

Yes. The simple correlations results for SLEI scales with attitude continue to decrease but remain significant. The relationship to self efficacy has increased with all the simple correlations results being greater than in year 10 but still less than year 9.

The correlations with attitude to science remain quite strong albeit decreasing over the three years. This was the predicted result and agrees with the research (Jinks & Morgan, 1997). The student's attitude is expected to become more fixed as he or she gets older and more independent. This means that the correlation with external factors would decrease.

The correlations with self-efficacy again show the "middle year anomaly" with the weakest value for year 10. This is most likely the result of the stronger value of efficacy shown here and the previously mentioned special nature of year 10 and year 10 students. They are at an age where independence from adults is becoming paramount and it is possible that this result is a reflection of this.

Part C

i. *Are there associations between students' attitudes to science and self efficacy at year 9 and their performance in NCEA Level 1?*

Yes. There is a small correlation between attitude to science at year 9 and a student's final achievement in year 11. The correlation of self efficacy with achievement is much stronger with close to 5% of his or her final achievement arguably dependant on how well he or she rates his or her own ability in year 9.

ii. *Are there associations between students' attitudes to science and self efficacy at year 10 and their performance in NCEA Level 1?*

Yes. In year 10 the correlation between attitude and achievement has gone but the relatively strong link with self-efficacy remains.

iii. *Are there associations between students' attitudes to science and self efficacy at year 11 and their performance in NCEA Level 1?*

Yes. As would be expected the correlations are strongest in the year of the assessment. Again, however, the correlation with attitude is much weaker than the correlation with self efficacy. This is most important in the light of the research of Jinks and Morgan (1999) showing that self efficacy is learned and not a strongly held belief.

There is clear correlation between self efficacy in all three years and final year achievement but the correlation between attitude and achievement only exists for years 9 and 11 and is about half the strength of the self efficacy result. The consistent correlation results for years 9 and 10 self efficacy is noteworthy in the light of the stronger efficacy in year 10.

Other research (Jinks & Morgan, 1999) has shown a link between self efficacy and achievement but this research shows that the correlation stretches back at least three years. This makes it extremely important that teachers work hard to build the self efficacy of their learners at all times. Teachers are able to influence how a student feels about his or her ability and the effect of this can not be under-estimated. There is a real need for teachers to have access to a simple way to measure their students' self-efficacy accurately and quickly so they can use this information to improve learner outcome. This is something that should be included in teacher training and professional development.

The reasons for the associations, attitude and self efficacy with achievement, are relatively straightforward. It makes logical sense that students who have a positive attitude and feel competent in the subject will do better than their counterparts of equal ability who dislike what they are studying and doubt their ability.

6.4 LIMITATIONS

The most obvious limitation on this study is the small geographic and demographic spread of the schools involved. The small range of decile numbers and all the schools being in Dunedin mean that extrapolation of the results is limited. It can not be assumed that what is shown in this study applies to other countries or even other parts of New Zealand. Similarly, the self selecting of the schools that actually completed the study over three years means that the type of schools involved covers a narrower range. It is, however, worth noting that this also presents an advantage in that the narrow spread makes the sample more homogeneous and therefore more reliable.

The use of the classroom teachers in the different schools to conduct the surveys also limits the study. This means that there could have been a range of approaches to how the surveys were conducted and presented. The attitude and behaviour of the various teachers as the students were given the surveys may well have influenced the way the students answered them. It is, for example, possible that a teacher may have left the surveys to be completed in his or her absence and this is almost certain to have an impact on how the students feel about their environment.

The number of participants is also a factor. The original survey in 2006 involved approximately 1,000 students but by the end of the three years there were only complete sets of data for around a third of this number. This was caused by schools withdrawing but also by students missing one or more of the actual survey days.

6.5 SIGNIFICANCE

6.5.1 Theoretical Significance

This study is significant simply by being one of very few longitudinal studies of classroom environment. It is also one of very few conducted in New Zealand and the first in Dunedin. This means that it has increased the geographical range of learning environment study as well as adding breadth to the type of study in this field.

The most important result in this study is best described as the "year 10 anomaly". This variation in year 10 has not been found anywhere else in the research. This is a factor that warrants a great deal more work to determine if this is isolated either to Dunedin, New Zealand or this particular cohort. Some of the possible reasons behind this anomaly have been discussed above but there is a need for much more investigation.

The associations between the learning environments of previous years and achievement in NCEA are also significant and have not been noted before. This, again, requires further study to determine if this relationship is casual or causal. This could possibly have important implications for how students are introduced to science.

6.5.2 Practical Significance

The implications for teachers in their everyday practice from this study are considerable. Assuming the results can be extrapolated outside the cohort and region involved there are several changes in practice that should be implemented. The difference in year 10 students has been noticed by teachers before but this study has given some real evidence to this widely held teacher belief.

The relationship between learning environment in each of the three years and final achievement in NCEA is important for teachers to know. For example, the fact that there is a demonstrable association between how well the students get on with each other in year 9 and how well they achieve in NCEA means that teachers need to work to harmonise their students from the start of their time at high school.

Similarly, the strong association between self efficacy, and to a lesser extent attitude to science, makes it imperative that teachers view these two attributes as important. Teachers need to be working to improve both these things as part of their everyday activity as much as focussing on the more obvious curriculum issues.

Finally the impact of the three things; learning environment, attitude to science and student self efficacy on achievement mean that teachers should take some time to assess these three things. The vast majority will have some intuition about these variables but will have done no assessment to define the actual position of their learners. It would have significant value to the teaching and learning in their classrooms if they were to dedicate some time to assessing these factors and working on making changes to improve any one or preferably all three.

6.6 THE FUTURE

There is a real need for further longitudinal studies to be carried out to determine the effects of earlier learning (environments) on later outcomes. The first exercise that needs to be done is a study similar to the one presented here to determine if this is a unique case or has more general application. Ideally it should be repeated not only with a different cohort but also in a different locale. The most striking result in this study is the year 10 anomaly. This needs to be revisited in future work to determine how common it is. If it is indeed as common as teachers believe then there needs to be real data to back up their intuition. This could then be used as a tool in developing policy and practice to make schools better places.

The common structure of education in most jurisdictions has students attending a primary school with generalist teachers for around the first six to eight years of education then moving into a secondary school with specialist teachers. This first transition in school type is necessarily accompanied by a major shift in the type of learning environment. This presents an opportunity for great gain or great loss and needs to be managed carefully. Given the results presented above and the impact the first year can have on final the outcome, it would be very helpful to have some data that cover the transition time and this presents a real opening in the current research.

The effect of interventions early in a students' secondary schooling on final outcome is also worthy of study. The results presented in Chapters Four and Five suggest that a good environment in one year can have an impact on performance at least two years later so what would happen to the outcomes in year 11 if there were an intervention to improve the learning environment in say, year 9?

Another area that warrants further study is the similarity between schools. Is this common? Would a different cohort in Dunedin produce a similar level of homogeneity? Would the same commonality be found in a larger geographic spread? Would a similar sized city in another part of New Zealand or another country produce similar results? Many of the factors that determine psychosocial environments come from outside and therefore it is possible that factors such as where you live are more important than where you go to school.

6.7 FINAL COMMENTS

Education in all its guises is by far the most important thing we do for our young people. It is, therefore, vitally important that we do all we can to understand how teaching and learning works. This knowledge will allow us to develop systems that maximise the potential of our learners. The truly remarkable factor, about this strive for understanding, is that the journey will never be finished. We stand on a platform built by our predecessors and it is our task to extend it so that those that follow can have more knowledge and understanding and continue to improve education systems.

This thesis began with a quote about the "modern" classroom written in 1928 and now finishes with two quotes showing that teachers have been aware that the needs of the learner must be paramount for at least two and a half millennia.

> "Do not train a child to learn by force or harshness; but direct them to it by what amuses their minds, so that you may be better able to discover with accuracy the peculiar bent of the genius of each."
>
> "All learning has an emotional base"
>
> Plato (BC 427-BC 347)

REFERENCES

Aldridge, J. M., Fraser, B. J., & Fisher, D. L. (2003, January). *Investigating Student outcomes in an outcome-based, technology-rich learning environment.* Paper presented at the Third Conference on Science, Mathematics and Technology Education, .East London, South Africa

Bell, B. (1985). *Form 1-5 Science review – Effecting change* Paper presented at the SERU seminars at University of Waikato.

Bell, B. (1987). Science curriculum development in New Zealand. *Research in Science Education 17*, 244-252.

Bell B., Jones, A., & Carr, M. (1995). The development of the recent national New Zealand science curriculum. *Studies in Science Education, 26*, 73-105.

Brown, S. (1976). *Attitude goals in secondary school science*. Stirling: University of Stirling.

Byrne, D. B., Hattie, J. A., & Fraser, B. J. (1986). Student perceptions of preferred classroom learning environments. *Journal of Educational Research, 8,* 10-18.

Carter, W., Sottile, J. M., & Carter, J. (2001). *Science achievement and self efficacy among middle school age children as related to student development*. Paper presented at the Eastern Educational Research Association, Hilton Head, South Carolina..

Créton, H., Hermans, J., & Wubbels, T. (1990). improving interpersonal teacher behaviour in the classrooms: A systems communication perspective. *South Pacific Journal of Education, 18*, 85-94.

Dainton, F. S. (1968). *Inquiry into the flow of candidates in science and technology into higher education (The Dainton Report)*. London: Council for Scientific Policy, HMSO.

Den Brok, P., Telli, S., Piyango, N. M., Cakiroglo, J., Taconis, R., & Terkkeya, C. (2005, January). *What type of learning environment is my classroom? Typologies of Turkish students' perceptions of their secondary biology classrooms.* Paper presented at the Fifth International Conference on Science Mathematics and Technology Education, Udon Thani, Thailand.

Department of Education (1967). *Science: syllabus and explanatory notes. Forms III & IV*.. NZ Curriculum Development Unit, Wellington, New Zealand

Department of Education (1978). *Science Forms 1-4 Draft Syllabus and Guide*. NZ Curriculum Development Unit, Wellington, New Zealand

Doherty, J., & Dawe, J. (1985). The relationship between development maturity and attitude to school science: an exploratory study. *Educational Studies, 11*(2), 93-107.

Doppelt, Y. (2006). Teachers' and pupils' perceptions of science–technology learning environments. *Learning Environments Research, 9*(2), 163-178.

Dorman, J. (2001). Associations between classroom environment and academic efficacy. *Learning Environments Research, 4*(3), 243-257.

Dorman, J. P., Fraser, B. J., & McRobbie, G. C. (1997). relationship between school-level and classroom-level environments on secondary schools. *Journal of Educational Administration, 35*, 74-91.

Eadie, G. (2002). Why the NCEA has failed. Retrieved from http://www.educationforum.org.nz/

Ebenezer, J. V., & Zoller, U. (1993). Grade 10 students' perception of and attitude toward science teaching and school science. *Journal of Research in Science Teaching, 30*, 175-186.

Evertson, C. M., Anderson, C. W., Anderson, L. M., & Brophy, J. E. (1980). relationships between classroom behaviors and student outcomes in junior high mathematics and English classes. *American Educational Research Journal, 17*(1), 43-60.

Fisher, D., Henderson, D., & Fraser, B. J. (1995). Interpersonal behaviour in senior high school biology classes. *Research in Science Education, 25*(2), 125-133.

Fisher, D. L., & Fraser, B. J. (1981). Validity and use of the My Class Inventory. *Science Education, 65*(2), 145-148.

Fisher, D. L., Rickards, T., & Fraser, B. J. (1996). Assessing teacher-student interpersonal relationships in science classes. *Australian Science Teachers Journal, 42*(3), 28-33.

Fraser, B. J. (1981). *Test of science related attitudes* Victoria Australia: Melbourne: Australian Council of Educational Research.

Fraser, B. J. (1990). *Individualised Classroom Environments Questionnaire*. Melbourne: Australian Council for Educational Research.

Fraser, B. J. (1998). Science Learning environments: Assessments, effects and determinants. . In B.J. Fraser & K. J. Tobin (Eds.), *International Handbook of Science Education*. Dordrecht, The Netherlands: Kluwer Academic Publishers.

Fraser, B. J. (1998b). Classroom environment instruments: Development, validity and applications. *Learning Environments Research: An International Journal, 1*, 7 - 33.

Fraser, B. J. (2001). Twenty thousand hours: Editor's Introduction. *Learning Environments Research: An International Journal, 4*, 1-5.

Fraser, B. J., Anderson, G. J., & Walberg, H. J. (1982). *Assessment of learning environments Manual for Learning Environment Inventory (LEI), and My Class Inventory (MCI), (Third Version)*. Perth, Australia: Western Australian Institute of Technology.

Fraser, B. J., & Fisher, D. L. (1986). Using short forms of classroom climate instruments to assess and improve classroom psychosocial environment. *Journal of Research in Science Teaching, 23*(5), 387-413.

Fraser, B. J., Giddings, G. J., & McRobbie, C. J. (1992). Assessing the climate of science laboratory classes. *What Research Says, No 8*. Perth, Australia: Curtin University of Technology.

Fraser, B. J., Giddings, G. J., & McRobbie, C. J. (1995). Evolution and validation of a personal form of an instrument for assessing science lab classroom environments. *Journal of Research in Science Teaching, 32*, 399-422.

Fraser, B. J., Giddings, G. J., & McRobbie, C. J. (1995). Evolution and validation of a personal form of an instrument for assessing science laboratory classroom environments. *Journal of Research in Science teaching, 32*(4), 399-422.

Fraser, B. J., & McRobbie, C. J. (1995). Science laboratory classroom environments at schools and universities: A cross-national study. *Educational Research and Evaluation: An International Journal on Theory and Practice, 1*(4), 289 - 317.

Fraser, B. J., McRobbie, C. J., & Giddings, G. J. (1993). Development and cross-national validation of a laboratory classroom environment instrument for senior high school science. *Science Education, 77*(1), 1-24.

Fraser, B. J., McRobbie, C. J., & Giddings, G. J. (1993). Development and cross-national validation of a laboratory classroom environment instrument for senior high school science. *Science Education, 77*(1), 1-24.

Fraser, B. J., & O'Brien, P. (1985). Student and teacher perceptions of the environment of elementary school classrooms. *Elementary School Journal, 85*, 567-580.

Fraser, B. J., & Treagust, D. F. (1986). Validity and use of an instrument for assessing classroom psychosocial environment in higher education. *Higher Education 15,* , 37-57.

Freedman, M. P. (1997). Relationship among laboratory instruction, attitude toward science, and achievement in science knowledge. *Journal of Research in Science teaching 34* (4), 343-357.

Gibson, H., L., & Chase, C. (2002). Longitudinal impact of an inquiry-based science program on middle school students' attitudes toward science. *Science Education, 86*(5), 693-705.

Giddings, G., & Hofstein, A. (1980). Trends in the assessment of laboratory performance in high school science instruction. *American Science Teachers Journal, 26*(3), 57-64.

Hackett, G., & Betz, N., E. (1989). An exploration of mathematics self-efficacy/mathematics performance correspondence. *Journal of Research in Mathematics Education, 20*(3), 261-273.

Haladyna T., Olsen, R., & Shaughnessy, J. (1982). Relations of student, teacher and learning environment variables to attitudes to science. *Science Education, 66*, 671-687.

Hassan, G. (2008). Attitudes toward science among Australian tertiary and secondary school students: *Research in Science and Technological Education 26*(2), 129 - 147.

Hegarty-Hazel, E. (1990). *Life in science laboratory classrooms at tertiary level.* London: Routledge

Henderson, D., Fisher, D., & Fraser, B. (2000). Interpersonal behaviour, laboratory learning environments, and student outcomes in senior biology classes. *Journal of Research in Science Teaching 37*(1), 26 - 43.

Hipkins, R. (2007). *Taking the pulse of NCEA*. Wellington: National Council for Educational Research.

Jinks, J. L., & Morgan, V. (1999). Children's perceived academic self-efficacy: An inventory scale. *Clearing House, 72*(224-230).

Jinks., J., & Morgan, V. L. (1997). Students' sense of academic efficacy and achievement in science: A useful new direction for research regarding scientific literacy? *Journal, 1*(2). Retrieved from http://ejse.southwestern.edu/original%20site/manuscripts/v1n2/articles/art01_jinks/jinks.html#Top

Joo, Y.-J., Bong, M., & Choi, H.-J. (2000). Self-efficacy for self-regulated learning, academic self-efficacy, and internet self-efficacy in web-based instruction. *Educational Technology Research and Development, 48*(2), 5-17.

Kelly, A. (1986). The development of girls' and boys' attitudes to science: A longitudinal study. *European Journal of Science Education, 8*(4), 399-412.

Liu, M., Hsieh, P. P. H., Cho, Y., & Schallert, D., L. (2006). Middle school students self-efficacy, attitudes and achievement in a computer-enhanced problem-based learning environment. *Journal of Interactive Learning Research, 17*(3), 225-242.

Ministry of Education. (1993). *Science in the New Zealand Curriculum*. Wellington, New Zealand

Ministry of Education. (2007) *The New Zealand Curriculum.* Learning Media, Wellington, NZ

Moos, R. H. (1974). *The social climate scales, An overview.* Palo Alto, CA: Consulting Psychologist Press.

Morrell, P. D., & Lederman, N. G. (1998). Students attitude toward school and classroom science: Are they independent phenomena? *School Science and Mathematics* (Feb 1998).

Murray, H. A. (1938). *Explorations of personality*. New York: Oxford University Press.

NZQA. (2009). NZQA Website Retrieved 25/05/09, 2009, from http://www.nzqa.govt.nz

Ormerod, M. B., & Duckworth, D. (1975). *Pupils attitude to science: A Review of the Research.* Slough: NFER.

Osbourne, J., Simon, S., & Collins, S. (2003). Attitudes towards science: a review of the literature and its implications. *International Journal of Science Education, 25*(9), 1049-1079.

Owens, L. C., & Straton, R. G. (1980). The development of a cooperative, competitive, and individualised learning preference scale for students. *British Journal of Education Psychology, 50*, 147-161.

Pace, C. R., & Stern, G. G. (1958). An approach to the measurement of psychological characteristics of college environments *Journal of Educational Psychology, 49*, 269-277.

Pickering, M. (1980). Are lab courses a waste of time *The Chronicle of Higher Education, 19*, 44-50.

Potter, J., & Wetherall, M. (1987). *Discourse and social psychology: Beyond attitudes and behaviour* London: Sage.

Quek, C. L., Wong, A. F. L., & Fraser, B. J. (2005). Student perceptions of chemistry laboratory learning environments, student-teacher interactions and attitudes in secondary gifted education classes in Singapore. *Research in Science Education, 35*, 299-321.

Radio, N. Z. (2005). Govt accused of stifling NCEA debate.

Rentoul, A. J., & Fraser, B. J. J. (1979). Conceptualisation of Enquiry-Based or Open Classroom Learning Environments. J*ournal of Curriculum Studies, 11*, 233-245.

Renwick, W. L. (1986). *Moving targets, Six essays on educational policy*. Wellington NZ NZCER.

Sachdeva, S. (2008, September 15). PPTA proposes 'Downsize me: NCEA Special,' Auckland Uni unconcerned. *Salient*, from http://www.salient.org.nz/news/ppta-proposes-%E2%80%98downsize-me-ncea-special%E2%80%99auckland-uni-unconcerned

Shearer, R. (2000). The NZ curriculum framework: A new paradigm in curriculum policy development. *Auckland College of Education Papers* (7).

Simpson, R. D., & Oliver, J. S. (1990). A summary of the major influences on attitude towards and achievement in science among adolescent students. *Science Education, 74*, 1-18.

Stern, G. G., Stein, M. I., & Bloom, B. S. (1956). *Methods in personality assessment*. Glencoe, IL: Free Press.

Strong, T. B. (1928). Present trend of education. In I. Davey (Ed.), *Fifty years of national education in New Zealand 1878-1928* (pp. 140-158). Auckland New Zealand: Whitcombe and Tombs.

Taylor, P. C., Dawson, V., & Fraser, B. J. (1995). *Classroom learning environments under transformation: A constructivist's perspective*. Paper presented at the annual meeting of the American Educational Research Association.

Taylor, P. C., Fraser, B. J., & Fisher, D. C. (1997). Monitoring constructivist classroom learning environments. *International Journal of Educational Research,. 27,*, 293-302.

Thomas, G., Anderson, D., & Nashon, S. (2008). Development of an instrument designed to investigate elements of science students' metacognition, self-efficacy and learning processes: The SEMLI-S. *International Journal of Science Education, 30*(13), 1701 - 1724.

Walberg, H. (1969, February). *A model for research on instruction.* Paper presented at the annual meeting of the American Educational Research Association, Los Angeles.

Walberg, H. J., & Anderson, G. J. (1968). Classroom climate and individual learning. *Journal of Educational Psychology, 59*, 414-419.

Wong, A. F. L., & Fraser, B. J. (1995). Cross-validation in Singapore of the Science Learning Environment Inventory. *Psychological Reports, 76*, 907-911.

Wubbels, T., Brekelmans, M., & Hooymayers, H. (1991). *Interpersonal teacher behaviour in the classroom.* London: Pergamon.

Wubbels, T., Brekelmans, M., & Hooymayers, H. (1991). Interpersonal teacher behaviour in the classroom. . In B. J. Fraser & H. J. Walberg (Eds.), *Educational environments: Evaluation, antecedents, and consequences.* London: Pergamon,.

Wubbels, T., & Levy, J. (Eds.). (1993). *Do you know what you look like: Interpersonal relationships in education*. London: Falmer Press.

Zvoch, K., & Stevens, J. J. (2006). Longitudinal effects of school context and practice on middle school mathematics Achievement. *Journal of Educational Research, 99*(6), 347.

APPENDICES

1. Letter to Principals and Heads Of Department
2. Survey Letter
3. Notes for Students and Teachers
4. Instructions to Supervising Teachers
5. Consent Form
6. Consent Form for Year 11
7. SLEI (Actual)
8. Attitude and Efficacy Survey
9. SLEI (Preferred)

Appendix 1

Letter for Principals and HODs

I am asking for permission to carry out a research study of the classroom climates of your year 9 Science classes. This is the first stage in a longitudinal study that will involve repeating the survey at years 10 and 11. I will also need to gather NCEA Science data for the same group. This study is part of my research project for my Doctor of Science Education degree.

This study will be carried out in Term 4, 2006 (repeated in 2007 and 2008) by way of a questionnaire to all students in year 9 Science. This will consist of a range of questions on how the view their classrooms. I will survey them again a week later to determine their preferred classroom climate. Their teachers will also be surveyed. Participation in the questionnaire is voluntary and students or schools may withdraw at anytime over the three years.

The information gathered from students will be kept and used to produce a set of data for analysis. No individual or school will be identified but I will need names to collate from year to year.

All data and subsequent interpretations pertaining to this study will be used to present a Thesis to the Curtin University (Perth WA), with copies available for the schools involved. All students will be given access to the final report and can view the data gathered. Any students or teacher interviewed will be given the opportunity to verify transcripts of the interviews.

The school will benefit from this research by gaining information on learning environments and their impact on student performance. I ask that permission be granted to allow me to carry out this research.

I will contact the Head of Science to confirm your acceptance to participate in this survey and arrange details in the next week.

Yours sincerely

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Appendix 2

Dear xxxxx

Thanks for agreeing to take part. Here are copies of the surveys, please have your Yxx teachers survey their classes and complete a questionnaire themselves.

Everyone should complete the “*Actual*” and the *Attitude and Efficacy* surveys (stapled up the consent form) first then the *“Preferred”* survey (single double-sided sheet) a week later.

When they are all completed please contact me by email or phone and I will come and pick them up.

Any questions contact me.

Thanks again

Murray Thompson
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Appendix 3

NOTES for TEACHERS and STUDENTS

The questionnaires are a part of a research project I am carrying out for my Doctor in Science Education degree. The questionnaires have been designed to gather data on your classroom climate.

I would like you to fill in the questionnaires. (Actual this week and preferred next week). I will be repeating this next year and again in 2008. I will use the data along with your NCEA results to study the effect of learning environment on student performance.

The information gathered will be kept confidential and students and teachers can choose not to take part in the study. I need names on the questionnaires so I can collate the data from year to year but no individual or school will be identifiable in the final report.

Any data gathered will be valuable for the school to know about the learning environments in Science. The thesis will be handed in to Curtin University in Perth WA and I will make copies available to the schools involved.

Personal Bio
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Appendix 4

INSTRUCTIONS TO SUPERVISING TEACHERS

- Thank you for taking the time to take part
- Ask the students to complete a consent form
- Please hand out the *Science Laboratory Environments Inventory*
    - Actual form first week preferred form second week
- The *Attitude and Efficacy Questionnaire* attached to the *Actual Form* should be completed at the same time.
- Please emphasise that this is not a test but a chance to study what their classroom is like
- Please complete a copy yourself answering as you think the average student would.

Appendix 5

<u>Classroom Environment Study Conducted by Murray Thompson</u>
Ethics Approval Number SMEC20070004

Consent Form

I, ________________________ give my consent for the data collected in these surveys to be used as part of Murray Thompson's research as outlined in the notes.

I understand that:

- I will not be identified or identifiable
- I can withdraw my consent at any time
- This is part of a 3 year study
- My NCEA science results will also be collected
- The results will become part of a thesis

Signed________________________ Date____/____/____

Name_________________________*(please print)*

Appendix 6

Classroom Environment Study Conducted by Murray Thompson

Ethics Approval Number SMEC20070004

Consent Form

I, ________________________ give my consent for the data collected in these surveys to be used as part of Murray Thompson's research as outlined in the notes.

I understand that:

- I will not be identified or identifiable
- I can withdraw my consent at any time
- This is part of a 3 year study
- My NCEA science results will also be collected
- The results will become part of a thesis

Signed________________________ Date____/____/____

Name________________________*(please print)*

Date of Birth____/____/____

The questionnaires are a part of a research project I am carrying out for my Doctorate. The questionnaires have been designed to gather data on your classroom climate.

I would like you to fill in the questionnaires. (Actual this week and preferred next week). I will use the data along with your NCEA results to study the effect of learning environment on student performance.

The information gathered will be kept confidential and students and teachers can choose not to take part in the study. I need names on the questionnaires so I can collate the data from year to year but no individual or school will be identifiable in the final report.

The thesis will be handed in to Curtin University in Perth WA and I will make copies available to the schools involved.

Murray Thompson

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Appendix 7

SCIENCE LABORATORY ENVIRONMENT INVENTORY (SLEI)

ACTUAL FORM

Directions for Students

This questionnaire contains statements about practices which could take place in this laboratory class. You will be asked **how often** each practice **actually takes place.**

There are no 'right' or 'wrong' answers. Your opinion is what is wanted.

Think about how well each statement describes what this class is like for you. Draw a circle around

1	if the practice takes place	**Almost Never**
2	if the practice takes place	**Seldom**
3	if the practice takes place	**Sometimes**
4	if the practice takes place	**Often**
5	if the practice takes place	**Almost Always**

Be sure to give an answer for all questions. If you change your mind about an answer, just cross it out and circle another.

Some statements in this questionnaire are fairly similar to other statements. Don't worry about this. Simply give your opinion about all statements.

Practice Example Suppose that you were given the statement: "I choose my partners for laboratory experiments." You would need to decide whether you think you **actually** choose your partners *'Almost Never', 'Seldom', 'Sometimes', 'Often' or 'Almost Always'*. For example, if you selected *'Very Often'*, you would circle the number 5 on your questionnaire.

Your Name:________________________

Teacher's Name:

School:

	*Remember that you are describing your **actual** classroom.*	Almost Never	Seldom	Sometimes	Often	Very Often	**For Teacher's Use**
1	I get on well with students in this laboratory class.	1	2	3	4	5	
2	There is opportunity for me to pursue my own science interests in this laboratory class	1	2	3	4	5	
3	What I do in our regular science class is unrelated to my laboratory work.	1	2	3	4	5	**R____**
4	My laboratory class has clear rules to guide my activities.	1	2	3	4	5	
5	I find that the laboratory is crowded when I am doing experiments.	1	2	3	4	5	**R____**
6	I have little chance to get to know other students in this laboratory class.	1	2	3	4	5	**R____**
7	In this laboratory class, I am required to design my own experiments to solve a given problem.	1	2	3	4	5	
8	The laboratory work is unrelated to the topics that I am studying in my science class.	1	2	3	4	5	**R____**
9	My laboratory class is rather informal and few rules are imposed on me.	1	2	3	4	5	**R____**
10	The equipment and materials that I need for laboratory activities are readily available.	1	2	3	4	5	
11	Members of this laboratory class help me.	1	2	3	4	5	
12	In my laboratory sessions, other students collect different data than I do for the same problem.	1	2	3	4	5	
13	My regular science class work is integrated with laboratory activities.	1	2	3	4	5	
14	I am required to follow certain rules in the laboratory.	1	2	3	4	5	
15	I am ashamed of the appearance of this laboratory	1	2	3	4	5	**R____**
16	I get to know students in this laboratory well.	1	2	3	4	5	
17	I am allowed to go beyond the regular laboratory exercise and do some experimenting of my own	1	2	3	4	5	
18	I use theory from my regular science class sessions during laboratory activities.	1	2	3	4	5	
19	There is a recognized way for me to do things safely in this laboratory.	1	2	3	4	5	
20	The laboratory equipment which I use is in poor working order.	1	2	3	4	5	**R____**
21	I am able to depend on the other students for help during laboratory classes.	1	2	3	4	5	
22	In my laboratory sessions, I do different experiments than some of the other students.	1	2	3	4	5	
23	The topics covered in regular science work are quite different from topics with which I deal in laboratory sessions.	1	2	3	4	5	**R____**
24	There are few fixed rules for me to follow in laboratory sessions.	1	2	3	4	5	**R____**
25	I find that the laboratory is hot and stuffy.	1	2	3	4	5	**R____**
26	It takes me a long time to get to know everybody by his/her first name in this laboratory class	1	2	3	4	5	**R____**
27	In my laboratory session, the teacher decides the best way for me to carry out the laboratory experiments.	1	2	3	4	5	**R____**
28	What I do in laboratory sessions helps me to understand the theory covered in regular science classes.	1	2	3	4	5	
29	The teacher outlines safety precautions to me before my laboratory sessions commence.	1	2	3	4	5	
30	The laboratory is an attractive place for me to work in.	1	2	3	4	5	
31	I work cooperatively in laboratory sessions.	1	2	3	4	5	
32	I decide the best way to proceed during laboratory experiments.	1	2	3	4	5	
33	My laboratory work and regular science class work are unrelated.	1	2	3	4	5	**R____**
34	My laboratory class is run under clearer rules than my other classes.	1	2	3	4	5	
35	My laboratory has enough room for individual or group work.	1	2	3	4	5	

Appendix 8

Attitude and Efficacy Questionnaire

	Attitude to Subject	Almost Never	Seldom	Some times	Often	Almost Always
1.	I look forward to lessons in this subject.	1	2	3	4	5
2.	Lessons in this subject are fun.	1	2	3	4	5
3.	I dislike lessons in this subject.	1	2	3	4	5
4.	Lessons in this subject bore me.	1	2	3	4	5
5.	This subject is one of the most interesting school subjects.	1	2	3	4	5
6.	I enjoy lessons in this subject.	1	2	3	4	5
7.	Lessons in this subject are a waste of time.	1	2	3	4	5
8.	These lessons make me interested in this subject.	1	2	3	4	5
	Attitude to Computer Use	Almost Never	Seldom	Some times	Often	Almost Always
9.	I'm good with computers.	1	2	3	4	5
10.	I like working with computers.	1	2	3	4	5
11.	Working with computers makes me ne					5
12.	I am comfortable trying new software					5
13.	Working with computers is stimulating					5
14.	I get a sinking feeling when I think of u					5
15.	I do as little work as possible using a computer.	1	2	3	4	5
16.	I feel comfortable using a computer.	1	2	3	4	5
	Academic Efficacy	Almost Never	Seldom	Some times	Often	Almost Always
17.	I find it easy to get good grades in this subject.	1	2	3	4	5
18.	I am good at this subject.	1	2	3	4	5
19.	My friends ask me for help in this subject.	1	2	3	4	5
20.	I find this subject easy.	1	2	3	4	5
21.	I outdo most of my classmates in this subject.	1	2	3	4	5
22.	I have to work hard to pass this subject.	1	2	3	4	5
23.	I am an intelligent student.	1	2	3	4	5
24.	I help my friends with their homework in this subject.	1	2	3	4	5

This section was completed by the students but not used in the final analysis

Appendix 9

SCIENCE LABORATORY ENVIRONMENT INVENTORY (SLEI)

PREFERRED FORM

Directions for Students

This questionnaire contains statements about practices which could take place in this laboratory class. You will be asked **how often** you would **prefer** each practice to take place**.**

There are no 'right' or 'wrong' answers. Your opinion is what is wanted.

Think about how well each statement describes what your preferred laboratory class is like. Draw a circle around

1	if the practice takes place	**Almost Never**
2	if the practice takes place	**Seldom**
3	if the practice takes place	**Sometimes**
4	if the practice takes place	**Often**
5	if the practice takes place	**Almost Always**

Be sure to give an answer for all questions. If you change your mind about an answer, just cross it out and circle another.

Some statements in this questionnaire are fairly similar to other statements. Don't worry about this. Simply give your opinion about all statements.

Practice Example Suppose that you were given the statement: "I would choose my partners for laboratory experiments." You would need to decide whether you thought that you would **prefer** to choose your partners *'Almost Never', 'Seldom', 'Sometimes', 'Often' or 'Almost Always'*. For example, if you selected *'Very Often'*, you would circle the number 5 on your questionnaire.

Your Name:________________________

Teacher's Name:

School:

Grade:

	*Remember that you are describing your **preferred** classroom.*	Almost	Seldom	Sometime	Often	Very	**For Teacher's Use**
1.	I would get on well with students in this laboratory class.	1	2	3	4	5	
2.	There would be opportunity for me to pursue my own science interests in this laboratory class.	1	2	3	4	5	
3.	What I do in our regular science class would be unrelated to my laboratory work.	1	2	3	4	5	**R___**
4.	My laboratory class would have clear rules to guide my activities.	1	2	3	4	5	
5.	I would find that the laboratory is crowded when I am doing experiments.	1	2	3	4	5	**R___**
6.	I would have little chance to get to know other students in this laboratory class.	1	2	3	4	5	**R___**
7.	In this laboratory class, I would be required to design my own experiments to solve a given problem.	1	2	3	4	5	
8.	The laboratory work would be unrelated to the topics that I am studying in my science class.	1	2	3	4	5	**R___**
9.	My laboratory class would be rather informal and few rules are imposed on me.	1	2	3	4	5	**R___**
10.	The equipment and materials that I need for laboratory activities would be readily available.	1	2	3	4	5	
11.	Members of this laboratory class would help me.	1	2	3	4	5	
12.	In my laboratory sessions, other students would collect different data than I would for the same problem.	1	2	3	4	5	
13.	My regular science class work would be integrated with laboratory activities.	1	2	3	4	5	
14.	I would be required to follow certain rules in the laboratory.	1	2	3	4	5	
15.	I would be ashamed of the appearance of this laboratory	1	2	3	4	5	**R___**
16.	I would get to know students in this laboratory well.	1	2	3	4	5	
17.	I would be allowed to go beyond the regular laboratory exercise and do some experimenting of my own	1	2	3	4	5	
18.	I would use theory from my regular science class sessions during laboratory activities.	1	2	3	4	5	
19.	There would be a recognized way for me to do things safely in this laboratory.	1	2	3	4	5	
20.	The laboratory equipment which I use would be in poor working order.	1	2	3	4	5	**R___**
21.	I would be able to depend on the other students for help during laboratory classes.	1	2	3	4	5	
22.	In my laboratory sessions, I would do different experiments than some of the other students.	1	2	3	4	5	
23.	The topics covered in regular science work would be quite different from topics with which I deal in laboratory sessions.	1	2	3	4	5	**R___**
24.	There would be few fixed rules for me to follow in laboratory sessions.	1	2	3	4	5	**R___**
25.	I would find that the laboratory is hot and stuffy.	1	2	3	4	5	**R___**
26.	It would take me a long time to get to know everybody by his/her first name in this laboratory class	1	2	3	4	5	**R___**
27.	In my laboratory session, the teacher would decide the best way for me to carry out the laboratory experiments.	1	2	3	4	5	**R___**
28.	What I do in laboratory sessions would help me to understand the theory covered in regular science classes.	1	2	3	4	5	
29.	The teacher would outline safety precautions to me before my laboratory sessions commence.	1	2	3	4	5	
30.	The laboratory would be an attractive place for me to work in.	1	2	3	4	5	
31.	I would work cooperatively in laboratory sessions.	1	2	3	4	5	
32.	I would decide the best way to proceed during laboratory experiments.	1	2	3	4	5	
33.	My laboratory work and regular science class work would be unrelated.	1	2	3	4	5	**R___**
34.	My laboratory class would be run under clearer rules than my other classes.	1	2	3	4	5	
35.	My laboratory would have enough room for individual or group work.	1	2	3	4	5	