Science and Mathematics Education Centre

A Comparison of the Preferred Learning Styles of Year 5, Year 7 and Year 9 Students in Science Using the Science Laboratory Environment Inventory (SLEI) and a Cooperative Learning Unit of Work Based on Multiple Intelligences

Linda Gay Pfeiffer

This thesis is presented for the Degree of
Doctor of Science Education
of
Curtin University

December 2011

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: ....

Date: 1 December 2011

ABSTRACT

Research has shown that students are increasingly disinterested in science (Gallagher, 1996). One only has to walk through the corridors of almost any secondary school to realise that students find science boring, irrelevant, not applicable and abstract. There is little doubt that if the science learning environment was made interesting and relevant to students, there could be a shift from the growing "unpopularity" of science. This study compared the preferred learning styles of 59 Year 5, 113 Year 7 and 113 Year 9 students in science using the *Science Laboratory Environment Inventory* (SLEI) and a Grid of a cooperative learning unit of work on Natural Events based on Multiple Intelligences. The study focussed particularly on students' perceptions of science, improving the classroom learning environment and whether gender played a role in preferred learning style.

From this investigation, formulating classroom learning environments where student-cohesiveness is high and learning activities are varied is paramount for improving student (and hence future generations) interest in science. Teachers of Year 5, Year 7 and Year 9 science students need to think "outside the square" and embrace a style of teaching that provides firm rules as well as a friendly environment. Older students should be exposed to the type of classroom that they experienced in lower primary school – clear and simple rules, fun, exciting, relevant, and memorable. It's time for teachers to "set young minds on fire".

ACKNOWLEDGEMENTS

I wish to express my sincere gratitude to my supervisors, who have assisted me with bringing this thesis to its completion especially Professor Darrell Fisher for his advice and motivation, Dr. Grady Venville for inspiring me to study this course in the beginning, and to Dr. Tony Rickards for keeping me on task when I was considering giving up.

I would like to thank my friend James Eddy and the principals, teachers and students involved in this study for giving me their time. To the many teachers who have inspired me throughout my education including my Year 4 teacher Mr. Johnson who created wonderful lifelong memories for all the children whom he taught at Dubbo South Primary School. Thank you to my lecturers during my Bachelor of Education (Science) studies especially Mr Murray Fitzgerald who really showed us how to "think outside the square", supervising teachers during my early career, and my colleagues especially Mr Don Bates who has been an inspiration to generations of science students and fellow teachers alike.

I would also like to thank my children Luke and Kasey for their support, and my dear parents Terry and Bev Daly for assisting with data entry and with many ideas over the years. Thank you to the rest of my family and the many, many friends who have supported me with this research over the past eight years while living in New South Wales, the Northern Territory and Queensland.

I give my deepest thank you to my husband, Matthew Pfeiffer, who provided me with the support to continue even throughout the birth of both of our children and despite suffering through chemotherapy treatment himself. I am eternally grateful for his ongoing patience and encouragement, particularly at the times when it seemed this thesis would never end.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1

INTRODUCTION

1.1 INTRODUCTION

“Students learn what they care about and remember what they understand.” (Ericksen, 1984, p. 51)

Individual students have their own unique styles of learning. Grashna (1996) has defined learning styles as “personal qualities that influence a student's ability to acquire information, to interact with peers and the teacher, and otherwise to participate in learning experiences” (Cartnal & Diaz, 1999, p. 130). Therefore, in order for effective learning to take place and for positive relationships and interactions to occur in the classroom there needs to be an environment that allows such individualisation to flourish.

Improved teaching will lead to improved learning. The teacher is the critical ingredient for quality learning to take place. The teacher creates the learning environment for the students (Sullivan, Mornane, Prain, Campbell, Deed, Drane, Faulkner, McDonough, & Smith, 2009). It is generally accepted that student attitude, behaviour, happiness and hence achievement stem from the behaviour and attitude of the teacher. Teachers have a responsibility to the wider community to deepen the scientific understanding and learning experiences occurring in their classrooms by recognising that the learning environment undergoes continuous evolution and must be constantly evaluated and modified accordingly.

This study investigated the preferred learning environment and the preferred learning styles of Year 5, Year 7 and Year 9 students in Science. The role gender plays and the ways that classrooms can be modified to cater for students’ learning preferences were also investigated.

The learning environment in this study was measured using the *Science Laboratory Environment Inventory* (SLEI) (Fraser, Giddings, & McRobbie, 1992). The learning styles in this study are based on Multiple Intelligence theory (Gardner, 2003) and were measured using a Grid made up of classroom activities selected by the students across these three age groups.

1.2 BACKGROUND

In 1980 Pickering wrote:

> The job of lab courses is to provide the experience of doing science. While the potential is rarely achieved, the obstacles are organizational and not inherent in laboratory teaching itself. That is fortunate because reform is possible and reform is cheap. Massive amounts of money are not required to improve most programs; what's needed is more careful planning and precise thinking about educational objectives. By offering a genuine, unvarnished scientific experience, a lab course can make a student into a better observer, a more careful and precise thinker, and a more deliberate problem solver. And that is what education is all about (cited in Hofstein, 2008, p. 211).

This was written 30 years ago yet is basically still true today. While reform is possible, however it is not necessarily cheap as it requires time for careful planning to take place and in today's society time is money.

Learning Environment

The idea that a learning environment exists came about as early as 1936 when Lewin proposed the formula B = f (P, E) where behaviour is a function of the environment and the interaction of the individual (Fisher & Khine, 2006). "Since an individual is always interacting with his or her environment, observed behaviour is a result of the combined effect of the interaction between variables P and E." (Chandra & Fisher, 2006, p. 463). Behaviour comes from a combination of both the environment provided as well as the interactions of the people in that environment. Within the classroom situation, this means both the physical factors and the interactions between students, and between teacher and student.

In education, research studies have shown that the classroom learning environment is a changeable variable which can "directly influence cognitive and affective outcomes" (Chandra & Fisher, 2006, p. 462). There are many variables involved in a learning environment for the student such as the physical factors of buildings, materials, temperature and lighting as well as the teaching styles, attitudes and motivation of teachers and interactions with peers.

The learning environment is one factor that can be modified to improve student outcomes. Teachers can modify their methods to suit the learning styles of their students in order to achieve quality learning in the classroom and increase students' motivation in science. In the mid 1970s Walberg (1976) and Moos (1973) independently began developing instruments to assess classroom learning environments from a student's perspective.

There are now many questionnaires available that can be implemented and evaluated with minimal time. These can provide useful data for modifying the learning environment to best suit the learning preferences of the participants. With the changes in enthusiasm and motivation that seem to be evident from upper primary to lower secondary science classes, the Science Laboratory Environment Inventory (SLEI) (Fraser, Giddings, & McRobbie, 1992) is a useful tool in measuring the preferred learning environment (and actual classroom environments) in a Year 5, Year 7 and Year 9 Science class. The SLEI was chosen not only because it provides useful information but also because it has been validated.

Learning Styles – Multiple Intelligences

In the 1980s, psychologist Howard Gardner questioned the notion that intelligence is a single entity (Gardner, 1983). He proposed seven intelligences:

Linguistic intelligence – a feel for language
Logical-mathematical intelligence – scientific and mathematical thinking

Musical intelligence – pitch, tone and rhythm

Bodily-kinaesthetic intelligence – physical skill, being good at sports

Visual-spatial intelligence – art and design or spatial tasks like map reading

Interpersonal intelligence – understanding other people

Intrapersonal intelligence – understanding yourself

Gardner 1983 (as cited in Pirozzo, 2001, p.12) identifies seven Multiple Intelligences:

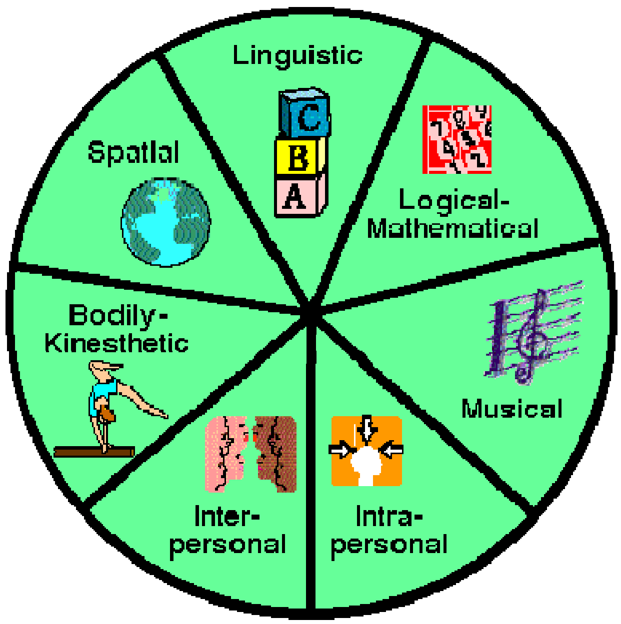


Figure 1.1. Multiple intelligences.

“We learn through at least seven different pathways…we should teach each lesson through at least seven different ways” (Pirozzo, 2001, p. 13).

Gardner (2003) defines intelligence as:

- A property of all human beings (all of us possess these seven intelligences).
- A dimension on which human beings differ (no two people – not even identical twins – possess exactly the same profile of intelligences).

Catering for the needs of the individual in the classroom by devising lesson plans that make the most of 30 children’s different Multiple Intelligences provides a challenge for all educators.

The Multiple Intelligence model provides some insight into a possible explanation of why some very bright individuals do not excel academically. That is, some kinaesthetic learners may find it difficult to settle down in class and can be labelled as troublemakers (Darby, 2006). The style of teaching that occurs in the classroom may be the preferred learning style of that particular teacher and not catering for the needs of the (varied) individual students (and may even favour students of the same gender as the teacher).

A Grid based on Multiple Intelligences has been adapted from Pirozzo (2001) as a measure of the types of activities that students prefer to engage in when given the option (see Table 1.1). This can be used by teachers for specific ages and gender to create classroom learning activities that suit the preferred learning styles of their students.

Table 1.1

Multiple Intelligence Activities

MULTIPLE INTELLIGENCE	ACTIVITIES
Verbal / Linguistic	Reading, writing, listening, debating, speaking, discussing, telling jokes, making speeches.
Logical / Mathematical	Calculating, assessing, classifying, estimating, measuring, predicting, hypothesising, using formulae.
Visual / Spatial	Drawing, painting, designing, imagining, visualising, making models, graphing, photographing, maps.
Body / Kinaesthetic	Sports, miming, acting, performing, building, dancing, role playing, modelling, hands-on activities.
Musical / Rhythmic	Listening to music, creating rhythms, remembering tunes, producing sound effects, playing instruments.
Interpersonal	Sharing, empathising, cooperating, negotiating.
Intrapersonal	Reflecting, planning, goal setting, writing diaries.

1.3 AIM AND RESEARCH QUESTIONS

The classroom learning environment can be modified by the teacher to cater for the needs of the individual student in order to achieve positive learning outcomes. If the teacher has some insight into the preferred learning styles of students then the learning environment can be modified to suit the students in the classroom. This can lead to improvements in student behaviour and attitudes toward science and learning and hence positive interactions between students and teachers. A flow-on effect can be an increase in job satisfaction for teachers and an increase in enthusiasm.

The Multiple Intelligence Model outlines various styles of learning that exist. The aim of this study is to identify any associations between age (Year 5, Year 7 and Year 9 students) and preferred style of learning in order to develop learning programs conducive to the type of intelligence present in students across these age groups. If classroom learning environments can be structured to cater for the preference of students, motivation to learn in science may be enhanced.

The overall aim of the study described in this thesis asks whether there is a difference between the preferred learning environment and the preferred learning styles of Year 5, Year 7 and Year 9 students in science; whether gender plays a role in preferred learning environment and preferred learning styles; and how actual classroom environments can be structured to cater for these preferred learning environments and preferred learning styles in science across these three ages.

There seems to be an obvious difference in the motivation and attitudes towards science across these three age groups. This study investigated how students preferred learning environment and preferred learning styles change across these three age groups, whether gender plays a role in the preferred learning environment and preferred learning styles of students at these ages, and how the classroom learning environment can be structured to cater for students' preferred learning environment and preferred learning styles.

To achieve this, the following research questions were proposed:

1. How do the actual and preferred learning environments change across the Years 5, 7 and 9 age groups?
2. How does the preferred learning style change across these three age groups?
3. Does gender play a role in:
   a. the preferred learning environment of students at these ages? (SLEI)
   b. the preferred learning style of students at these ages? (Grid)
4. How can actual classroom learning environments be structured to cater for students' preferred learning environment and preferred learning styles across these ages?

The research questions were investigated by using the SLEI in Part A and the Grid in Part B. The SLEI identifies student perceptions of the actual and preferred classroom learning environment based on five scales: SC (student cohesiveness), OE (open endedness), I (integration), RC (rule clarity), and ME (material environment). The responses for these five scales were compared across the three age groups: Year 5, Year 7 and Year 9 students.

The Grid based on a cooperative learning unit developed by Pirozzo gave students the opportunity to select preferred classroom activities. The results from the three age groups were collated. Gender differences were recorded for the five scales of the SLEI and compared. The number of activities selected in the Grid by each gender was also compared. General trends were then determined that could be used to develop classroom learning activities that are best suited to the gender and age of students.

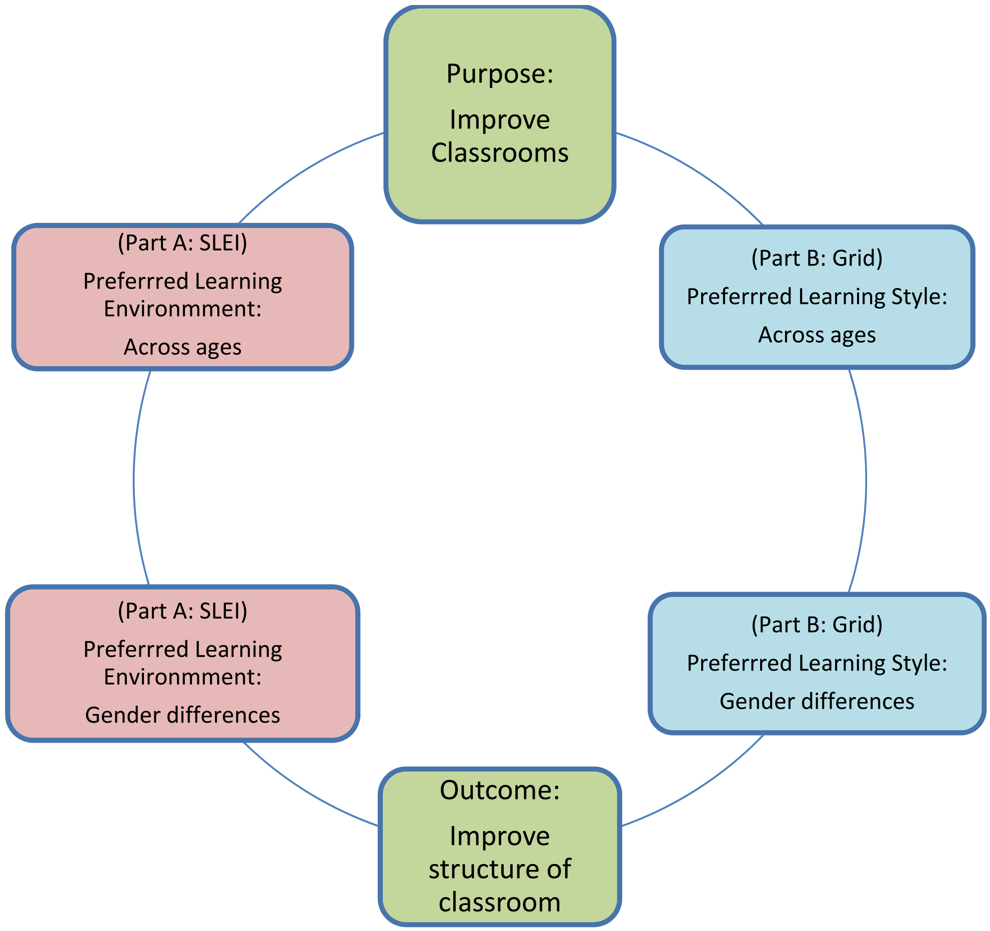


Figure 1.2. Research overview.

1.4 OVERVIEW OF METHODOLOGY

First, in Part A the SLEI (actual and preferred) was administered to 59 Year 5 students by their classroom teachers and to 113 Year 7 and 113 Year 9 students by their science teachers in their science classes. Questions were read out in some cases in an attempt to offer a better understanding to those students having difficulty interpreting the statements. The results obtained in Part A were used to compare the preferred and actual learning environments between the ages and between genders.

Secondly, in Part B a Grid based on the work of Pirozzo (2001) was given to students in their classroom environment. Students were asked to select 15 tasks from the choices of learning activities in the grid.

A sample of students from Years 7 and 9 (27 Year 7 students and 31 Year 9 students) were asked the following questions:

1. Which Activity would be your favourite? Why?
2. Which Activity would be the easiest? Why?
3. Which Activity would be the most interesting? Why?
4. Which Activity would be the most challenging? Why?

The results obtained in Part B were used to compare preferred learning styles between the ages and between genders.

1.5 SIGNIFICANCE

There is little doubt that there has been a decline in student interest in science over the years. There are many factors that could contribute to students' lack of interest in the science classroom such as a lack of enjoyment, lack of teacher motivation and a perception that science is "too hard" (Hassan & Fisher, 2005). In order to attempt to reverse this trend in the science classroom, teachers need to provide learning environments conducive to the needs of the individual students. Teachers need to create science learning environments that promote positive student outcomes and meaningful learning.

Instruments devised to measure students' (and teachers') perceptions can be utilised so that teachers can compare their own preferences with that of the students and visualise where there are differences and formulate plans to modify the learning environment accordingly (den Brok, Cakiroglu, Taconis, & Tekkaya, 2008). This study provides a method for teachers to create learning experiences which are enjoyable and meaningful to their students.

The Grid used in Part B of this study (Appendix 3) could be modified to suit any "topic" in science and allows teachers to quickly determine the preferred activities of the students in a particular class by allowing students to select the activities they would prefer and recording this data in order to structure learning activities accordingly.

Teachers can modify the methods of instruction used in the science classroom to suit the interests of their students. For example, the use of hands-on experiences, posters and methods of presentation that are relevant and interesting to students can lead to an increase in motivation and hence a decrease in behaviour management issues and an increase in job satisfaction for the teacher. A sample from a unit of work developed for a Year 8 class called “Survivor Science” is presented as an interest topic that was used in a school in Dubbo. The students were involved in this topic at the end of the year after examinations and reporting had been completed. Students seemed to enjoy the unit of work as it was related to the television show “Survivor” and included hand-on activities, group work and role playing. It was competitive and there were minimal behavioural issues (personal experience).

This study presents a continuum of learning (Figure 2.3) which outlines a list of topics based on themes that can be utilised to teach science from year seven right through to year ten. Each year has a general theme that is then broken down into topics. The general themes also run across the year groups making science relevant to the student as well as interesting.

This thesis also provides an example of how to set up a science classroom (Figure 5.2) that could provide students with the opportunity to explore scientific concepts in a non-threatening environment with their own choice of activities. An example of a Grid (Table 5.1) that could be used to create the activities for each topic is also provided.

Hassan and Fisher (2005) found that students’ motivation and interest in science is declining with age. This has been a consistent finding of similar studies. There is a need for an increase in students’ enjoyment of science to increase their interest and career choice in this increasingly unpopular subject.

There is little doubt that active learning in the classroom increases student interest and therefore decreases student boredom, decreases student behaviour issues, increases teacher job satisfaction and so on. However, in practice active learning strategies do not seem to be occurring in every secondary school science laboratory in New South Wales.

There are many reasons why teachers can be reluctant to utilise these sometimes foreign classroom strategies.

Employing active learning strategies in a classroom takes up a lot of teaching time thus reducing the amount of time to cover mandatory content. Preparation time for teachers is increased when “brand new” lessons are developed rather than teaching “old lectures”. Large class sizes and lack of materials or equipment can also be seen as obstacles to fostering active learning in the classroom (Bonwell, 1991). Teachers also face the risk of meeting an unwillingness to participate from students, less class control, students not enjoying the experience or even criticism from peers.

Another obstacle to implementing change in schools can be the “grammar of schooling” (Venville, Wallace, Rennie, & Malone, 1999). This term refers to the culture embedded in a school over time. The term “grammar” itself is old and traditional, hence the term is used to imply that some cultures and traditions in schools are the same and often can be difficult to change. The main barriers stem from the government (policies and money), the school board, the school administration, teachers and parents. These people influence the grammar of the school in some way and hence such things as curriculum documents, assessment structures, department policies, school structure and timetabling.

> Learning and teaching should not stand on opposite banks and just watch the river flow by; instead, they should embark together on a journey down the water. Through an active, reciprocal exchange, teaching can strengthen learning and how to learn (Malaguzzi, 1998 p. 83).

Teachers can play an active role in tackling the obstacles that stand in the way of creating classroom environments that are conducive to effective learning. Teachers can be actively involved in the consultation process of writing syllabus documents that are produced by the government and can also be actively involved in promoting teaching in order to improve working conditions which will attract graduates and hence raise teaching standards.

Problems that affect learning in the physical classroom environment such as large class sizes can attempt to be solved by collecting evidence for the educational benefits of smaller class sizes and presenting this information to governing bodies. Limited resources can be minimised by sharing resources among schools and brainstorming alternatives.

Teachers can improve their own education by actively participating in courses and can then in-service peers and promote alternative pedagogies available. Any changes that are considered in a school or even in a classroom may need to be implemented slowly over time. Teachers can conduct interviews of the students to allow insight into their preferred classroom learning environments, types of activities and learning styles and offer workable suggestions within the school context.

The main factors that will enhance the chances of change occurring in the classroom include time for planning and goal setting as well as support from the school community. Teachers need to be open to trying cooperative learning strategies, be organised and creative in their thinking and teachers need to be provided with ongoing support.

This study can assist teachers create classroom environments that are conducive to learning by utilising the types of activities that are preferred by the students of a particular age group in science.

1.6 OVERVIEW OF THESIS

This study investigated the preferred learning environments and the preferred learning styles of students in Year 5, Year 7 and Year 9 using two methods. First, in Part A the SLEI was administered to each age group, and secondly, in Part B a Grid giving students choices of preferred activities was presented. In both instances, data was collected and analysed. Comparisons were made for the actual and preferred learning environments and the preferred learning style (based on multiple intelligence theory) between the age groups and gender.

The literature review (Chapter 2) that follows is divided into sections starting with an introduction discussing the decline in student interest in science as age increases. This may be contributed to by boring and irrelevant curriculum as well as teacher quality. This is followed by a section on student learning, types of learning and gender differences, as well as the importance and benefits of exposing student's to multiple methods of teaching are discussed. The study of learning environments is next, the associations between learning environments and student achievement and attitudes toward science and a presentation of various classroom environment questionnaires are discussed.

The literature review then discusses practical work in science followed by a section specifically on describing the Science Laboratory Environment Inventory as well as an overview of SLEI research. Multiple Intelligence theory is described and an overview of multiple intelligence model research is discussed. Lastly, an outline of suggestions for modifying the classroom learning environment including a continuum of learning is presented.

The Methodology (Chapter 3) is divided into sections starting with an introduction and then a brief outline of the research questions and the methods selected. The instruments (SLEI and Grid) are discussed in more detail. Data gathering including ethics and the data sources are discussed followed by data interpretation and finally a chapter summary.

The Data Analysis (Chapter 4) provides tables and graphs of the data collected and their interpretation. Part A (SLEI) is presented in terms of:

- Reliability and validity;
- Actual and preferred differences;
- Year differences actual;
- Year differences preferred;
- Gender differences actual; and
- Gender differences preferred.

The Grid used in Part B is discussed by interpreting the data from Year 5, then Year 7 and finally Year 9. Chapter 4 goes on to outline issues encountered when collecting and analysing the data and concludes with an overall presentation of the results.

This thesis ends with a conclusion (Chapter 5) that presents an overview of the study conducted, the major findings (general trends and how the research questions have been answered), recommendations for teachers (the implications for the classroom and practical ways to implement change in the classroom), limitations (to changing classrooms as well as limitations to this study in general), significance (in theory and in practice), and final comments (including suggestions for future research). This study presents practical ways in which the classroom learning environment can be modified in order to "set young minds on fire."

CHAPTER 2

LITERATURE REVIEW

2.1 INTRODUCTION

“Any fool can know, the point is to understand” (Einstein)

In order for meaningful learning to take place, there needs to be an appropriate learning environment. A learning environment that is created in such a way as to cater for individual students’ learning styles gives students meaning to their learning. Utilising a variety of activities in the classroom that address the various learning styles can assist in providing understanding (without necessarily knowing – that is the ability to not just use stimulus to answer a question on the day but to be able to explain a concept months later). Teaching in this way arms students with the knowledge to answer questions and apply learning to situations outside the classroom (Venville, Wallace, Rennie, & Malone, 2002).

There is an observable decline in positive attitudes and motivation toward science with increase in age from Year 5 to Year 9 (Simpson & Oliver, 1985). Students in Year 5 seem to display an excitement and natural curiosity for the world around them, while Year 7 display a moderate interest in the experiences to be gained in the science laboratory. Year 9 students generally display little enthusiasm for science. This observable decline in student interest in science may be contributed to by gender, boring and irrelevant curriculum, and teacher quality. There is a need for educators to identify the kinds of classroom environments and activities that can be utilised in order to engage pupils in the science classroom (Osborne, Simon, & Collins, 2003).

This lack of interest in science during the middle years of schooling (Years 5 to 9) is a concern in education as it could lead to students not selecting science subjects later in their educational pathway (senior high school and tertiary education) and hence as a career.

A lack of interest in science as a career is of critical importance to society as a whole therefore increasing students' interest in science during the middle years of schooling is crucial (Singh, Granville, & Dika, 2002).

Ensuring curriculum content is relevant to students is one method of enhancing student motivation. Introducing career advice and making direct connections between classroom learning and post-school choices at an earlier age also may have advantages for younger students (Sullivan, et al., 2009). For example, from Year 7 introducing students to the types of careers that utilise each and every concept encountered in the science classroom may assist students in making connections between the classroom environment and the wider community.

Curriculum that is designed purely for the purpose of formal written testing can lead teachers to formulate an ability-focussed classroom learning environment. These learning environments result in low levels of motivation and lack of confidence in science ability (Anderman & Young, 1994).

With increasing advances in technology occurring globally, there is a need for an increasingly skilled workforce (Ingvarson & Rowe, 2008). Although OECD education ministers have committed their countries to the goal of raising the quality of learning for all, this ambitious goal will not be achieved unless all learners, irrespective of their characteristics, backgrounds and locations, receive high-quality teaching (OECD, 2005).

Since teachers are the most valuable resource available to both schools and higher education institutions in the realisation of this goal, an investment in *teacher quality* and ongoing professionalism is vital (Ingvarson & Rowe, 2008).

> The Council of Australian Governments (COAG) has identified the quality of the teaching profession as pivotal to its education reform agenda (Council of Australian Governments, 2008, as cited in Ingvarson, 2010, p. 46).

This study investigates the way in which classroom learning environments and activities can be structured in order to achieve optimum learning in science through

Years 5, Year 7 and Year 9. Structuring the classroom activities in order to present the curriculum in an effective manner and also to cater for the diverse learning styles that are in the one classroom is explored. Chapter 2 contains the following sections: Student Learning – definitions of learning styles, types of learning and gender differences, and the importance and benefits of exposing student's to multiple methods of teaching; Learning Environment – definitions of classroom learning environment, associations between learning environment and student achievement and attitudes towards science, and a brief history of instruments used to measure learning environments; Practical Work in science – the practical nature of the science classroom learning environment is discussed; the SLEI – a brief history and description of the SLEI, and an overview of studies that have used the SLEI is given; Multiple Intelligences – a brief history of multiple intelligence theory, description of the multiple intelligence model, and an overview of studies that use the multiple intelligence model; Modifying Classrooms – suggestions for modifying classrooms are presented with more details following in Chapter 5; and finally a Summary of the chapter.

2.2 STUDENT LEARNING

> One must learn by doing the thing, for though you think you know it – you have no certainty until you try. *(Sophocles, 5th c. B.C.)*

Individuals process information, learn concepts, and solve problems in different ways. An individual's learning preference is "a personally preferred way of dealing with information and experience that crosses content areas" (Kruzich, Friesen, & Van Soest, 1986 as cited in Brock & Cameron, 1999). There is no "best" learning preference, there are just different ones. Many educators report frustrations at not being able to meet the educational goals that they have for their students. Among the many possible reasons for this frustration is a mismatch between the teachers' learning preferences, which may determine his or her teaching style, and the students' learning preferences, which may affect their level of comprehension of material covered in a course.

Student motivation is influenced by teacher's pedagogical strategies rather than an interest in the subject matter. In order to generate and sustain student motivation, teaching strategies must broadly match student motivational characteristics. "Curious students", "conscientious students", "sociable students", and "achiever students" were identified in a study by Kempa and Diaz (1990) that found links between student motivational traits and their preferences for different instructional procedures used in science education.

Learning preference mismatches may cause students to perform below their potential, view the subject as being difficult, and reduce the teacher's enthusiasm for teaching. Once these mismatches are identified and understood, they can be easily counteracted, usually without substantial course reorganisation (Brock & Cameron, 1999). This study used the SLEI and a Grid to identify learning preferences of students in order to develop teaching strategies that can be used in the science classroom.

2.2.1 Year Differences

Schurr (1996) identified some of the problems that students have at school and related these problems to the needs that young (adolescent) people have. She identified problems that adolescent students face at school, such as boredom, irrelevance to life, disjointedness (not cohesive), not student-centred, alienating and superficial learning (not higher order) and the possible cause being little or no room for expansion of depth of student knowledge (not challenging cognitively) and little or no room for success. These problems relate to the intellectual needs of students.

Ebenezer and Zoller (1993) found that Grade 10 students prefer science teaching and learning where they play an active role. It was also found that teaching style was a major determining factor influencing student attitude towards science and that more emphasis needed to be placed on the teachers' role and their teaching style in order to achieve an educational change in the constructivist direction.

Ames (1992) and Dweck (2000) categorised learning in terms of "mastery" goals and "performance" goals (Sullivan, et al., 2009). Students with mastery goals seek to understand the content, and evaluate their success by whether they feel they can transfer their knowledge to another situation. These types of students tend to remain focussed even when challenged and they believe that effort leads to success. Students with performance goals are mainly interested in whether they perform tasks correctly with recognition from the teacher. They tend to avoid or give up on challenging tasks.

Students' apparent lack of engagement in the middle years of schooling in Australia (at around Year 5 to Year 9) can be contributed to by inappropriate curriculum content as well as teaching styles.

A common recommendation is for students to engage with rich tasks and meaningful activities in an integrated curriculum that focus on a larger idea rather than small, trivial content (Sullivan, et al., 2009).

A project named *Productive Pedagogies* enquired into the teaching practices of Queensland teachers in Year 6, 8 and 11 classrooms. Concerns were raised about the dis-engagement of middle-years students and the findings support the notion that there is a misalignment between curriculum and pedagogy. The need for developing engaging classroom practices and more rigorous curriculum as well as teacher training were identified (Prosser, 2008).

The 1971 *Karmel Report* proposed replacing the "tradition of uncaring imparting of information from the teacher to whole classes of children with a caring commitment to the educational development of the individual child" (Collins & Yates, 2009, p. 129). The *Karmel Report* described curriculum in terms of certain basic skills and the school's purpose is to provide these skills.

Sullivan, et al. (2009) identified students' feeling that they are capable and also wanting to please their parents as the two main factors for trying at school. A sense of interest in the subject, personal encouragement from teachers and being considered smart were not recorded as positive reasons for trying at school.

An interpretation that students may not expect school to be interesting is given as a possible reason for these findings (Sullivan, et al., 2009).

In Korea, there is an emphasis on scientific literacy. A study by Nam, Choi, and Hand (2010) with Grade Eight students indicated that teachers used classroom discussion less than ten percent of the time. This shows that teacher-directed classrooms are utilised most of the time rather than group work activities. Lowe (2004) used the *Test of Science Related Attitudes* (TOSRA) (Fraser, 1981) with students in New Zealand and found that cooperative group work incorporating a variety of classroom activities including field work and practical lessons enhanced students' positive attitudes to science.

2.2.2 Gender Differences

Hofstein and Mandler (1985) compared the performance of boys and girls in science in Israel and found that boys outperformed girls on total test scores. Hofstein, Cohen, and Lazarowitz (1996) revealed gender differences in the actual and preferred classroom learning environment in a biology class in Israel. Girls perceived the actual classroom more positively on the scales of Teacher Support, Involvement, and Student Cohesiveness while boys were higher on the Open-endedness scale. In preferred classroom learning environment, girls scored higher than the boys on seven of the eight subscales: Teacher Support, Involvement, Student Cohesiveness, Integration, Organisation, Rule Clarity and Material Environment.

The Relevance of Science Education Project (ROSE) in England was conducted with over 1200 students from 34 schools. There were marked differences in responses to the 250 questions between boys and girls (Jenkins & Pell, 2006). The girls displayed a greater priority towards topics related to health, the mind and well being while boys were more interested in topics related to destruction, technologies and events. The data also suggested that many students have made up their minds whether or not they wish to pursue a career in science by the age of 14 or 15. This implies quality teaching of science to younger students could contribute to increasing the number of students studying science at a later age.

Kahle (2005) conducted a study of 103 freshman students in Kamehameha (Hawaii) using the *Constructivist Learning Environment Survey* CLES and found that girls found physics more relevant than biology. However, girls seemed to view the actual biology classroom as one where they have more say in what they do in class than in physics. It was found that boys felt they had more say in physics than in the biology classroom. These results indicate that the biology teachers may be involving the girls more while the physics teachers may be giving the boys more opportunities to be involved in the classroom learning environment.

With gender playing a role in learning styles, perhaps single sex classes could improve students motivation and hence achievement in science. At a school in Dubbo, New South Wales, single sex classes were trialled in science for one year. In general, female teachers found that the ungraded male classes were difficult to manage while the male teachers favoured the single sex ungraded male classes where the learning was more hands-on (personal experience). The students were not interviewed nor were achievement levels measured, however this could be an area for future research.

Students may perform below their potential and view science as a difficult subject simply due to their learning style not being met. This could occur simply by the teacher "mismatching" students' preferred learning styles with their own preferences and styles of teaching (Brock & Cameron, 1999). Individuals process information, learn concepts and solve problems in different ways. There is no "best" way, just different ways.

An advantage of investigating the preferred learning styles of students and utilising these in the classroom is the increase in students' motivation to learn and to apply their learning to a wide range of situations. It allows students to relate concepts in a creative manner – many times students have asked "Why are we doing a debate? This is science not English!" or "Why are we playing music. This is science." Using traditional "chalk and talk", textbook summarising or other potentially boring methods of teaching explicitly in the classroom restricts students' thinking and development by making the process of learning artificial and alien compared with their life experiences.

A solar boat project conducted at "Eagleton Middle School" (false name) in Perth, Western Australia as part of the ATP (Academic Talented Program) found that students gained motivation. The students designed and produced a solar powered vessel that would out-perform others. The study found that compartmentalised knowledge was bridged and an environment of application, meaning, context and relevance was obtained (Venville, et al., 1999).

Ebrahim (2009) compared teacher-centred and cooperative learning techniques in Kuwait. The results revealed that cooperative learning strategies have significantly more positive effects on student achievement and social skills than teacher-centred techniques. This would be expected as cooperative learning engages students and is seen to be more fun than the traditional method of teacher-centred instruction.

Unfortunately, many educators in Kuwait continue with teacher-centred methods of instruction as they are seen to comply with educational mandates, school environment expectations, and classroom structures and management (Ebrahim, 2009).

There is little doubt that there is a continuing decline in numbers of students choosing to study science. Some factors that influence students' attitudes towards science that were identified in a study by Osborne, Simon, and Collins (2003) included gender, teachers, and curricula. Literature points to the crucial importance of gender and the quality of teaching. This study argued that there is a need for more research to identify the aspects of science teaching that engage students and increase motivation.

> The teacher creates the environment for learning, sets the stage, guides, helps learners learn how to learn, provides materials and where to obtain them, assesses, evaluates, helps learners to self-evaluate, encourages, appreciates, exhibits joy in learning and leading others (students) to learn, respects students, must love learning or learn to love to learn. The student is at the centre. (Haney, Lumpe, & Czemiak, 2003, p. 366)

The learning environment and more specifically the science classroom learning environment which involves practical work are investigated in this study. The following sections discuss learning environments, practical work, and multiple intelligence theory.

2.3 LEARNING ENVIRONMENT

The classroom learning environment can be defined as the physical structures of the room – chairs, desks, equipment, air temperature, lighting and so forth as well as the social factors: the teacher, attitudes and behaviour, student teacher interactions and teacher personality are all part of the classroom learning environment.

An association between students' learning outcomes and student classroom environment perceptions shows the importance of how students perceive the classroom to be on their achievement. For example, if the students feel that they play an integral part in the decision-making process and they have a say in their learning they are more likely to achieve the learning outcomes. This would most likely be due to an increase in motivation to learn and hence less fear of failure and more students "getting in and having a go".

Haney, Lumpe, and Czemiak (2003) conducted a study in an American high school on the perceptions of teachers and students of the science learning environment. This study also included the perceptions of parents, administrators and community members. The general findings were that the participants found that a positive learning environment would exist when the teacher displays the following qualities:

- enthusiasm and a "genuine love" for teaching;
- the ability to motivate students;
- acts as a guide;
- has good content knowledge;
- is caring;
- has good communication skills;
- is a good classroom manager;

- respects students; and
- provides multiple ways of learning

"Houtz (1995) found that science achievement was linked more closely to students' attitudes toward science than to aptitude among students." (Hassan & Fisher, 2005, p. 8). Therefore, in order for students to achieve educational outcomes effectively there is a need to improve the classroom environment including attitudes and behaviour and not just the physical factors such as class sizes (which are still important).

Students spend the majority of their daily hours at school. Therefore, teachers are a major influence on students. The behaviour and attitudes of a teacher can influence the behaviour and attitudes of their students (Koul & Fisher, 2004).

Many questionnaires have been developed in order to measure the learning environment that teachers create for their students. The use of questionnaires is an important factor in assessing the learning environment and this study focuses on the use of questionnaires and in particular the SLEI. Table 2.1 presents the names of a sample of these learning environment questionnaires together with some outcomes measuring questionnaires often associated with the learning environment questionnaires in research studies and referred to in this chapter.

Table 2.1

Sample of Classroom Environment Questionnaires

Questionnaire	Name
SLEI	Science Laboratory Environment Inventory
TOSRA	Test of Science Related Attitudes
QTI	Questionnaire on Teacher Interaction
MCI	My Class Inventory
CLEI	Computer Laboratory Environment Inventory
ACCC	Attitude toward Computers and Computer Courses
CLES	Constructivist Learning Environment Survey
TROFLEI	Technology-Rich, Outcomes-Focussed, Learning Environment Inventory
WIHIC	What Is Happening In This Class?
PLACES	Place-Based and Constructivist Environment Survey
ESLEI	Environment Science Learning Inventory
SOLEI	Science Outdoor Learning Environment Instrument
SMASES	Student's Motivation, Attitude and Self-Efficacy in Science
SMTSL	Students' Motivation Towards Science Learning
AEQ	Attitude and Efficacy Questionnaire

The *Questionnaire on Teacher Interaction* (QTI) (Wubbels & Levy, 1993) provides useful information about teacher interpersonal behaviour. The QTI consists of eight scales: Leadership, Understanding, Uncertain, Admonishing, Helpful/Friendly, Student Responsibility and Freedom, Dissatisfied, and Strict. The QTI has been used in The Netherlands, USA, Australia, Singapore, and some other Asian countries.

Among the large collection of studies that have been conducted utilising the QTI, Fisher and Rickards (1998) found that students' attitudes to class and their achievement were positively correlated to teacher's displaying leadership, being helpful and friendly and understanding. Teachers who displayed uncertainty, strict, and dissatisfaction had a negative effect on student attitudes.

Fisher, Rickards, and Fraser (1996) conducted a study on Australian secondary science students and teachers using the QTI which led to teachers becoming aware of the ways in which they could improve their classroom environments.

Rickards (1999) found that students have more positive attitudes in classrooms where they have some leadership, are helpful and friendly, and there are cooperative behaviours. Females perceived their teachers in a more positive way than did males. Lang (2005) found significant associations between students' attitudes and the interpersonal behaviour of Chemistry teachers.

The QTI was used by Wubbels (1993) on Australian secondary school students' perceptions of their science teachers. It was found that the "best teachers" are strong leaders, friendly, understanding and display less uncertainty according to the students. Similar studies conducted by Fisher and others in Singapore and Australia display the same results – teacher's who are friendly, helping and display leadership contribute to positive student attitudes (Koul & Fisher, 2004). This reiterates the important role the teacher plays in ensuring students find science enjoyable and the necessity for teachers to be passionate about their choice of career.

The *My Class Inventory* (MCI) is another classroom environment questionnaire that is useful for primary and lower secondary classes as the items use simple language. This questionnaire consists of both an actual and a preferred classroom form and has five scales: Satisfaction, Friction, Competitiveness, Difficulty, and Cohesiveness (Fraser, 1989).

Newby and Fisher (1997) developed two instruments for measuring the classroom learning environment in computer classrooms. The *Computer Laboratory Environment Inventory* (CLEI) is based on the SLEI with five scales: Student Cohesiveness, Open-endedness, Integration, Material Environment, and Technology Adequacy instead of Rule Clarity as in the SLEI. The *Attitude toward Computers and Computer Courses* (ACCC) instrument has four scales: Anxiety, Enjoyment, Usefulness of Computers, and Usefulness of Course.

These instruments were administered to students taking courses within Curtin University Business School at both undergraduate and postgraduate levels and it was found that students enjoy using computers in the classroom when the laboratory classes are integrated with the lectures, there is a clear purpose, and the classrooms are suitably equipped (Newby & Fisher, 1997).

The Constructivist Learning Environment Survey CLES (Taylor, Fraser, & Fisher, 1997) consists of 30 items with the responses Almost Always, Often, Sometimes, Seldom, and Almost Never. These are scored 5, 4, 3, 2, 1 respectively and an average score is calculated. There are five scales as described in Table 2.2.

Table 2.2

Descriptions of the Five Scales of the CLES

Scale	Description
Relevance	Relating science to out-of-school experience or personal relevance
Uncertainty	Experiencing science as arising from inquiry and viewing science as ever changing
Critical Voice	Questioning pedagogical plans and methods and expressing concerns about impediments to learning
Shared Control	Sharing control of the learning environment, goals, activities, assessments
Negotiation	Interacting with other students to improve understanding through explaining, justifying, and listening

(Kahle, 2005)

Aldridge et al. (2000) utilised the CLES in a cross-national study between Australia and Taiwan. The advantages of using comparisons between different countries include a greater range in teaching methods and student attitudes as well as questioning the "familiar" educational practices of one country that may be vastly different in another. Overall, it was found that students in Taiwan had a more positive attitude towards science than students in Australia. Furthermore, students in

Taiwan tend to have more respect for their teachers than their Australian counterparts.

There was also more respect within the community for teachers in Taiwan, where teachers are regarded as experts in their profession, than in Australia. Australian teachers in this study revealed that they felt more like a service than a profession and had low status in the community (Aldrige et al., 2000). In Taiwan, the teachers' knowledge was never questioned. The Australian students tended to find science lessons boring and science as a subject *endured* because it was compulsory. In Taiwan, the curriculum is driven by textbooks that contained the content to be covered for examinations. Therefore, due to the examination based curriculum classrooms tend to be teacher-centred. In Australian schools, the middle years are not examination driven and as such teachers have the opportunity to explore varied methods of instruction and to structure the classroom learning environment more student-centred.

Taiwan students could not think of an example of shared control, had little critical voice whereas Australian students had a lot of critical voice, Taiwan students felt they had less opportunity for student negotiation, however, personal relevance was higher in Taiwan than in Australia (Aldridge, et. al., 2000).

The *Technology-Rich, Outcomes-Focussed, Learning Environment Inventory* (TROFLEI) (Aldridge, Fraser, Fisher, & Wood, 2002) is another questionnaire that can be used to measure student perceptions of the classroom learning environment. There are 10 scales: Student Cohesiveness, Task Orientation, Cooperation, Equity, Young Adult Ethos, Computer Usage, Differentiation, Investigation, Involvement, and Teacher Support. Kerr (2005) administered the TROFLEI to 816 year 11 science students in 35 classrooms from each of Tasmania's eight public secondary colleges. The study found strong associations between students' psychosocial learning environment and satisfaction.

The *What Is Happening In this Class* (WIHIC) (Aldridge, Fraser, & Huang, 1999) instrument has been widely used as a measure of the classroom learning environment. This instrument has seven scales: Student Cohesiveness, Teacher

Support, Involvement, Investigation, Task Orientation, Cooperation, and Equity. Wolf and Fraser (2005) conducted a study involving 165 seventh-grade students in New York over an eight-week period where one group participated in inquiry classes and the other in non-inquiry lessons. Students in the inquiry classroom perceived more student cohesiveness and a friendlier environment than those in the non-inquiry classroom. It was also revealed that students in the inquiry group were more likely to ask peers for explanations rather than copying answers.

The *Place-Based and Constructivist Environment Survey* (PLACES) (Koul & Zandvliet, 2008) was developed from the *Environment Science Learning Inventory* (ESLEI) (Henderson & Reid, 2000), WIHIC, SLEI and the *Science Outdoor Learning Environment Instrument* (SOLEI) (Orion, Hofstein, Pinchas, & Giddings, 1994). Seven scales taken from these four instruments were used: Student Cohesion, Integration, Involvement (from ESLEI), Teacher Support, Cooperation (from WIHIC), Open-Endedness (from SLEI), and Environmental Interaction (from SOLEI). Koul and Zandvliet (2008) utilised this instrument on 326 students in the Republic of Mauritius and found a positive association between integration and all of the other scales. That is, students found more relevance in the classroom when there was student cohesion, involvement, cooperation, teacher support and open-endedness.

Reid and Fisher (2008) conducted a study using the QTI and the *Students' Motivation, Attitude and Self-Efficacy in Science* (SMASES) questionnaire. The SMASES uses 32 items taken from three questionnaires to measure students' motivation (14 items from *Students' Motivation Towards Science Learning* – SMTSL), attitudes towards science (10 items from TOSRA), and academic self-efficacy (8 items from *Attitude and Efficacy Questionnaire* – AEQ). This study highlighted the importance of teacher interpersonal behaviour on student motivation, as well as the effects teacher behaviour can have on determining high quality and valuable learning is taking place in a classroom learning environment.

Conducting educational research and administering questionnaires can provide teachers with the motivation and knowledge to evaluate their teaching methods and the learning environments that they create, because in science practical work plays such an important role in the science classroom and this is discussed in the following section.

2.4 PRACTICAL WORK IN SCIENCE

Hodson (1988) considered that the terms *practical work, laboratory work* and *experiments* have been used to cover up confusion that failed to recognise that “not all practical work is carried out in a laboratory, and not all laboratory work comprises experiments” (Bradley, 2005 p. 53). Eight different types of science practicals are described by Bradley (2005) and represented in Figure 2.1. The model is built on the work of Ausubel (1963), Novak (1978) and Elton (1987).

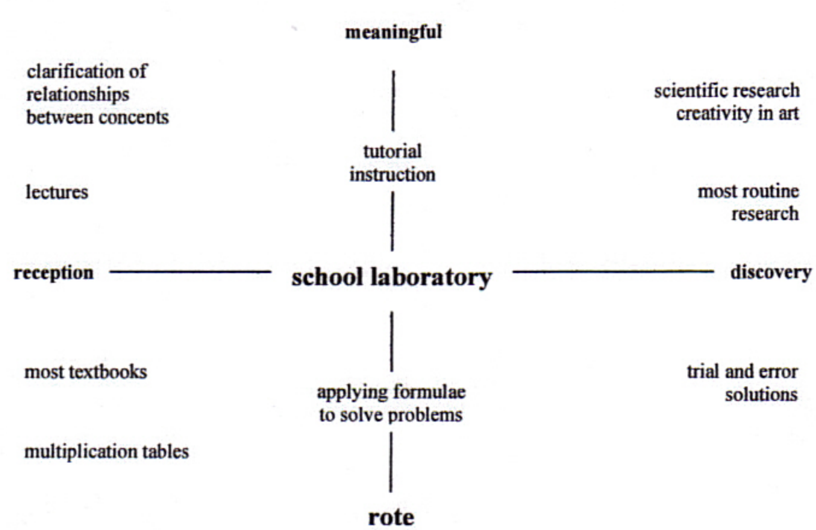


Figure 2.1. Types of science practicals.

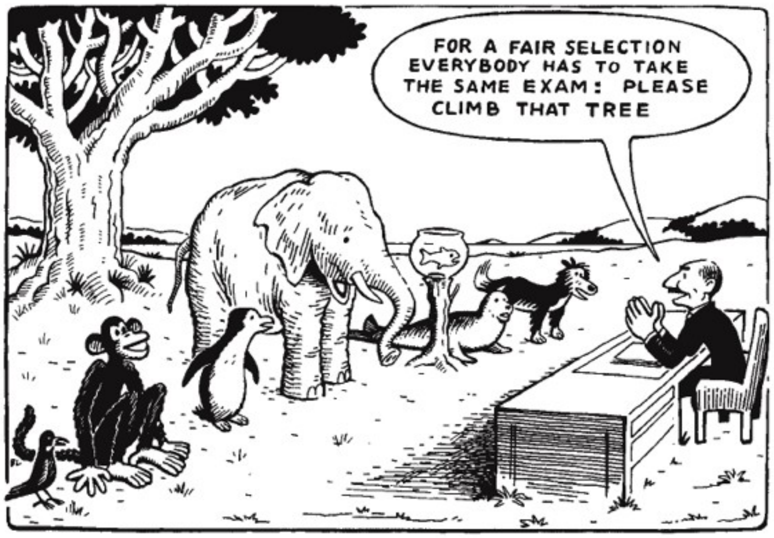
> The types of practicals used in science programs will depend on the particular emphasis and goals of the program. The practicals may be part of science programs or used as part of cross-disciplinary context-based programs (Bradley, 2005 p. 5).

A study in North Carolina (Jones, Howe, & Rua, 1999) of Grade six students’ experiences, topics of interest and future jobs found gender differences existed. In regard to out of school experiences, males favoured tools, electric toys, batteries, fuses, microscopes and pulleys whereas the female students' experiences were bread-making, knitting, sewing, and planting seeds.

It is interesting to note that these students (at such a young age) relate these everyday experiences to science. Topics of interest for males included atoms, cars, computers, x-rays and technology while females listed animal communication, rainbows, healthy eating, weather and AIDS as topics of interest. Again, it is interesting to note that the students had a realisation that world issues, health and the environment are all general areas of science. Finally, males seemed to find controlling others, fame, money and having an easy job as important whereas females wanted to "help other people".

This also adds to the dimension that not only do students have such a broad range of different learning styles, but they also have a wide range of priorities in regard to the importance of inter-personal relationships. Unfortunately, but not surprisingly, this study showed that females tend to find science difficult to understand while males find science destructive and dangerous as well as more suitable for boys.

This could explain why teachers often have difficulty with behaviour management of boys in practical science lessons and with encouraging girls to participate. Sullivan, et al. (2009) found that twice as many girls as boys indicated that they hoped and thought they would follow a professional career.



http://simmonsatshowcase.wikispaces.com/Universal+Design+for+Learning+-+A+Partnership+Model

Figure 2.2. Cartoon.

Figure 2.2 (a political cartoon) shows a man sitting behind a desk in a natural landscape with a bird, monkey, penguin, elephant, fish in a bowl, seal, and a dog lined up before him. He says, “For a fair selection everybody has to take the same exam: Please climb that tree.” The monkey looks pleased while the others look upset. This depicts the way in which expectations of learners in education can often seem as simple as a “fair exam” but actually does not take into consideration the individual differences of each one of the learners. Treating all learners fairly does not mean giving everyone the same thing, it means giving everyone the things they need in order to learn. This figure was taken from the internet.

In order to increase students' interest in science through years five to nine, investigating the structure of the classroom learning environment and the preferred learning styles of students at these ages is necessary. This study used the SLEI to investigate the preferred classroom learning environment and a Grid to record the preferred learning activities of students based on Howard Gardner's theory of multiple intelligences.

The following section discusses the SLEI in more detail as it is an instrument that ties together the learning environment and practical work.

2.5 SCIENCE LABORATORY ENVIRONMENT INVENTORY (SLEI)

Since the 1970s there has been a focus on the use of instruments used to measure the classroom learning environment from the students' perspective. However, these instruments were developed for non-laboratory learning environments. Consequently, Fraser, Giddings, and McRobbie (1992) developed a new instrument to investigate student perceptions of laboratory learning environments, and hence the Science Laboratory Environment Inventory (SLEI) was created.

The development of the class form of the SLEI involved five stages:

1. A review of literature.
2. An examination of the scales used in existing non-laboratory instruments.
3. Coverage of the three general categories of relationships, personal development, and system maintenance and change as identified by Moos (1979).
4. Feedback from science teachers and students of draft versions of the SLEI.
5. Development of a small number of scales and items to minimise the time for administering and scoring the instrument (Fraser & McRobbie, 1995).

Once the SLEI was developed, it was validated by use in secondary schools and Universities in many countries. Table 2.3 displays the number of students that the SLEI was administered to in the school setting.

Table 2.3

Descriptions of Original Cross-National Sample of School Students Responding to Class Form.

Schools	Country	Students	Classes	Sites
Schools	Australia	1,875	111	14
	USA	885	45	3
	Canada	282	12	9
	England	108	9	2
	Israel	359	15	10
	Nigeria	218	6	2
Total		3,727	198	40

(Fraser & McRobbie, 1995)

Table 2.4

Scales of SLEI According to Moos' Categories

SCALES		
Relationship	Personal development	System maintenance and change
Student Cohesiveness	Open-Endedness	Rule Clarity
	Integration	Material Environment

(Fraser, Giddings, & McRobbie, 1992)

The SLEI consists of 35 statements, seven for each of the five scales as displayed in Table 2.4. The response choices are Almost Never (1) , Seldom (2) , Sometimes (3), Often (4) , Very Often (5). Examples of statements include:

> I use the theory from my regular science class sessions during laboratory activities (Integration)
> We know the results we are supposed to get before we commence a laboratory activity (Open-endedness)

The SLEI is used to measure actual classroom learning environment and preferred classroom learning environment.

The SLEI is economical as an instrument for measuring classroom environments as the 35 items take approximately 15 minutes to administer, fit on a single page and are easy to hand score.

The SLEI was administered individually in both Actual Form and Preferred Form. Students were asked how often each practice actually takes place in the Actual Form and how often they would prefer each practice to take place in the Preferred Form. Sample items include:

> I get on well with students in this laboratory class (Actual Form)
> I would get on well with students in this laboratory class (Preferred Form)
>
> My laboratory class has clear rules to guide my activities (Actual Form)

> My laboratory class would have clear rules to guide my activities (Preferred Form)

Student achievement may be enhanced by modifying the actual classroom environment to more closely resemble the environment preferred by students (Fraser, 1998b). Fraser and McRobbie (1995) found strong positive associations between classroom environment and student attitude.

The SLEI was utilised in 1995 in Israel to assess the effectiveness of chemistry and biology learning environments. The results of this study ultimately led to massive curriculum reform five years later. In both the chemistry and biology groups, students wanted to be more involved in the learning process.

> Altogether students would like their environment to be more cohesive, experiments to be more open-ended and be more integrated in the subject matter, activities to be better organised, rules to be clearer and the provision of a better material environment.
> (Hofstein, Cohen, & Lazarowitz, 1996, p. 111)

The SLEI was translated into Korean and administered to 439 students (Fraser & Lee, 2008). This study found open-endedness and integration to be low in the science classroom.

The Korean education system has a strong emphasis on examinations with little focus on expanding student's potential. Teachers in Korea often provide model answers for students to "learn" for examinations and practical experiments are usually used to merely reiterate a concept rather than as a tool for enhancing creativity.

Lightburn and Fraser (2007) administered the SLEI to 761 high school biology students and found that students' attitudes to science were more positive where there is strong integration between theory and practical experiences, a high amount of student cohesiveness and clearly defined rules.

In Tasmania, Henderson et al. (2000) administered the SLEI to 489 students in Year 11 and Year 12 biology classes and found a strong association between students' attitudes and the classroom environment. Also in Tasmania, Fisher et al. (1997) using the SLEI on 387 students found that physics classes were more open-ended than biology and chemistry, both physics and chemistry classes were more integrated than biology, and chemistry investigations had more rule clarity than physics or biology.

An association between students' learning outcomes and student classroom environment perceptions was found in a study by Fraser and McRobbie (1995) in which 80 high school chemistry students were administered the SLEI (Fraser, 1998a). Students' learning outcomes are enhanced when there is a classroom learning environment which they perceive as being cohesive, integrated, clear in rules and open-ended as well as having an adequate physical (material) environment.

Teh and Fraser (1995) administered the SLEI to 671 geography students in 24 classes in Singapore and also found that there was an association between classroom environment and achievement of students as well as student attitudes (Fraser, 2002). Student cohesiveness and integration displayed strong associations with positive student attitudes in a study conducted by Fraser et al. (1995) as cited in Henderson, Fisher and Fraser (1998) using the SLEI. Wong and Fraser (1995) used the SLEI with chemistry students in Singapore and found that integration and rule clarity were positively related to students' attitudes.

Hofstein, Cohen, and Lazarowitz (1996) found that in both chemistry and biology classes in Israel students prefer more teacher support, and to be more involved in their learning. Students would prefer more cohesiveness, open-ended activities, more integration, better organisation, more rule clarity and improved material environment.

These studies have found associations between classroom learning environments (such as teacher attitudes and behaviour as well as physical factors such as class sizes) and student achievement and attitudes toward science using the SLEI as an instrument.

It is clear that the classroom learning environment is an important factor in achieving quality education. It has also been shown that the type of learning styles students possess is also critical in developing an effective classroom learning environment. Learning styles of students are therefore, discussed in the following section.

2.6 MULTIPLE INTELLIGENCES

"It's not how smart you are but how you are smart." (Gardner cited in Fowler, 2009, p. 2)

All students come into the classroom with a different set of developed intelligences – strengths and weaknesses. These will determine how easy or difficult it is for that particular student to learn information presented in a particular manner. This is referred to as learning style (Brualdi, 1996). Learning style broadly refers to the way in which one processes information. There are many different ways in which learning can take place.

In the 1980s, psychologist Howard Gardner questioned the notion that intelligence is a single entity (Gardner, 1983). He proposed seven intelligences:

- Linguistic intelligence – a feel for language
- Logical-mathematical intelligence – scientific and mathematical thinking
- Musical intelligence – pitch, tone and rhythm
- Bodily-kinaesthetic intelligence – physical skill, being good at sports
- Visual-spatial intelligence –art and design or spatial tasks like map reading
- Interpersonal intelligence – understanding other people
- Intrapersonal intelligence – understanding yourself

Theories describing learning styles and preferences can be very useful to teachers for making generalisations about individual students and responding to these through teaching activities. Not all teachers are aware of these theories but create their own theories and understandings through observations and practical experience. In a study by Smith (2004) some of the teachers in the case study had developed their own theories that closely resembled established theories.

One teacher had developed an understanding of learning very similar to the theory of multiple intelligences but had not heard of Gardner or this theory before.

Gardner's book, *Frames of Mind: The Theory of Multiple Intelligences* (1983) seemed to answer many questions for experienced teachers (Guignon, 2010). It provided somewhat of an explanation for those students who seemed "bright" but did not perform well on tests.

Gardner (2003) defines intelligence as:

- A property of all human beings (all of us possess these seven intelligences)
- A dimension on which human beings differ (no two people – not even identical twins – possess exactly the same profile of intelligences)

"We learn through at least seven different pathways…we should teach each lesson through at least seven different ways" (Pirozzo, 2001, p. 13). These seven different areas consist of numerous activities that nurture each particular field. There are more than just seven ways that teachers should teach their lessons in an ideal world. That is, verbal/linguistic type learning takes place utilising reading, writing, listening, debating, speaking, discussing, telling jokes, making speeches. Logical/mathematical skills are used in calculating, assessing, classifying, estimating, measuring, predicting, hypothesising, using formulae.

Activities such as drawing, painting, designing, visualising, graphing, making models and photography involve visual/spatial skills. Body/kinaesthetic includes sports, miming, acting, performing, building, dancing, role playing, modelling and hands-on activities while musical/rhythmic learners thrive on listening to music, creating rhythms, remembering tunes, producing sound effects and playing instruments. Then there is interpersonal learning which involves sharing, empathising, cooperating and negotiating and intrapersonal skills in reflecting, planning, goal setting and writing diaries (Pirozzo, 2001).

An eighth intelligence has been identified. Gardner discussed the "eighth intelligence" with Kathy Checkley, in an interview for *Educational Leadership*, "The First Seven... and the Eighth." Gardner said,

> The naturalist intelligence refers to the ability to recognize and classify plants, minerals, and animals, including rocks and grass and all variety of flora and fauna. The ability to recognize cultural artefacts like cars or sneakers may also depend on the naturalist intelligence. …(S)ome people from an early age are extremely good at recognizing and classifying artefacts. For example, we all know kids who, at three or four, are better at recognizing dinosaurs than most adults." Gardner identified Charles Darwin as a prime example of this type of intelligence. The naturalist intelligence meshed with Gardner's definition of intelligence as "…the human ability to solve problems or to make something that is valued in one or more cultures.
> (cited in Guignon, 2010).

Table 2.5

Detailed Descriptions of the Types of Intelligence.

Intelligence	Description
Linguistic Intelligence	Involves having a mastery of language; the ability to effectively manipulate language to express oneself rhetorically and poetically; involves using language as a means to remember information.
Logical Intelligence	Consists of the ability to detect patterns, reason deductively and think logically.
Spatial Intelligence	Ability to manipulate and create mental images in order to solve problems; also formed in blind children.
Bodily Intelligence	Ability to use mental abilities to coordinate one's own bodily movements.
Musical Intelligence	Capability to recognize and compose musical pitches, tones and rhythms.
Interpersonal Intelligence	Ability to understand and discern the feelings and intentions of others.
Intrapersonal Intelligence	The ability to understand one's own feelings and motivations.

(Brualdi, 1996)

Briefly, the types of intelligences can be described as:

linguistic intelligence “word smart”;
logical-mathematical intelligences “number / reasoning smart”;
spatial intelligence “picture smart”;
bodily / kinaesthetic intelligence “body smart”;
musical intelligence “music smart”;
interpersonal intelligence “people smart”;
intrapersonal intelligence “self smart”; and
naturalistic intelligence “nature smart” (Armstrong, 1996).

The Grid used in this study uses the original seven intelligences identified by Gardner and does not include the eighth naturalistic intelligence. The original work conducted by Pirozzo (2001) was based on the original seven intelligences and the naturalistic intelligence was therefore excluded in this study.

A summary of the types of careers associated with each of the intelligences is found in Table 2.6 and can be used in the classroom as a tool for assisting students to develop ideas about the usefulness of the types of learning in a wide range of careers.

Table 2.6

Summary of Careers Associated with Multiple Intelligences.

Intelligence	Career
Linguistic Intelligence	Poet, journalist, writer, teacher, lawyer, politician, translator
Logical Intelligence	Scientist, engineer, computer programmer, researcher, accountant, mathematician
Spatial Intelligence	Navigator, sculptor, visual artist, inventor, architect, interior designer, mechanic, engineer
Bodily Intelligence	Athlete, physical education teacher, dancer, actor, firefighter
Musical Intelligence	Musician, disc jockey, singer, composer
Interpersonal Intelligence	Counsellor, salesperson, politician, business person
Intrapersonal Intelligence	Researcher, theorist, philosopher

(Bogod, 1998)

Using the multiple intelligences in the classroom "makes learning personal, purposeful, meaningful and relevant and gives the brain reason to pay attention, understand and remember." (Fogarty 1998 p. 657 as cited in Bailey, 2005).

Gardner (1995) argued for pluralist intelligences where no one intelligence was more or less important than another, whereas, schools traditionally focus attention on linguistic and logical-mathematical intelligences. Some children are labelled with learning difficulties if their unique way of learning is not addressed (Armstrong, 1996).

Bailey (2005) identified two types of individuals. Prodigies and idiot savants – prodigies are individuals who display extreme accomplishments in certain areas (e.g., chess, mathematics, music or other disciplines) from a very young age, but have unexceptional abilities in other areas. Idiot savants in comparison have low IQs yet display remarkable skills in a particular domain. For example, drawing with great accuracy or figuring out whether March 15, 2018 will fall on a Wednesday (Gardner, Kornhaber, & Wake, 1996 as cited in Bailey, 2005).

The theory of multiple intelligences suggests that teachers be trained to present their lessons in a wide variety of ways using music, cooperative learning, art activities, role play, multimedia, field trips, inner reflection and much more (Armstrong, 1996).

> Multiple intelligence theory proposes that it is more fruitful to describe an individual's cognitive ability in terms of several relatively independent but interacting cognitive capacities rather than in terms of a single "general" intelligence. (Moran, Kornhaber, & Gardner, 2007 p. 26)

The analogy that the types of intelligences can be compared to Lego building blocks describes the types of structures that can be built using only one type of block in comparison to using many different types of building blocks (Moran, Kornhaber, & Gardner, 2007). This emphasises the fact that what can be achieved in the classroom is only limited by the teacher's ability to utilise activities that call upon the use of as many of the intelligences as possible.

Unfortunately, policy and funding currently develop curriculum that favour primarily linguistic and mathematical intelligences. The types of intelligences can interact with one another in the classroom learning environment and in almost all career paths. For example, a dancer utilises musical, spatial and bodily intelligences; a waiter needs linguistic, spatial, interpersonal and bodily intelligences; and a marine biologist combines naturalistic and mathematical intelligences (Moran, Kornhaber, & Gardner, 2007). Employers in most organisations place great value on teamwork yet many teachers have reservations about utilising cooperative group work in the classroom due to classroom management issues that may arise (Lowe, 2004).

Pimthong, et al. (2009) conducted a study to improve the teaching of matter to Grade 6 students in Thailand. A unit of work was developed utilising teaching strategies such as models, role play, experiments, and questioning. The study found that the teaching activities challenged and encouraged students and the student-teacher interactions were positive. In addition, teachers needed to improve their pedagogical methods as well as develop their content knowledge.

Project-based learning (PBL) is an instructional approach developed in the USA in which science concepts are explored around a central question of a real-world situation (Rogers et al., 2009). The idea of using a central theme to teach several concepts is one method that can be used to produce a learning environment that caters for the learning styles present in a classroom. The following section explores in detail methods of modifying classrooms in order to increase motivation of both students and teachers.

2.7 MODIFYING CLASSROOMS

There seems to be a relationship between a decrease in student motivation and enthusiasm in science classrooms and an increase in age (Simpson & Oliver, 1985; Anderman & Young, 1994; Osborne, Simon, & Collins, 2003). This poses the question: How can teaching be modified to produce learning environments that cater for preferred learning styles? An increase in classroom behaviour management issues around the age of Year 9 students could be related to teachers not creating suitable learning environments and by creating such environments these discipline problems may be avoidable.

Hassan and Fisher (2005) identify two main ways to motivate students to learn. First, by maintaining science as a useful career that is not difficult and is learnable and second, to make science more relevant to students' everyday life.

Students take an active role in constructing new knowledge. In order for students to undertake meaningful learning and integrate new knowledge with existing knowledge, they need to perceive the learning tasks as valuable. When classroom learning activities are perceived to be meaningless, surface learning strategies such as memorisation are employed by students (Tuan, Chin, & Schieh, 2005).

Chandra and Fisher (2009) recorded some comments made by students referring to a web-based learning *Getsmart* program:

- *There are diagrams and well planned notes to help you understand and interpret the work.*

Students learn in different ways and by providing information and learning environments in a variety of ways such as diagrams and notes that are concise and well planned can increase students' achievement and following on from an increase in achievement and understanding, an increase in motivation.

- *I must admit, however, that the chat sessions were quite helpful. They forced me to keep up with the work being covered in class and presented some more stimulating questions*.

Providing a classroom learning environment in which students have access to active discussions with their peers can be beneficial in improving the classroom learning environment.

- *Lessons...are easier to understand and comprehend because you can read it at your own pace and you do not have to listen to a teacher mumble on*.

This comment emphasises the fact that many students do not learn from just "listening" but need to be exposed to a variety of methods in order to be stimulated in the classroom learning environment.

Allowing students some choices in the types of activities in the classroom that are suitable to their interests and preferred learning styles is one way of increasing the motivation to learn in the classroom.

Another important factor to try to minimise lack of motivation in secondary school science is to create "topics" that are relevant to the students.

Creating meaningful learning tasks that are relevant to students' everyday life experiences and building upon these over time could be achieved with a continuum of learning with programs written in themes as presented in Figure 2.3

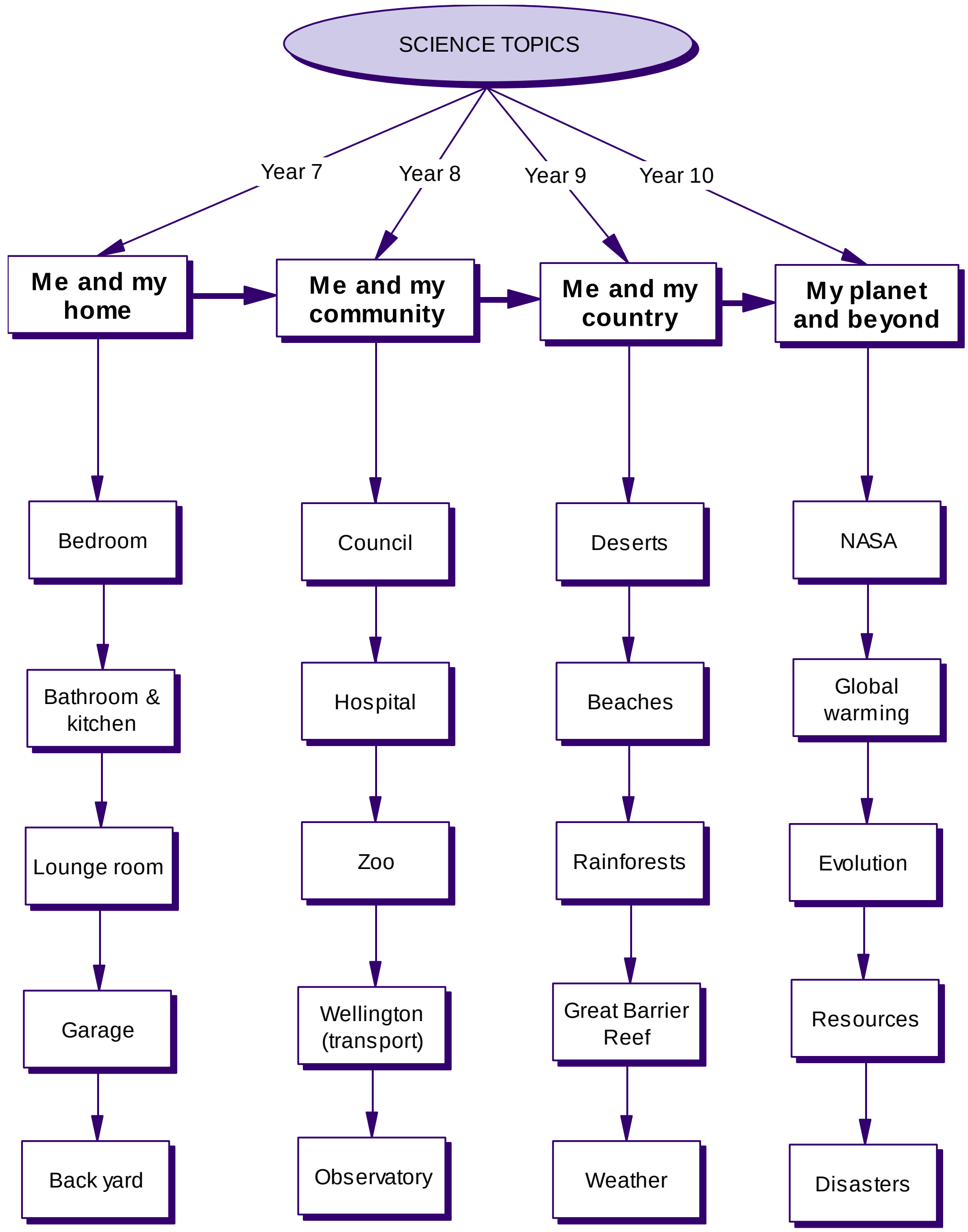


Figure 2.3. Continuum of learning.

This idea has a general theme for each Year level that can be expanded upon as the students go through school. That is, in Year 7 students study Me and My Home for the entire year. There are five topics throughout the year (incorporating different places around the home) and students would investigate the science in each topic.

For example, Backyard could include some work on living things, ecosystems, geology, stars and planets, water and the list is endless and only limited by the teacher's imagination. The theme for Year 8 could expand outside the home and into the community.

The topics for the year could be written to suit the geographical location of the school, for example, this idea (above) could be used in Dubbo, New South Wales. Alternatively, this general idea could be used in all schools across Australia as a basis for writing programs in science.

Developing classroom learning activities that cater for the range in learning styles present in the classroom is one method of improving student interest in science. Offering a suite of a la carte activities that cater for each of the learning styles is a good starting point (Schaller, 2007).

During a First Aid course recently attended the presenter utilised various methods of instruction to the participants. The usual method of presenting a First Aid course, from experience, has been reading overheads and listening to a speaker. This presenter catered for most of the types of intelligences in her presentation of the course by using the following strategies:

- spoke to the whole group in a circle (verbal/linguistic intelligence),
- called upon a small group of volunteers to simulate CPR (visual/bodily Intelligences),
- paired up the participants to complete hands-on CPR (bodily intelligence),
- developed a whole group accident scenario (interpersonal intelligence),
- utilised laminated cards with coloured pictures of animals for bites and stings with four letters on the white board in which participants called out answers when each picture was held up (visual and verbal intelligences as well as bodily intelligence for catching the chocolate),
- small group activity sitting at desks matching cards with Velcro into a book describing the signs and symptoms of various illnesses (logical intelligence),
- lastly a pen and paper multiple choice test to end.

This course was not only interesting but also enjoyable and memorable. The more ways a topic is presented to an audience, the more effective the presentation will be (Fowler, 2009). Everyone learns differently therefore if a topic is presented with several learning types in mind, then the audience (or students in a classroom situation) should be able to relate to at least one of the methods.

Whatever is being taught, the teacher should attempt to connect it with:

- Words (linguistic intelligence)
- Numbers or logic (logical-mathematical intelligence)
- Pictures (spatial intelligence)
- A physical experience (body-kinaesthetic intelligence)
- Music (musical intelligence)
- A social experience (interpersonal intelligence)
- Self-reflection (intrapersonal intelligence) and / or
- An experience in the natural world (naturalist intelligence)

(Armstrong, 1996).

Multiple Intelligence theory suggests that all eight intelligences are needed and are equally important. This is in conflict with tradition views of education where linguistic and logical intelligences dominate. The implication for education is that teachers should teach to a broader range of talents and skills (Brualdi, 1996).

Hofstein (2010) identified a common theme among science education:

> The content of school science and its related pedagogical approaches are not aligned with the interests and needs of both society and the majority of students (Hofstein, Eilks, & Bybee, 2010, p. 1).

Hofstein (2010) described the need for socio-scientific ideas to be introduced into the science curriculum. *Popularity and Relevance (of) Science Education (for scientific) Literacy* (PARSEL) project developed about 60 different modules for teaching science across eight different countries. These modules were designed to make science learning more relevant to students and to increase student interest in science.

The modules were written around themes such as Milk: Keep It Refrigerated. It was found that the main barrier to implementing these student-centred modules was that the teachers were placed in an unfamiliar situation. Most teachers had not been exposed to these methods of instruction both during pre-service training and professional development. Teaching modules with a theme relevant to everyday life also involves time in researching areas such as economics, politics, nutrition, and the environment.

In a school in Indiana, the idea of teaching to a theme is visible in a second-grade classroom (Page & Coppedge, 2004). Three areas stand out: the classroom environment, the use of thematic teaching, and the hands-on teaching approach. The physical environment is set up as a forest for the entire year using colours, shapes, and objects found in a forest as well as puppets, stuffed animals, and even live animals. A branch is hung from the ceiling with an empty hornet's nest; logs and stumps are arranged in one corner in a semi-circle around the painted cardboard tree with students names painted on the leaves. The thematic approach taken by the teacher is a forest theme with different concepts being explored throughout the year including animals from different countries (geography), the concept of nocturnal (language), and nature stories. The teacher brought in a frog to demonstrate the concept of camouflage and had students lie on their backs and imagine being a frog and "act out" a story as told by the teacher. Page and Coppedge (2004) explain that it was "difficult to determine where the science started and where it ended".

In Australia, there would be few classrooms set up as vividly as the forest mentioned above. Teachers need to develop classroom learning environments that utilise a thematic approach especially in the upper primary and early to middle secondary years of schooling (Year 5, Year 7 and Year 9) in science.

In a report on a study on the effectiveness of the *Getsmart* teacher-designed website on Australian students' perceptions of the classroom learning environment, Chandra and Fisher (2006) noted that many students find science boring and irrelevant. The school system does not engage learners effectively and as such students tend to have a "where will I use this" attitude towards science.

The content taught in most science classrooms is still based on the "Moses model' where the content is conveyed by the teacher and students are expected to memorise and regurgitate the information.

> There is little to gain by working to improve students' orientations to learning, and much to gain by improving the ways that classrooms operate (Sullivan, et al., 2009, p. 182).

Developing effective professional development programs for teachers is one method for implementing educational change. In order for teachers to modify their attitudes and the way in which their classroom learning environments are structured, teachers need to be given the necessary tools to implement changes. The development of professional development programs for teachers is a major challenge in many countries (Klieger & Bar-Yossef, 2009).

Kellner, Gullberg, et al., (2009) discussed *pedagogical content knowledge* (PCK) for prospective teachers. That is, pre-service teachers need to consider how to make a topic comprehensible to students. The report states that prospective teachers' pre-conceived ideas about teaching could prevent them from considering ideas that are unknown. These notions could be explored and used in teacher education programmes.

2.8 CHAPTER SUMMARY

The Australian Prime Minister, Julia Gillard announced on Tuesday, May 3rd 2011 in the media that the *Best teachers (are) to be financially rewarded*. Based on this comment, she revealed that teachers' performance are going to be measured using lesson observations, students test results, feedback from parents, qualifications and professional development. Rewarding teachers is a positive step, however comparing student test scores in order to label a teacher as a "good teacher" could create classroom learning environments where the emphasis is on achieving high test scores rather than cooperative learning environments which allow students the freedom to flourish, explore and develop their own individual interests.

Australia's education system introduced the National Assessment Program – Literacy and Numeracy tests (NAPLAN) for Years 3, 5, 7 and 9 in 2008. There are also National Assessment Programs for Science Literacy (SL), Civics and Citizenship (CC) and Information and Communication Literacy (ICTL) administered three-yearly. In New South Wales, the Basic Skills Test (BST), English Language and Literacy Assessment (ELLA) and Secondary Numeracy Assessment Program (SNAP) have been replaced by the NAP assessments. While using national tests is important in making comparisons between students, a strong emphasis on test scores could create classroom learning environments that are teacher-centred, examination focussed and boring for students. In Taiwan, there is a great emphasis on student scores in examinations thus creating a highly competitive teaching environment with considerable pressure placed on teachers from principals, parents and their peers (Aldridge, Fraser, & Taylor, 2000).

The theory of multiple intelligences is currently being utilised in hundreds of schools across Australia to modify classroom practices. The challenge is to develop curriculum policies and develop pedagogies that utilise this theory in all classrooms in order to make the classroom learning environment enjoyable, interesting and memorable to students (Armstrong, 1996).

The New South Wales Department of Education and Training (DET) developed the *Our Middle Years Learners – engaged, resilient, successful: An Education Strategy for Years 5 to 9, 2010 – 2012* strategy. This is an acknowledgement that the Middle Years (Years 5 to 9) which are taught in Primary School (Years 5 and 6) and Secondary School (Years 7 to 9) involve significant differences in learning environments. This strategy is an attempt to rectify this situation and support the students in these age groups by providing challenging and cohesive curriculum, foster creative thinking where students extend their learning beyond the classroom and into the real world context, and implement Connected Outcomes Groups (COGs) across key learning areas.

The strategy aims to improve the continuity of learning, implement integrated curriculum strategies in the classroom, and improve the quality of teaching occurring in the middle years. The DET recognises:

> That we need to understand and adapt the ways in which we teach, guide, encourage and relate to these students within the context of our growing knowledge about how they develop, think and learn. We must also respond to the technologies that are increasingly shaping their lives and defining 21^{st} Century learning environments (DET, 2010 p. 15).

This study used the SLEI and a Grid based on multiple intelligences to identify the preferred science classroom environment of students in Years 5, 7 and 9. The following chapter describes the methods used in this study in order to develop strategies that can be used to improve the classroom learning environment and therefore increase the motivation of science students across these ages.

CHAPTER 3

METHODOLOGY

3.1 INTRODUCTION

The curriculum in science and the pedagogical practices employed by some teachers in science classrooms have led to a decrease in enthusiasm for science in many Australian schools. The interests of students and the teaching methods are not aligned with the content of school science for the majority of students. Most students do not find the science classroom interesting and motivating (Hofstein, Eilks, & Bybee, 2011).

The identification of the preferred learning styles and preferred learning environment of students can assist teachers to improve the classroom environment by catering for learning styles. Modifying lessons to cater for students' preferred learning styles could lead to an increase in student motivation in science.

Improvements in student motivation could lead to improved student attitudes toward science.

Improved attitudes toward science could lead to a decrease in discipline problems.

Increased motivation and an improvement in student attitudes could lead to an increase in the number of students electing to study sciences in senior school and at tertiary level.

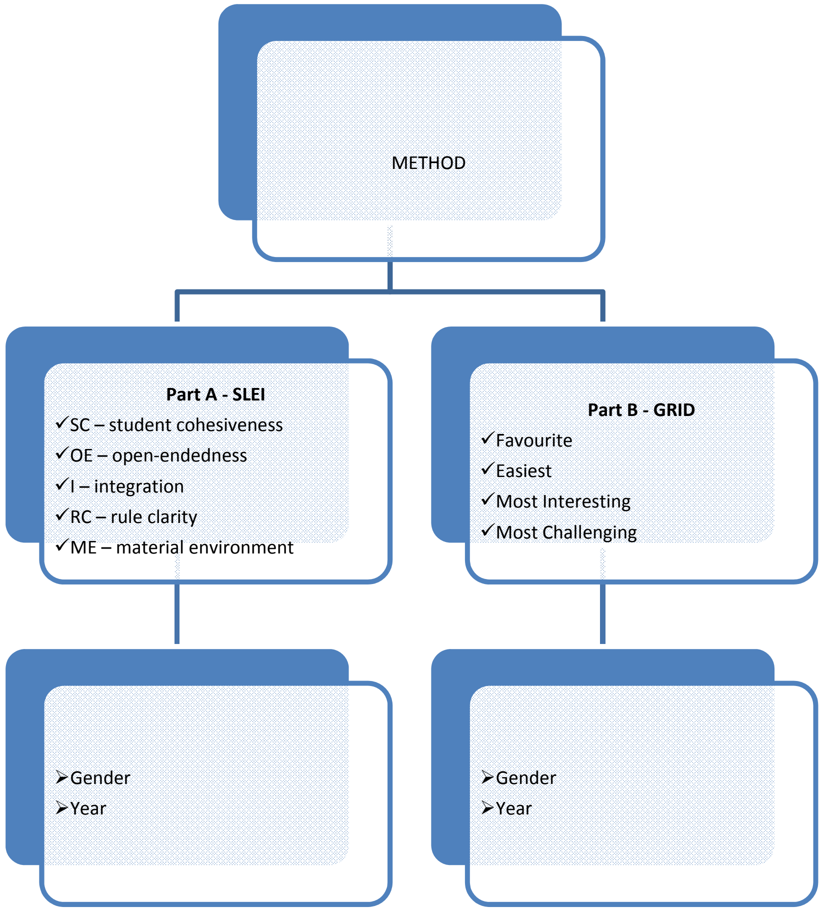


Figure 3.1. Method overview.

Figure 3.1 summarises the method used in this study in order to determine the preferred learning environment and the preferred learning styles (and types of activities) of students in Years 5, 7 and 9 in order to improve the interests of students in science. This study involved two parts: Part A used the SLEI as an instrument to measure the preferred classroom learning environment of students and Part B involved a Grid based on Multiple Intelligence theory to measure and record the preferred learning styles (in terms of classroom activities) of students across these three age groups. The Grid was based on the work of Pirozzo (2001) and gave students a range of learning activities covering seven types of intelligences in which to choose their most preferred 15 from.

3.2 RESEARCH QUESTIONS

The overall aim of the study described in this thesis asks whether there is a difference between the preferred learning environment and the preferred learning styles of Year 5, Year 7 and Year 9 students in science; whether gender plays a role in preferred learning environment and preferred learning styles; and how actual classroom environments can be structured to cater for these preferred learning environments and preferred learning styles in science across these three ages. To achieve this, the following research questions were proposed:

1. How do the actual and preferred learning environments change across the Years 5, 7 and 9 age groups?
2. How does the preferred learning style change across these three age groups?
3. Does gender play a role in:
    a. the preferred learning environment of students at these ages? (SLEI)
    b. the preferred learning style of students at these ages? (Grid)
4. How can actual classroom learning environments be structured to cater for students' preferred learning environment and preferred learning styles across these ages?

Tuan, Chin, and Shieh (2005) found that when students take an active role in their learning they will be more engaged. It was found that teaching strategies, including presenting material that is relevant, stimulated students' motivation to learn in the science classroom.

The SLEI was chosen as an instrument in Part A of the methodology as it directly measures the actual and preferred learning environments of students. The research questions investigate the actual and preferred learning environments of students across Years 5, 7 and 9. The SLEI is an instrument that measures preferred learning environments specifically in science as this study is specifically concerned with the learning occurring in the science classroom across these ages.

The Grid was chosen as a method for measuring preferred learning style in Part B of the methodology as it is designed using the multiple intelligences specifically. It offers a quick way to measure the preferences students have for various activities that are directly linked to the learning style. The research questions investigate the learning styles of students across Years 5, 7 and 9 and the Grid provides a direct measure of this.

The methods chosen in this study were quick to administer and both the SLEI and the Grid were direct measures of preferred learning environments and preferred learning styles of students in the science classroom, respectively. These instruments are discussed in more detail in the following section.

3.3 INSTRUMENTS

There is consistent evidence from the studies discussed in the previous chapters to indicate that there is an association between students' perceptions of their classroom learning environment and their motivation and interest in the subject. Therefore, in keeping with this line of educational research, the preferred classroom learning environments of students were investigated in this study. However, unlike previous studies in this field of research, this study investigated preferred learning environment of students across the "middle years" of schooling (Years 5, 7 and 9) using the SLEI and also added the use of a Grid to add the dimension of the preferred classroom activity of students across these ages. This study centres on the age groups of Year 5, Year 7 and Year 9 to compare the preferred learning environment and the preferred learning style with the aim of making practical improvements to the quality of learning occurring in the science classroom.

The research questions were investigated by using the SLEI in Part A and the Grid in Part B. The SLEI identifies student perceptions of the actual and preferred classroom learning environment based on five scales: SC (Student Cohesiveness), OE (Open-Endedness), I (Integration), RC (Rule Clarity), and ME (Material Environment). The responses for these five scales were compared across the three age groups: Year 5, Year 7 and Year 9 students and gender differences compared.

The Grid based on a cooperative learning unit developed by Pirozzo (2001) gave students the opportunity to select preferred classroom activities.

This was used to find out if there are any general trends across Year 5, Year 7 and Year 9 and any gender trends in terms of most popular activities and hence preferred learning styles to assist teachers create classroom learning environments that suit the preferred learning styles of their students. These two instruments are now described in more detail in the following sections.

3.3.1 SLEI

The SLEI consists of 35 items. Students indicate their perceptions on response sheets, using a five-point Likert scale format. Scoring involves the numbers 1, 2, 3, 4, and 5 for the responses Almost Never, Seldom, Sometimes, Often, and Very Often. However, some items have a negative meaning which means the scoring was reversed (Kijkosol & Fisher, 2008, p. 291). Students indicated their class (age) and gender at the beginning of the questionnaire by circling the appropriate response.

Table 3.1 provides descriptive information about each of the five scales of the SLEI together with sample items.

Table 3.1

Descriptive Information and Sample Item for Each Scale of the SLEI

Scale name	Description of scale	Sample item
Student Cohesiveness (SC)	Extent to which students know, help and are supportive of one another.	I get on well with students in this science class.
Open-Endedness (OE)	Extent to which the laboratory activities emphasise an open-ended, divergent approach to experimentation.	There is opportunity for me to pursue my own science interests in this laboratory class.
Integration (I)	Extent to which the laboratory activities are integrated with non laboratory and theory.	What I do in my regular science class is unrelated to my laboratory work.
Rule Clarity (RC)	Extent to which behaviour in the laboratory is guided by formal rules.	My laboratory class has clear rules to guide my activities.
Material Environment (ME)	Extent to which the laboratory equipment and material are adequate.	I find that the laboratory is crowded when I am doing experiments.

(Kijkosol & Fisher, 2008, p. 290)

In Part A of the methodology, the SLEI (actual and preferred) was administered to 59 Year 5 students by their classroom teachers and to 113 Year 7 and 113 Year 9 students by their science teachers in their science classes. Questions were read out in some cases in an attempt to offer a better understanding to those students having difficulty interpreting the statements. The results obtained in Part A were used to compare the preferred and actual learning environments between the ages and between genders. The word "lab" was replaced with "science lesson" verbally for the Year 5 participants as they were not familiar with studying science in a lab at this school.

Each of the 570 sheets (285 actual and 285 preferred) were firstly scored down the side (1, 2, 3, 4 or 5 written for each item and reversed for items number 3, 5, 6, 8, 9, 15, 20, 23, 24, 25, 26, 27 and 33). Secondly, the totals were recorded on the bottom of each sheet for SC, OE, I, RC and ME (by adding the scores for items 1, 6, 11, 16, 21, 26 and 31 for SC; totalling items 2, 7, 12, 17, 22, 27 and 32 for OE; adding up items 3, 8, 13, 18, 23, 28 and 33 for I; adding items 4, 9, 14, 19, 24, 29, and 34 for RC; and adding items 5, 10, 15, 20, 25, 30 and 35 for ME). The totals for SC, OE, I, RC, and ME from each of the 570 sheets were entered into a spreadsheet which included the students age and gender.

For examination of the validation of questionnaires, Cronbach alpha reliability coefficients as indices of scale internal consistency were estimated and mean correlations between the scales for the SLEI were also investigated as a measure of discriminant validity. Cronbach alpha has been used extensively in learning environment research and hence was used in this study. The Pearson correlation was used to measure the strength of the relationship between each scale with the other scales within the SLEI, and analysis of variance (ANOVA) was used to determine the ability of each of the scales of the SLEI to differentiate between the perceptions of students in different classes (Kijkosol & Fisher, 2008, p. 291).

All data collected from the SLEI sheets were entered on an Excel spreadsheet and re-checked for accuracy. Two assistants hand scored the SLEI and recorded the total on the sheet and assisted with data entry into the Excel spreadsheet. Students' age and gender were also recorded and entered into the spreadsheet.

3.3.2 Grid

The Grid (Appendix 3) was a table containing various activities under several sub-headings (1 – Rocks, 2 – Fossils, 3 – Earthquakes, 4 – Volcanoes, 5 – Cyclones) to cover the content area for a Unit on Natural Events.

The activities were based on Multiple Intelligence model of types of intelligences:

Table 3.2

Overview of Grid

Intelligence	Sub-heading
A – Verbal/ Linguistic	Poster
B – Verbal/ Linguistic	Speech, story of newspaper article
C – Logical/ Mathematical	Flowchart, design an experiment...
D – Visual/Spatial	Draw maps, charts...
E – Body/ Kinaesthetic	Build a model, board game...
F – Musical/ Rhythmical	Dance, write a song...
G – Interpersonal	Interviews...
H – Intrapersonal	Predict, describe...

Students were given the choice of learning activities using the Grid. They were asked to select 15 tasks in total – one from each column (content sub-headings) and no more than three from each row (type of intelligence). This limitation was imposed in order to allow students to engage in a variety of learning activities and the various topics needed to be covered for the particular unit (in this case, Natural Events). The choices made for each age and gender were recorded and compared.

A sample of students from Years 7 and 9 (27 Year 7 students and 31 Year 9 students) were asked the following questions:

1. Which Activity would be your favourite? Why?
2. Which Activity would be the easiest? Why?
3. Which Activity would be the most interesting? Why?
4. Which Activity would be the most challenging? Why?

Year 5 students were not asked these questions due to time restrictions.

The total number of students who selected each activity were tallied and recorded using an Excel spreadsheet that had all 40 activities labelled across the top and all 285 students numbered down the side. The data were entered and then totalled for each age group and gender. The results obtained in Part B were used to compare preferred learning styles between the ages and between genders.

3.4 DATA GATHERING

3.4.1 Ethics

Permission was granted (Appendix 4) from the New South Wales Department of Education and Training State Education Research Approval Process (SERAP number 2007126) using SERAP form K. The benefits of this study were outlined as:

> In ascertaining the preferred learning styles of Years 5, 7 and 9 students in Science teachers can create science learning environments that are conducive for effective and enjoyable learning to take place – increasing student and staff motivation and decreasing possible behavior problems.

This study contributes to the goals and strategies of the New South Wales Department of Education by assisting in identifying the preferred learning environment of students across the Middle Years in order to:

support enhanced learning through innovative and more flexible ways of using learning environments to provide engaging learning experiences and respond to the needs of students in a local context (SERAP Form K).

This study also met the requirements of the New South Wales Department of Education and Training:

- School Principals have the right to withdraw the school from the study at any time. The approval of the Principal for the specific method of gathering information for the school must be sought.

The Principals from each of the schools used in this study were met for a face to face discussion of the study being conducted after receiving a letter seeking permission to…

> Conduct this study using some of the students from your school. This would involve Year 5 students:
> **Part A**: completing two surveys (one for actual classroom learning environment and one for preferred classroom learning environment) in regards to their Science lessons and
> **Part B**: selecting preferred classroom activities from a grid.
> I would envisage the completion of these items would take approximately **30 minutes**.

The SLEI actual and SLEI preferred and the Grid were presented at the interviews with the Principals.

- The privacy of the school and the students is protected.

The schools and students used in this study are to remain anonymous.

- The participation of teachers and students must be voluntary and must be at the school's convenience.

The classroom teachers of the Year 5, Year 7 and Year 9 students used in this study administered the SLEI actual, SLEI preferred and the Grid during class time at their convenience.

- Any proposal to publish the outcomes of the study should be discussed with the Research Approvals Officer before publication proceeds.

Publication of the outcomes of this study would be discussed with the Research Approvals Officer if publication was to occur.

Approval was also granted (Appendix 5) through Curtin University Human Research Ethics Committee (approval number RD-12-07). Written consent forms (Appendix 6) were obtained from the participants and their parents. To protect confidentiality, the names of the people involved and the names of the schools have not been used.

As the participants were minors (under 18 years of age), the circumstances in which the surveys took place provided for the safety of the students (as they occurred in the classroom situation). Participation was entirely voluntary and consent was obtained as mentioned above.

Privacy and confidentiality were maintained and data has been stored in a secure location for five years. Access to data has been restricted to the researcher, assistants and supervisors, and all participants signed a consent form and were given an information sheet (Appendix 7) which included the following note:

- Your involvement in the research is entirely voluntary.
- You have the right to withdraw at any stage without it affecting your rights or my responsibilities.
- Your privacy is greatly respected and any information that could identify you will be removed.
- You will be asked to complete a consent form.
- All information will be stored confidentially for 5 years. After this time, the information will be destroyed.

Both the New South Wales Department of Education and Training and the Curtin University research committees found the research design acceptable by providing approval.

The general research question asks whether there is a difference between the preferred learning styles of Year 5, Year 7 and Year 9 students in science. This study investigated how students' perceptions of, and attitudes toward, science change across these three age groups by using the SLEI questionnaire and the Grid on some students from public schools in Dubbo, New South Wales. The data sources are outlined more specifically in the following section.

3.4.2 Data Sources

Dubbo is a town in Central New South Wales approximately five hours drive from Sydney. Dubbo is about half way between Melbourne and Brisbane. The population of the town was approximately 38,000 people in 2007 when the data were collected (Australian Bureau of Statistics, 2007). 21% of the population were aged between 5 and 17 years (school age).

The Dubbo schools were selected for this study mainly due to access to these schools but also due to a personal interest in science education itself. There was a reform of the secondary school system in 2000 which invoked interest in research as well as having been a student and a teacher in Dubbo.

Average household incomes for the largest groups of people (11.3% and 11.5% respectively) is between \$500 - \$649 per week and between \$1000 - \$1200 per week (Australian Bureau of Statistics, 2007). This indicates that most families are earning either \$500 - \$649 per week or double that amount. Most of the population (46.3%) are either Professionals (16.7%), Technicians and Trade workers (15%) or Clerical and Administrative Workers (14.6%).

In terms of education, Figure 3.2 shows the breakdown of the qualifications obtained by the people who live in the town. The majority of people in Dubbo have no qualification which may contribute to the little interest displayed by students in the Middle Years in science at school (Australian Bureau of Statistics, 2007).

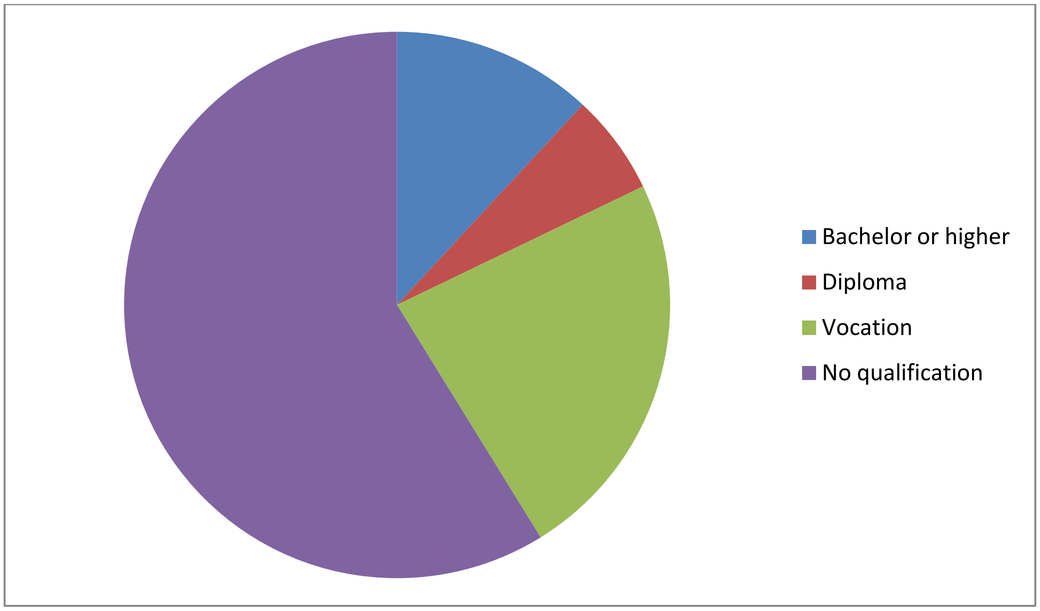


Figure 3.2. Education of people in Dubbo, New South Wales.

In science, there has been a vast array of changes to the curriculum. The New South Wales science syllabus has had the most changes of any of the 150 or so syllabuses in New South Wales. The Stage 4/5 science syllabus (Stage 4 being years 7 and 8 and Stage 5 being years 9 and 10) had dramatic changes take place in 1998 in conjunction with the "new" standards-based curriculum. It was updated again in 2005 for Year 7 and 9 and in 2006 for Years 8 and 10 (New South Wales Board of Studies, 2007).

In this study, students from Year 5/6 at a local Department Primary School (59 students in total – 34 males and 25 females) and students in Years 7 (113 students – 61 males and 52 females) and Year 9 (113 students – 53 males and 60 females) from a local Department Secondary School were used to complete the SLEI (actual), SLEI (preferred) and the Grid. This gave a balanced view of gender with 51.9% of participants being male and 48.1% female.

In Dubbo, an independent consultant conducted an investigation into the Middle Years of schooling in the town (Kennedy, 2010). This was in response to parent and teacher concerns regarding the effectiveness of a model that had been adopted in 2000 which turned three separate high schools into one "Dubbo College" which consisted of two junior campuses (Years 7 – 9) and one Senior College (Years 10 – 12) on a site next to the Charles Sturt University campus and near Dubbo College of TAFE. The idea was to provide the senior students with greater access to University and TAFE subjects during their Higher School Certificate (HSC) but concerns have been raised about the quality of learning taking place in the junior campuses.

Smart Outcomes Educational Consultancy (2010) found an immediate need to address student engagement and teacher quality in the junior campuses.

> There is a view within the school community and some sections of the wider Dubbo community that student behaviour on the junior campuses is of considerable concern...there was a very consistent message from staff that student behaviour was a constant irritant and disrupted effective teaching and learning. Teachers felt overwhelmed by the constancy of dealing with junior classes in which there were persistent behaviour incidents (Kennedy, 2010, p. 30).

It was suggested that cross-subject units of work be developed as well as more support and training be provided for the teachers in the junior campuses. Kennedy acknowledged the advantage of having Years 7 to 9 on one campus as:

> an outstanding opportunity for flexible approaches to middle schooling and student engagement to be implemented. The proximity of the partner primary schools, lack of a school certificate year and the relatively small class sizes could spawn a whole range of innovative, flexible approaches to meeting the needs of and engaging adolescent learners through well researched and proven middle schooling strategies (Kennedy, 2010, p. 48).

3.5 DATA INTERPRETATION

The quantitative data analyses for Part A using the SLEI involved obtaining reliability using the Cronbach alpha value:

$$\propto = \frac{N\,\bar{\rho}}{1 + \bar{\rho}\,(N - 1)}$$

N = the number of total items being tested

$\bar{\rho}$ = average of the correlation between each pair of items

$\propto$ (alpha) has an upper bound of 1 therefore the closer the result is to 1 the higher the reliability of the scale

Comparisons were then made between each scale of the SLEI with the other four scales using Pearson correlation. This measures the strength of the linear relationship between two variables. It is signified by ρ (rho) and can be -1.0 to +1.0 where -1.0 is a perfect inverse correlation (that is, as X increases, Y decreases), 0 is no correlation and +1.0 is a perfect positive correlation.

A one-way analysis of variance (ANOVA) was used to test for differences across the scales in classroom environment. The F statistic was used to determine the ratio of variance between groups to the variance within groups. The F statistic comes from the mean square (mean squared deviations from the mean) between groups divided by the mean square within groups. It was found that the means differ, (for both gender and across the years) but this does not indicate how they differ. Therefore, post-hoc tests were carried out on the data in order to obtain where the differences occur.

The post-hoc test selected was Tukey HSD (Honestly Significant Difference) which gave comparisons of the mean scores in order to determine more specifically where differences occurred.

The means and standard deviations for each age group across the five scales of the SLEI actual and SLEI preferred were compared in order to determine the preferred learning environment in terms of the five scales that the SLEI measures for each age group. The means and standard deviations for each gender were compared for each of the five scales that the SLEI measures in order to determine gender differences in the preferred learning environment of males and females.

Part B of the methodology involved tallying up the number of activities that students of each age and gender selected from the Grid. Comparisons were made between:

- activities selected by Year 5, activities selected by Year 7, and activities selected by Year 9 students (age comparisons);
- activities selected by males in total and activities selected by females in total (gender comparisons); and
- activities selected by males and females in Year 5, males and females in Year 7, and males and females in Year 9 (gender comparisons across the ages).

The responses were tabulated from the 27 Year 7 students and 31 Year 9 students to the questions:

1. Which Activity would be your favourite? Why?
2. Which Activity would be the easiest? Why?
3. Which Activity would be the most interesting? Why?
4. Which Activity would be the most challenging? Why?

Table 3.3 displays an extract of the table used to collate the responses to the questions above. Each activity number and description was recorded and the responses were written in each box. The total numbers for each activity selected by each age group and for each gender were totalled and comparisons were made.

Table 3.3

Extract of Table used for Responses

Question	Year	Gender	Activity	Responses
Favourite	7	M	4E model volcano	*Blow up*
	7	M	4A poster	*I like designing posters*
Easiest	7	M	4C classify volcanoes	*Sounds like no writing whatsoever*
	7	M	3G earthquake interview	*Mum has been in one*
Most interesting	7	M	4E model volcano	*Sounds easy*
	7	M	5D compare cyclones to twisters	*Going to be fun*
Most challenging	7	M	2F create a dance	*I am not a good dancer*
	7	M	1H predict earth in future	*Don't know the answer*

The total numbers of each activity chosen by the students were compared for each question (favourite, easiest, most interesting and most challenging).

3.6 CHAPTER SUMMARY

The methods selected in this study were used for the purpose of investigating the preferred learning environment and preferred learning style of students in Years 5, 7 and 9 in science. The SLEI was quick to administer and simple to score and the Grid provided an interesting insight into the types of classroom activities that students prefer to engage in specifically.

This chapter provides an overview of the instruments used, the data gathering techniques employed (including ethics approval and data sources) and a brief overview of data interpretation. The following chapter reports on the results obtained in more detail.

CHAPTER 4

RESULTS

4.1 INTRODUCTION

This study investigated how students preferred learning environment and preferred learning styles change across Years 5, Year 7, and Year 9, whether gender plays a role in the preferred learning environment and preferred learning styles of students at these ages, and how the classroom learning environment can be structured to cater for students' preferred learning environment and preferred learning styles. As described in Chapter 3, the methods used involved the SLEI in Part A and The Grid in Part B.

Section 4.2 discusses the reliability of the data using Cronbach alpha reliability (internal consistency), mean correlations of each scale with the other four scales (discriminant validity) and the ability of each scale to differentiate between the perceptions of students in different classrooms using analysis of variance (ANOVA). This section presents the mathematical methods used to calculate mean correlations and eta^2 and concludes with a comparison of the overall means of the five scales for actual and preferred classroom learning environments.

Section 4.2 goes on to present the data tables and discuss the results for each of the following:

- ratio of variance between groups to the variance within groups (F statistic), means and standard deviations, and Tukey HSD results for year difference SLEI actual;
- ratio of variance between groups to the variance within groups (F statistic), means and standard deviations, and Tukey HSD results for year difference SLEI preferred;
- ratio of variance between groups to the variance within groups (F statistic), and means and standard deviations for gender difference SLEI actual;

- ratio of variance between groups to the variance within groups (F statistic), and means and standard deviations for gender difference SLEI preferred.

The data analysis for Part B involving data collected using The Grid is discussed in Section 4.3. These results are presented followed by an interpretation of the data for each of the following: Year 5 general trends; Year 7 general trends including discussion of results for favourite, easiest, most challenging, and most interesting activities; Year 9 general trends including discussion of results for favourite, easiest, most challenging, and most interesting activities.

This chapter ends with Section 4.4 giving an overall presentation of the results, generalisations obtained from the data, and a conclusion to the chapter.

4.2 DATA ANALYSIS PART A SLEI

4.2.1 Reliability and Validity

Table 4.1 shows that the reliability coefficients for the different SLEI scales ranged from 0.45 to 0.65 for the Actual Form and from 0.53 to 0.66 for the Preferred Form. The figure for Open-endedness was low at 0.51 but this is consistently low in other studies. For example, Open-endedness was reported at 0.58 by Henderson et al. (2000) and at 0.41 by Wong & Fraser (1995). Rule Clarity was also low (0.45 Actual Form and 0.53 Preferred Form) so caution is needed when interpreting results for this scale. This low value indicates that the clearness of rules in the actual classroom may be higher than the students perceive them to be. All other reliability results were above the accepted level of 0.60 (Nunnally, 1978).

Table 4.1

Scale Internal Consistency (Cronbach Alpha Reliability), Discriminant Validity (Mean Correlation of a Scale with Other Scales) and Ability to Differentiate between Classrooms (ANOVA) for The SLEI

Scale	Form	Alpha Reliability	Discriminant Validity	ANOVA (eta^2)
Student	Actual	0.65	0.15	0.06^*
Cohesiveness	Preferred	0.66	0.40	
Open-	Actual	0.51	0.11	0.03^*
Endedness	Preferred	0.61	0.14	
Integration	Actual	0.65	0.29	0.48^*
	Preferred	0.66	0.30	
Rule Clarity	Actual	0.45	0.29	0.16^*
	Preferred	0.53	0.30	
Material	Actual	0.54	0.30	0.28^*
Environment	Preferred	0.69	0.41	

Notes: $n = 285$; * $\rho < 0.01$

The alpha reliability for some studies using the SLEI is outlined in Table 4.2 in order to compare the reliability ranges achieved in this study to those of other studies. It can be seen that the ranges achieved in this study are acceptable when compared to these. For example, the range of 0.45 to 0.65 for the Actual Form is within the range from 0.41 to 0.72 achieved by Wong and Fraser (1995). With the exception of the low value for Rule Clarity in the Actual Form, the reliability measures achieved in this study are above the 0.5 level recommended by De Vellis (1991) and most are greater than the 0.6 level recommended by Nunnally (1978) indicating that the data gathered in this study is reliable.

Table 4.2

Internal Consistency Reliability (Cronbach Alpha Coefficient) for the SLEI in Numerous Studies

Scale	Unit of analysis	α Reliability					
		Six countries[a]	Australia			Singapore	USA
		Fraser and McRobbie (1995)	Fraser et al. (1995)	Hend-erson et al. (2000)	Fisher et al. (1998)	Wong and Fraser (1995)	Light-burn and Fraser (2007)
Student	Student	0.77	0.78	0.81	0.71	0.68	0.86
Cohesiveness	Class	0.92	0.80	0.91		0.83	0.95
Open-	Student	0.70	0.71	0.58	0.85	0.41	-
Endedness	Class	0.81	0.80	0.73		0.54	-
Integration	Student	0.83	0.86	0.85	0.75	0.69	0.80
	Class	0.95	0.91	0.92		0.87	0.93
Rule Clarity	Student	0.75	0.74	0.72	0.79	0.63	0.80
	Class	0.92	0.76	0.88		0.84	0.90
Material	Student	0.75	0.76	0.77	0.71	0.72	0.79
Environment	Class	0.88	0.74	0.85		0.82	0.91
Sample Size	Student	5447	1594	489	387	1592	761
	Class	269	92	28	20	56	25

[a] The six countries were Australia, USA, Canada, England, Israel and Nigeria

Fraser and Lee (2009)

Investigations were then made in comparing each scale of the SLEI with the other four scales to determine discriminant validity. This is measured by using the mean correlation of a scale with the other four scales. This value is the average Pearson correlation value between a scale and each of the other four scales. It is a measure of the strength of the linear relationship between two variables. It is signified by r and can be -1.0 to +1.0 where -1.0 is a perfect inverse correlation (that is, as X increases, Y decreases), 0 is no correlation and +1.0 is a perfect positive correlation. Table 4.1 shows that the discriminant validity coefficients (the mean correlation of a scale with the other four scales) ranged from 0.11 to 0.30 for the Actual Form and from 0.14 to 0.41 for the Preferred Form. The discriminant validity (mean correlation) was calculated using the data from Tables 4.3 and 4.4.

Table 4.3

Discriminant Validity (Mean Correlation of Scales of the SLEI Actual with Other Four Scales)

	SC	OE	I	RC	ME	Mean
SC	1	0.07	0.16	0.27	0.32	0.15
OE		1	0.21	0.09	0.06	0.11
I			1	0.37	0.42	0.29
RC				1	0.42	0.29
ME					1	0.30

These correlations are generally small enough to show that the scales of the Actual Form of the SLEI are measuring distinct, although somewhat overlapping aspects of the classroom environment.

Table 4.4

Discriminant Validity (Mean Correlation of Scales of the SLEI Preferred with Other Four Scales)

	SC	OE	I	RC	ME	Mean
SC	1	0.30	0.32	0.41	0.58	0.40
OE		1	0.05	0.09	0.11	0.14
I			1	0.41	0.53	0.30
RC				1	0.41	0.30
ME					1	0.41

These correlations are generally small enough to show that the scales of the Preferred Form of the SLEI are also measuring distinct although somewhat overlapping aspects of the classroom environment.

In keeping with previous research on learning environments (Fraser, 1998a, b) an analysis of variance (ANOVA) was used to determine the ability of the actual version of each SLEI scale to differentiate between the perceptions of students in different classrooms. The one-way ANOVA for each scale involved class membership as the independent variable and the individual student as the unit of analysis. The ANOVA results (eta^2) show that all five of the SLEI scales used in this study differentiate significantly between classes ($p < 0.01$; see Table 4.1).

This is an important statistic as the ability to differentiate between classrooms can signal that the instrument is sensitive to the differences between individual teachers or classrooms and how they can influence the classroom environment. Thus, students within the same class perceive the classroom environment in a relatively similar manner. The eta^2 statistic ranged from 0.03 to 0.48 and was significant for all scales. The figure of 0.03 for Open-Endedness indicates that Open-Endedness did not vary much between classrooms - the students all felt it was lacking in the actual classroom regardless of which class they were in.

The results obtained for the reliability of the data using the Cronbach alpha reliability (internal consistency), mean correlations of each scale with the other four scales (discriminant validity) and the ability of each scale to differentiate between the perceptions of the students in different classrooms (eta^2 statistic from ANOVA) can be considered acceptable. The data presented in the tables support the contention that the SLEI is a valid and reliable classroom environment instrument for assessing students' perceptions of their actual classroom environments in science across the middle school years.

4.2.2 Actual and Preferred Differences

The SLEI comes in two forms: the Actual Form to assess students' perceptions of their actual classroom environments and the Preferred Form which asks students for their perceptions of the classroom environment they would prefer or envisage as an ideal classroom environment. For example, in the actual form the SLEI has an item "My regular science class work is integrated with laboratory activities" that has a corresponding item in the preferred form describing the preferred classroom states "My regular science class work would be integrated with laboratory activities". The two forms allow comparisons to be made between students' preferred classroom environment and the actual classroom environment. Learning environment research and thus this study indicate that closing the gap between actual classroom environments and preferred learning environments improves student motivation and achievement.

Table 4.5

Mean SLEI Scores for Actual versus Preferred Classroom Environments

	Mean		Standard deviation		Difference	t score
	Actual	Preferred	Actual	Preferred	(P – A)	
SC	3.85	3.90	0.67	0.78	0.05	4.74***
OE	2.68	3.42	0.56	0.71	0.74	16.24***
I	3.46	3.43	0.69	0.80	-0.03	4.48***
RC	3.69	3.56	0.57	0.67	-0.13	0.41
ME	3.71	3.86	0.65	0.87	0.15	10.95***

Notes: $n = 285$; $^{***}p < 0.0001$

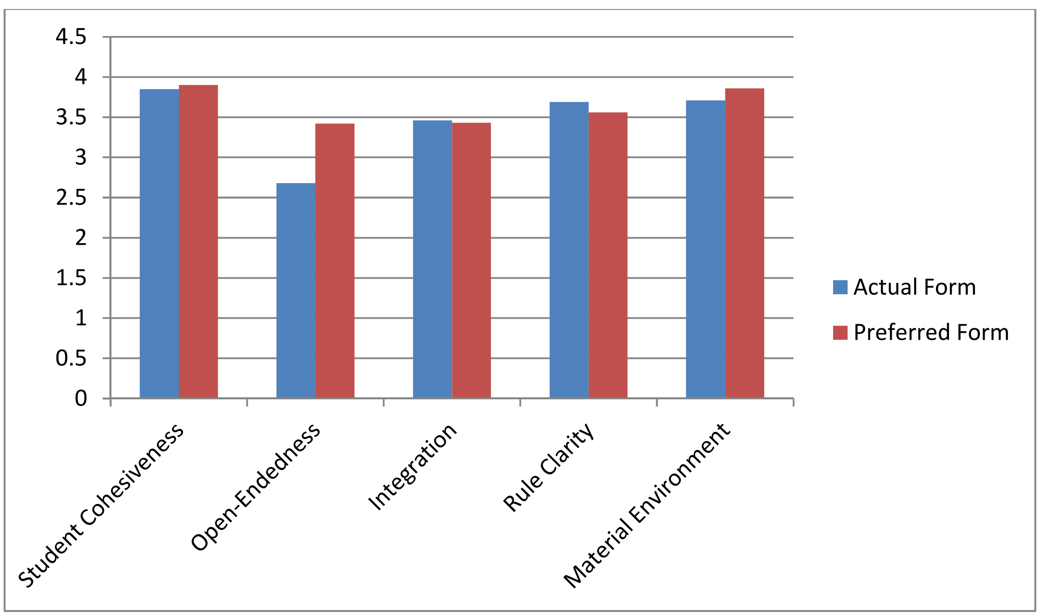


Figure 4.1. Mean SLEI scores for actual versus preferred classroom environments.

From these results, it was found that the means differ. It can be clearly seen in Figure 4.1 that there is a large difference between open-endedness in the actual classroom and in the preferred classroom learning environment. Tests of significance revealed significant differences (Table 4.5) between the actual and preferred classroom learning environments on four of the five scales (all except Rule Clarity).

4.2.3 Year Differences Actual Classroom

This study compared the learning environments of students in science across Years 5, 7 and 9. The means and standard deviations for each year level were compared for each of the five scales of the SLEI in order to determine differences in the actual learning environment of students in Years 5, 7 and 9.

Table 4.6

Means and Standard Deviations for Year Difference SLEI Actual

	Year Level						
	Year 5 (n = 59)		Year 7 (n = 113)		Year 9 (n = 113)		F value
	Mean	SD	Mean	SD	Mean	SD	
SC	4.19	0.56	3.85	0.69	3.61	0.61	14.51**
OE	2.79	0.58	2.56	0.52	2.80	0.58	6.88**
I	3.17	0.53	3.55	0.74	3.48	0.65	6.73**
RC	3.68	0.43	3.81	0.58	3.50	0.58	8.82**
ME	3.82	0.57	3.65	0.66	3.72	0.67	1.40

Notes: ** $p < 0.001$

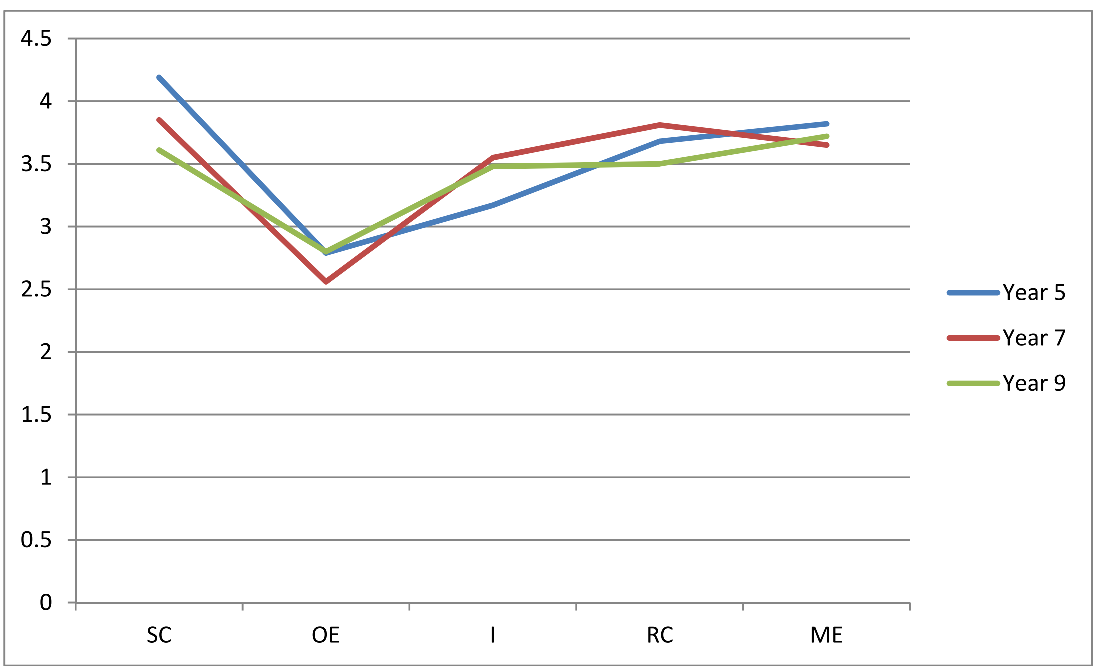


Figure 4.2. Year difference SLEI actual.

In the actual classroom learning environment, there were significant year differences for Student Cohesiveness, Open-Endedness, Integration, and Rule Clarity as shown in Table 4.6. Post hoc tests were carried out in order to investigate further where the differences occurred between each of the years on these four scales.

Table 4.7

Tukey HSD for Year Difference SLEI Actual

Dependent Variable	(I) Year	(J) Year	Mean Difference (I – J)	Sig. (*p*)
SC	5	7	0.342	0.002
		9	0.580	0.000
	7	5	-0.342	0.002
		9	0.238	0.017
	9	5	-0.580	0.000
		7	-0.238	0.017
OE	5	7	0.237	0.016
		9	-0.005	0.999
	7	5	-0.237	0.016
		9	-0.241	0.004
	9	5	0.005	0.999
		7	0.241	0.004
I	5	7	-0.380	0.001
		9	-0.310	0.019
	7	5	0.380	0.001
		9	0.071	0.718
	9	5	0.310	0.019
		7	-0.071	0.718
RC	5	7	-0.135	0.253
		9	0.177	0.139
	7	5	0.135	0.253
		9	0.312	0.000
	9	5	-0.177	0.139
		7	-0.312	0.000
ME	5	7	0.165	0.226
		9	0.094	0.665
	7	5	-0.165	0.226
		9	-0.071	0.62
	9	5	-0.940	0.665
		7	0.071	0.692

Student Cohesiveness: Tukey post-hoc comparisons of the three groups indicate that the Year 5 group gave significantly higher ratings for Student Cohesiveness in the actual classroom than the Year 7 group (p = 0.002), and the Year 9 group (p = 0.000). Using the means in Table 4.6 it can be seen that Year 5 (M = 4.19, SD = 0.56) was greater than both Year 7 (M = 3.85, SD = 0.69) and Year 9 (M = 3.61, SD = 0.61) and that Year 9 was also significantly greater than Year 7 (p= 0.017) which shows that there is less student cohesiveness in the actual classroom as students go through the years.

Open-Endedness: Year 5 (M = 2.79, SD = 0.58) and Year 9 (M = 2.80, SD = 0.58) students both have greater open-endedness in the actual classroom than Year 7 (M = 2.56, SD = 0.52). There was no significant difference between Year 5 and Year 9 students. This shows that Year 7 students perceive less student cohesiveness in the actual classroom and is an area that could be improved for students in Year 7.

Integration: There was no significant difference between Year 7 and Year 9 in terms of Integration in the actual classroom. However, both Year 7 (M = 3.55, SD = 0.74) and Year 9 (M = 3.48, SD = 0.65) were greater than Year 5 (M = 3.17, SD = 0.53). This means that Year 5 students had the least integration in the actual classroom.

Rule Clarity: The only significant difference across the ages for Rule Clarity in the actual classroom was between Year 7 and Year 9 students. Year 7 had higher Rule Clarity (M = 3.81, SD = 0.58) than Year 9 (M = 3.50, SD = 0.58) in the actual classroom environment. This may contribute to higher student management issues occurring in Year 9 classrooms.

Material Environment: There were no significant differences across the ages in terms of the Material Environment in the actual classroom, therefore, no post hoc tests were used.

4.2.4 Year Differences Preferred Classroom

The means and standard deviations for each year level were compared for each of the five scales that the SLEI measures in the preferred learning environment of students in Years 5, 7 and 9.

Table 4.8

Means and Standard Deviations for Year Difference SLEI Preferred

	Year Level						
	Year 5 (*n* = 59)		Year 7 (*n* = 113)		Year 9 (*n* = 113)		F value
	Mean	SD	Mean	SD	Mean	SD	
SC	4.09	0.56	3.98	0.81	3.63	0.79	7.99**
OE	3.75	0.64	3.35	0.70	3.30	0.71	8.54**
I	3.24	0.52	3.58	0.84	3.32	0.85	5.05**
RC	3.58	0.55	3.61	0.67	3.46	0.74	1.22
ME	3.80	0.68	4.01	0.81	3.67	1.05	4.08**

Notes: ** $p < 0.001$

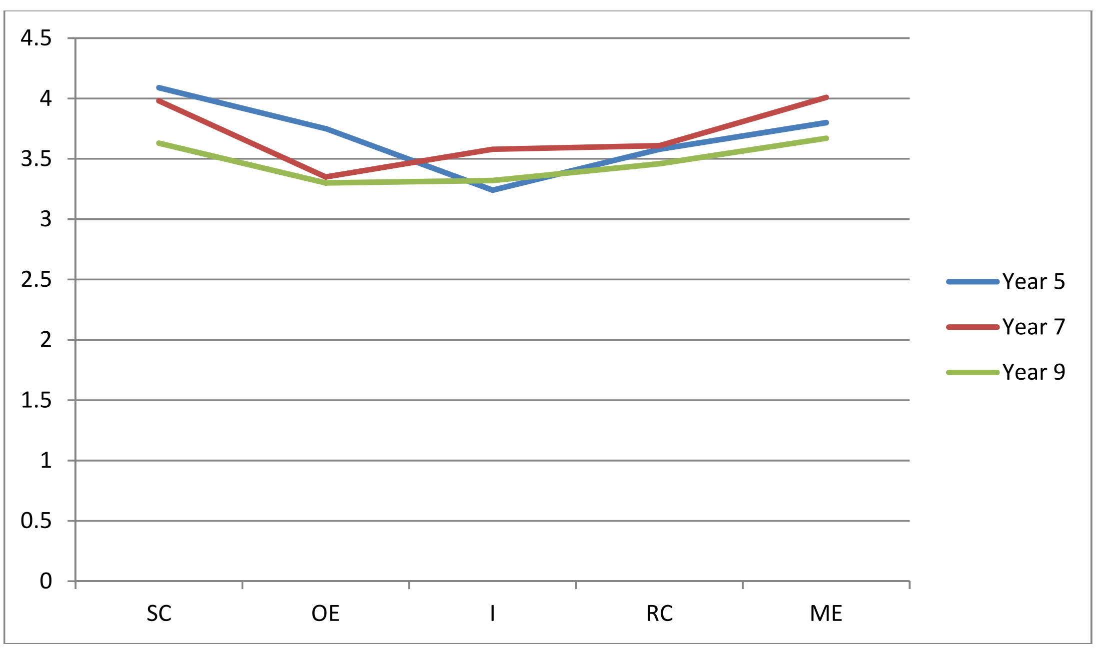


Figure 4.3. Year difference SLEI preferred.

In the preferred classroom learning environment, there is a significant year difference for Student Cohesiveness, Open-Endedness, Integration and Material Environment as shown in Table 4.8. Post hoc tests were carried out in order to investigate further where the differences occur between the three year levels on these three scales.

Table 4.9

Tukey HSD for Year Difference SLEI Preferred

Dependent Variable	(I) Year	(J) Year	Mean Difference (I – J)	Sig. (*p*)
SC	5	7	0.115	0.593
		9	0.467	0.001
	7	5	-0.115	0.593
		9	0.352	0.003
	9	5	-0.467	0.001
		7	-0.352	0.003
OE	5	7	0.401	0.001
		9	0.445	0.001
	7	5	-0.401	0.001
		9	0.044	0.892
	9	5	-0.445	0.001
		7	-0.044	0.892
I	5	7	-0.339	0.016
		9	-0.077	0.833
	7	5	0.339	0.016
		9	0.261	0.046
	9	5	0.077	0.833
		7	-0.261	0.046
RC	5	7	-0.031	0.951
		9	0.112	0.584
	7	5	0.031	0.951
		9	0.144	0.270
	9	5	-0.112	0.584
		7	-0.144	0.270
ME	5	7	-0.206	0.273
		9	0.127	0.663
	7	5	0.206	0.273
		9	0.333	0.016
	9	5	-0.127	0.663
		7	-0.333	0.016

Student Cohesiveness: Tukey post-hoc comparisons of the three groups indicate that the Year 9 group gave significantly less rating to Student Cohesiveness in the preferred classroom environment than the Year 5 group ($p = 0.001$), and the Year 7 group ($p = 0.003$). Using the means in Table 4.8 it can be seen that Year 9 (M = 3.63, SD = 0.79) was less than both Year 5 (M = 4.09, SD = 0.56) and Year 7 (M = 3.98, SD = 0.81). There was no significant difference between Year 5 and Year 7 in terms of Student Cohesiveness in the preferred classroom environment. Year 9 students have less preference for Student Cohesiveness in the classroom than Year 5 and Year 7.

Open-Endedness: Year 5 (M = 3.75, SD = 0.64) students have greater preference for Open-Endedness in the classroom than Year 7 (M = 3.35, SD = 0.70) and Year 9 (M = 3.30, SD = 0.71). There was no significant difference between Year 7 and Year 9 students. This shows that Year 5 students have a great preference for open ended classroom environments and this could be utilised in preparing activities for students of this age.

Integration: There was no significant difference between Year 5 and Year 9 in terms of Integration in the preferred classroom. However, both Year 5 (M = 3.24, SD = 0.52) and Year 9 (M = 3.32, SD = 0.85) were less than Year 7 (M = 3.58, SD = 0.84). This means that Year 7 students had the highest preference for integration in the classroom learning environment and this should be taken into consideration when teaching students of this age.

Rule Clarity: There were no significant differences across the ages in terms of Rule Clarity in the preferred classroom.

Material Environment: The only significant difference across the ages for Material Environment in the preferred classroom was between Year 7 and Year 9 students. Year 7 placed greater importance on Material Environment (M = 4.01, SD = 0.81) than Year 9 (M = 3.67, SD = 1.05) in the preferred classroom.

4.2.5 Gender Differences Actual Classroom

This study compared the actual learning environments of students in science across Years 5, 7 and 9 and also whether there are any gender differences. The means and standard deviations for each gender were compared for each of the five scales that the SLEI measures in order to determine gender differences in the actual learning environment of males and females.

In the actual classroom learning environment, there are significant gender differences for Integration, Rule Clarity and Material Environment, as shown in Table 4.10.

Table 4.10

Means and Standard Deviations for Gender Difference SLEI Actual

	Gender				
	Female (n = 59)		Males (n = 113)		F value
	Mean	SD	Mean	SD	
SC	3.93	0.63	3.79	0.69	2.73
OE	2.62	0.50	2.71	0.60	1.79
I	3.69	0.66	3.30	0.67	23.64**
RC	3.82	0.55	3.60	0.56	11.02**
ME	3.88	0.58	3.59	0.67	14.93**

Notes: ** $p < 0.001$

The difference in means was significant ($p < 0.001$) for Integration, Rule Clarity and Material Environment. On each of these, the females scored higher than the males.

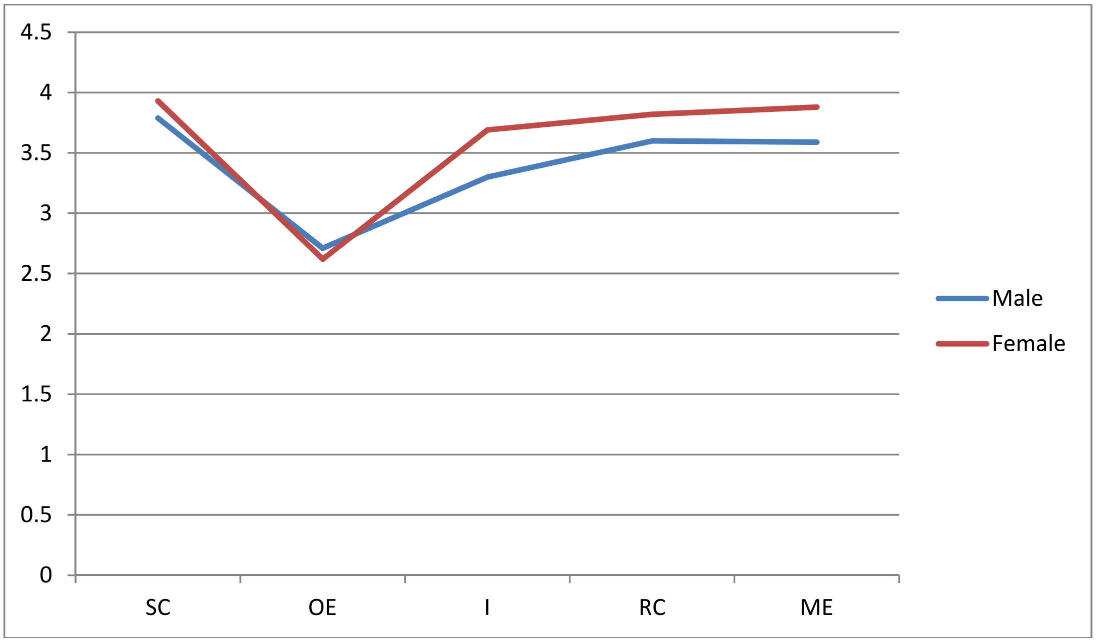


Figure 4.4. Gender difference SLEI actual.

4.2.6 Gender Differences Preferred Classroom

Table 4.11

Means and Standard Deviations for Gender Difference SLEI Preferred

	Gender				
	Female (n = 59)		Males (n = 113)		F value
	Mean	SD	Mean	SD	
SC	4.05	0.75	3.75	0.78	11.10**
OE	3.38	0.70	3.46	0.73	0.93
I	3.59	0.78	3.28	0.79	10.58**
RC	3.71	0.64	3.41	0.66	15.37**
ME	4.02	0.89	3.71	0.83	9.07**

Notes: ** $p < 0.001$

There were significant gender differences (p<0.001) for Student Cohesiveness, Integration, Rule Clarity and Material Environment. The females showed a greater preference for these areas of the classroom learning environment than did the males.

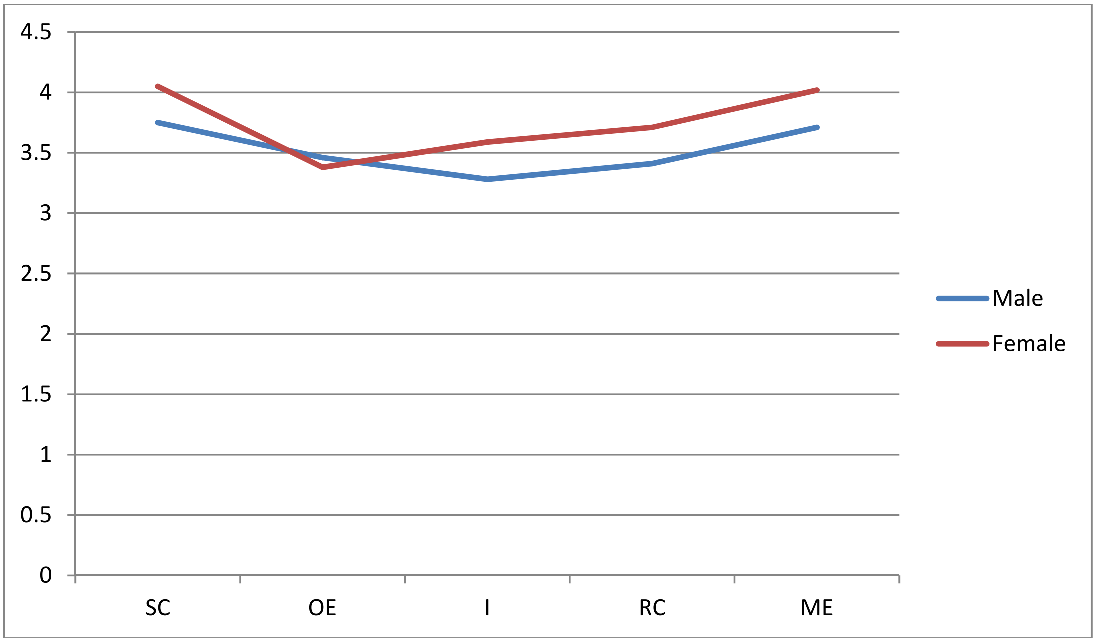


Figure 4.5. Gender difference SLEI preferred.

The data analysis for Part B Grid is outlined in the next section. An overall discussion of the data results from the SLEI (actual and preferred) comparing age and gender and the data results from the Grid are presented in Section 4.4 Overall Results.

4.3 DATA ANALYSIS PART B GRID

4.3.1 Overview

Part B of this study used a Grid (see Appendix 3) based on Multiple Intelligences consisting of various activities that students select in order to make comparisons between activities student prefer to participate in and year level and also gender. Table 4.12 displays an extract of the Grid.

Table 4.12

Extract of the Grid used in Part B

	1 – Rocks	**2 – Fossils**	**4 – Volcanoes**
A – Verbal/ Linguistic	Design a poster showing the layers of the Earth	Design a poster showing how fossils form	Design a poster describing volcanoes
B – Verbal/ Linguistic	Write a speech, story or news article describing plate tectonics	Write a speech, story, or news article about fossils	Write a speech, story or news article about a specific volcanic eruption
C – Logical / Mathematical	Describe life cycle of a piece of magma from inside asthenosphere until it becomes a rock	Prepare a flowchart outlining the process of fossilisation	Classift volcanoes as shield, cinder cone and composite
D – Visual/ Spatial	Draw and label a map of the Earth showing the crustal plates	Create a timeline showing the age of the Earth from fossil records	Draw the three main types of volcanoes and label the various parts
E – Body/ Kinaesthetic	Devise a board game titled "Earth" and prepare a manual	Make cut outs of different types of fossils	Build a model of a volcano
F – Musical/ Rhythmical	Use various rocks as musical instruments	Act and choreograph a dance to represent fossilisation	Write a song about volcanoes
G – Interpersonal	In groups, construct a rock collection and label each sample	Design a possible environment for a species from the past	Construct a radio interview of a made up person who survived volcanic eruption
H - Intrapersonal	Predict what will happen to the earth in 40 million years	Construct a concept map showing ways of identifying the age of Earth	Describe how you would feel if you were in a volcanic eruption

Part B of the methodology involved tallying up the number of activities that students of each age and gender selected from the Grid. Comparisons were made between:

- activities selected by Year 5, activities selected by Year 7, and activities selected by Year 9 students (age comparisons);
- activities selected by males in total and activities selected by females in total (gender comparisons); and
- activities selected by males and females in Year 5, males and females in Year 7, and males and females in Year 9 (gender comparisons across the ages).

The total number of students who selected each activity was tallied up and recorded using an Excel spreadsheet that had all 40 activities labelled across the top and all

285 students numbered down the side (Table 4.13). The data were entered and then totalled for each age group and gender. The data could be easily sorted by year and gender.

Table 4.13

Example of Extract of Excel Spreadsheet

Person	A1	A2	A3	H5	Gender	Year
1				1	M	5
2	1			1	M	5
3		1		1	M	5
4				1	M	5
5	1		1	1	M	7
6	1				M	7
7	1				M	7
8			1		F	7
9		1	1		F	7
10	1			1	F	9
285			1	1	F	9

The responses were tabulated from the 27 Year 7 students and 31 Year 9 students to the questions:

1. Which Activity would be your favourite? Why?
2. Which Activity would be the easiest? Why?
3. Which Activity would be the most interesting? Why?
4. Which Activity would be the most challenging? Why?

Table 4.14 displays an extract of the table used to collate the responses to the questions above. Each activity number and description was recorded and the responses were written in each box. The total numbers for each activity selected by each age group and for each gender were totalled and comparisons were made.

Table 4.14

Extract of Table used for Responses

Question	Year	Gender	Activity	Responses
Favourite	7	M	4E model volcano	*Blow up*
	7	M	4A poster	*I like designing posters*
Easiest	7	M	4C classify volcanoes	*Sounds like no writing whatsoever*
	7	M	3G earthquake interview	*Mum has been in one*
Most interesting	7	M	4E model volcano	*Sounds easy*
	7	M	5D compare cyclones to twisters	*Going to be fun*
Most challenging	7	M	2F create a dance	*I am not a good dancer*
	7	M	1H predict earth in future	*Don't know the answer*

The total numbers of each activity chosen by the students were compared for each question (favourite, easiest, most interesting and most challenging).
Quantitative data analysis was performed by making generalisations based on the written responses given and comparing the totals for each age and gender.

4.3.2 Year 5

The trends found for Year 5 using the Grid choices were that the students in this age group like making posters (except 2A). The poster 2A was not popular but that was probably because students did not have knowledge of the conditions under which fossils form, therefore would not be able to design a poster for that particular content.

Year 5 students also liked musical instruments, body/kinaesthetic activities especially building the model of a volcano and males tended to like the idea of writing an advertisement for television.

A moderately popular activity for this age group was to compare cyclones and twisters (visual/spatial). The Year 5 female students did not like the radio advertisement which was surprising. Another surprise was the popularity among the males of a predicting activity. However, upon further investigation the popular activity was the prediction in the intrapersonal row not the prediction in the logical / mathematical row. The popular activity was to predict what will happen to the earth in 40 million years. When the students were asked to justify their choices it became evident that the males liked this activity because there is no right or wrong answer and therefore there was no fear of failure.

A sample of students from Years 7 and 9 were asked to select which activity would be their favourite, the easiest, the most interesting and the most challenging and to explain why. Students from Year 5 were not asked these questions due to time restraints.

4.3.3 Year 7

Year 7 students also like to design posters. Again, poster 2A was the exception. Year 7 students selected body/kinaesthetic activities with the building a model volcano a popular choice as was the case for Year 5.

Again, musical instruments were popular especially among the female students while the males liked to write songs. The males selected the predicting what the earth would be like in 40 million years activity and the females did not like to write a radio advertisement.

Both males and females selected designing an experiment. This would probably stem from the interest in hands-on activities. There was moderate interest in performing a play and making comparisons (visual/spatial).

A sample of students (27 Year 7 students) were asked to select which activity would be their favourite, the easiest, the most interesting and the most challenging and to explain why.

Favourite

- Year 7 males
  - 50% chose activity 4E which was to build a model volcano
  - 62% chose something from column 4 on volcanoes

The reasons given for these choices were that building a model did not involve any theory, the activity would be easy, fun, cool and "you do no work".

- Year 7 females
  - 30% chose activity 4E to build a model volcano
  - 60% chose something from column 4 on volcanoes

The main reason for the females to select their favourite activity was fun. Both the males and females found activities in column 4 on volcanoes to be favourites probably because they have prior experience and some knowledge of this content area and are therefore more likely to select an activity that they have some familiarity with.

Easiest

- Year 7 males
  - 23% chose 4E model volcano
  - 23% also chose 4A posters volcanoes
  - 62% chose something from volcano column

The males chose the model building because they see this activity as "no theory" and easy. A similar reason was given for selecting posters in that it is "just a poster" or "just a piece of paper" and would not require much thinking. The Volcano column was popular in terms of easy, again probably because there is some prior learning in this content area. The interviewing of someone who has been in a quake was chosen by a few students as an easy task only where they already knew someone who had been in one.

- Year 7 females
  - 80% chose posters

The posters were popular among the female students because they are “easy to make” as it just involves putting information onto paper.

Most interesting

- Year 7 males
    - 28.5% chose activity 4E building a model volcano

The Year 7 males chose the model volcano as the most interesting because it “sounds fun” and it could be made to erupt.

- Year 7 females
    - No information as the questions were asked incorrectly (easiest, most challenging, like to do the most, like to do the least)

Most challenging

- Year 7 males
    - 31% chose activity 1H to predict the earth in 40 million years
    - 23% chose something musical

The Year 7 males found that predicting what the earth would be like in 40 million years would be a difficult task as it is “hard to predict”.

The males also found musical activities would be challenging for reasons such as “I’m not a good dancer” or “I can’t write songs”. The males find activities that they cannot succeed at challenging. Speeches were also quite a popular choice for difficult tasks but the reasons were because it would be “shame”.

- Year 7 females
    - 40% chose visual / spatial activities

The female students chose two visual/spatial activities to be difficult. This was because they didn’t know the content knowledge that was to be presented (chart of p, s, l waves and types of volcanoes). Activity 3G (interview someone that had been in a quake) was identified as one that would be challenging and the reason given was that it could be hard to find someone to interview.

4.3.4 Year 9

Year 9 students found designing posters to be a popular activity as was the case for the other two year groups. Again, poster 2A was the exception. Year 9 students also selected body/kinaesthetic activities with the building a model volcano a popular choice as was the case for Years 5 and Year 7.

Again, the males selected the predicting what the earth would be like in 40 million years activity. The females in this age group preferred group work activities.

Both males and females displayed moderate interest in designing an experiment and there was also a moderate interest in making comparisons (visual/spatial).

A sample of students (31 Year 9 students) were asked to select which activity would be their favourite, the easiest, the most interesting and the most challenging and to explain why.

Favourite

- Year 9 males
    - 50% chose activity 4E building a model volcano

The reason given by the Year 9 males for selecting the model volcano activity as a favourite was because it would be interesting.

- Year 9 females
    - 80% chose a poster

The females preferred posters. The reasons were that they are fun, “nice to present”, there was opportunity to “be creative”, they are easy and simple.

Easiest

- Year 9 males
  - 50% chose activity 1H predict earth in 40 million years

The males in Year 9 chose this activity because there is "no wrong answer" and "you could make stuff up cos no one really knows".

- Year 9 females
  - 80% chose rocks as musical instruments
  - 100% chose musical / rhythmical row

Year 9 females' selected musical activities as the easiest because they are "enjoyable", "fun", "easy" and there is "not much thinking" involved.

Most Interesting

- Year 9 males
  - No clear pattern

The reasons that were given for the variety of tasks chosen by the Year 9 males as the most interesting activities were "want to know", "find it interesting" and could learn about it while researching. In other words, the males have their own variety of content areas that they find interesting.

- Year 9 females
  - 80% chose something from volcanoes (familiarity)
  - 40% 4H how would you feel
  - 40% body / kinaesthetic
  - make you think, descriptive, expressive, enjoy empathy tasks, enjoy model building

Most Challenging

- Year 9 males
  - Most popular activity was 3H quake diary

The reasons given for finding the diary activity difficult included that "you would only know if you had been in one". That is, the males found it difficult to visualise being in an earthquake and empathising with another person or situation.

- Year 9 females
  - 40% chose speech
  - 40% chose intra-personal

The females in year 9 selected speeches as challenging activities because they "don't like speeches" and chose intra-personal activities as difficult because, like the males in this age group, they feel that you would "need to experience it" in order to write about something unfamiliar. Activity 3G (interview someone who had been in an earthquake) was identified as difficult because it would be hard to find someone.

4.4 CHAPTER SUMMARY

In using the SLEI as a measure of learning environments, it was found that student cohesiveness and rule clarity in the actual learning environment decreased with age. Students in Year 9 had the least amount of rule clarity in the actual classroom. This could explain why there is often a higher level of behaviour management issues for teachers of Year 9 students. Clarifying rules is an important factor in establishing effective classroom management practices and hence creating conducive learning environments. There was less student cohesiveness as the students get older in the actual classroom and Year 9 students identified student cohesiveness as the least important factor in their preferred learning environment. Both male and female students in Year 9 found intra-personal activities challenging. Perhaps an increase in student cohesiveness could decrease the "shame" and "uncool" attitudes associated with these types of learning activities and assist these young adolescent students build relationships which are less confronting in the classroom learning environment.

There was no difference among the year groups about the importance of the material environment on classrooms. In other words, students in Year 5, Year 7 and Year 9 have no real interest in the material environment. Schools spend money on resources and tend to place emphasis on things like computer to student ratios and impose large fees on parents to accumulate physical resources.

There is little doubt that resources can assist in the learning taking place in a classroom. However, building student relationships and teacher – student interactions are far more important in building effective classroom learning environments and hence increasing student's motivation to learn, decreasing behaviour issues and increasing teacher job satisfaction.

While Year 9 students had the least preference for student cohesiveness, Year 7 and Year 5 students have a greater emphasis on personal development categories. Year 7 prefer classroom learning environments with a high level of integration while Year 5 preferred environments with open-endedness.

For all ages the least popular activities were those involving writing a speech, story or newspaper article (verbal/linguistic) as opposed to the popularity of posters (also verbal/linguistic) as it also contains a visual aspect. This could be that students find speeches boring, non-memorable and also embarrassing to stand up in front of their peers. Low literacy levels could also contribute to these types of activities being avoided by students.

Posters were popular across all ages as they allow students the opportunity to be creative and expressive in the presentation of the material while not challenging them to think for themselves.

Body/kinaesthetic and model building activities were popular as they provide students with the opportunity to participate in hands-on tasks. They are seen as being "no theory", "cool", fun and easy.

Students in Years 7 and 9 did not like the activity of writing an advertisement for television as it was not "cool" and generally seen as "baby-ish". Year 9 did not like the idea of using musical instruments for similar reasons (uncool, baby-ish). Year 5, however, liked musical instruments as they were probably familiar with their use as part of the curriculum for that age group.

Gender comparisons made using the SLEI as a measure of classroom learning environment indicated that females place a larger importance on student-cohesiveness than do males.

Males prefer activities (based on the Grid) where they perceive there is “no right or wrong” answer, “no theory”, and body/kinaesthetic hands-on activities. Males found “predicting” as the hardest and some males suggested that musical activities were “hard” if they were not good at singing or dancing. Female students enjoy activities that are “fun”, group work, expressive, musical and like posters because they are “nice to present”.

Year 9 females favoured group work activities probably because they can be less confronting in terms of a fear of failure. Year 9 males favoured predicting the earth in 40 million years as a means of avoiding failure. It is interesting to note that Year 7 males chose the predict earth activity as the most challenging because it is difficult to make predictions whereas the Year 9 males chose it as the easiest as there is no right or wrong answer.

A 100% of Year 9 females chose musical/rhythmical row for easiest activity (not much thinking, enjoyable) but 0% from Year 7 males, Year 7 female and Year 9 males chose musical/rhythmical row as easiest.

In regard to interviewing a person who had been in an earthquake, Year 7 and Year 9 females thought that finding someone to interview could hamper this activity whereas the males avoided this activity unless they already knew someone who had been in a quake. The males seemed to take the easy options where possible (or what they consider to be the easy options) which reiterates the notion that males place an importance on selecting jobs (for their future) that are easy (Jones & Rua, 1999).

This study investigated how students preferred learning environment and preferred learning styles change across Years 5, Year 7, and Year 9, whether gender plays a role in the preferred learning environment and preferred learning styles of students at these ages, and how the classroom learning environment can be structured to cater for students’ preferred learning environment and preferred learning styles. There seems to be an obvious difference in the motivation and attitudes towards science across these three age groups.

The general trend across all three age groups was that there was a preference for posters and body/kinaesthetic (model building) type learning. All three age groups also disliked performing speeches. Year 5 students prefer open-endedness, Year 7 have a preference for integrated learning and Year 9 prefer student centred learning and have a need for rule clarity in their classroom environment.

The findings in this study agree with previous research. Ebenezer and Zoller (1993) found that students prefer to play an active role and Koul and Zandvliet (2008) highlighted the importance of Integration. This study has identified the need for more integration between theory and practical work in science, particularly in the Year 7 group. Hofstein, Cohen and Lazarowitz (1996), Lightburn and Fraser (2007), and Reid and Fisher (2008) have all identified the importance of teach behaviour in terms of providing a classroom learning environment with integration, student cohesiveness, open-endedness and clearly defined rules.

This data analysis can be used to provide teachers with some generalizations of the preferred learning environments and preferred learning styles of students across Years 5, Year 7 and Year 9. Teachers can therefore structure the classroom learning environment to include hands-on activities, open-ended teaching strategies and clear and structured rules. This can lead to improvements in student behaviour and attitudes toward science and learning and hence positive interactions between students and teachers. A flow on effect can be an increase in job satisfaction for teachers, an increase in enthusiasm for teaching as a profession and improved quality of education for all.

The final chapter of this thesis presents an overview followed by a more detailed discussion of the major findings. The major findings are then presented as answers to the research questions proposed. Chapter 5 goes on to provide recommendations for teachers in the form of practical ways in which they can utilise the results obtained from this study create “outside the square” classroom learning environments that cater for the preferred learning styles of students in Years 5, 7 and 9.

CHAPTER 5

CONCLUSION

5.1 INTRODUCTION

Science laboratories need to be able to enable students to interact *intellectually* as well as *physically*, involving both *hands-on* investigation and *minds-on* reflection (Hofstein, 2008, p. 210).

This chapter presents an overview of the study conducted, the major findings (general trends and how the research questions have been answered), recommendations for teachers (the implications for the classroom and practical ways to implement change in the classroom), limitations (to changing classrooms as well as limitations to this study in general), significance (in theory and in practice), and final comments (including suggestions for future research).

> Students who enjoy science are more likely to pursue a career in science. Science careers are perceived to be unattractive by students and parents. Community negative perception of science is a motivational factor. Lack of role model and science image problem have contributed to decline in students' motivation. Students are more interested in material achievements rather than career in science. Other contributing factor in the decline is that science is moving too fast and the speed of change frightens people, particularly parents. Science has become a frightening place to go (Hassan & Fisher, 2005, p. 8).

President Obama's call to "celebrate scientists as we do football players" is a small step in the right direction. Society as a whole needs to embrace science in all of its forms and begin to view it as interesting, relevant, important, fun and exciting.

5.2 OVERVIEW OF THESIS

This study investigated the preferred learning environments and the preferred learning styles of students in Year 5, Year 7 and Year 9 using the SLEI in Part A, and in Part B a Grid giving students choices of preferred activities. In both instances, data were collected and analysed. Comparisons were made for the actual and preferred learning environments and the preferred learning style between the age groups and gender.

These comparisons were used to summarise the results and formulate possible methods that can be utilised in the actual classroom in order to improve the quality of teaching occurring. Improved teaching leads to effective learning. Effective learning leads to increases in motivation and interest in science, more chance of students pursuing science as a career and higher levels of scientific literacy within society as a whole.

Figure 5.1. Effect of improved science classroom learning environments.

5.3 MAJOR FINDINGS

There seems to be an obvious difference in the motivation and attitudes towards science across Years 5, 7 and 9. This study has found significant and important information regarding the preferred learning environments and preferred learning styles of students across these year groups.

The SLEI as a measure of learning environments revealed some important differences across the Years 5, 7 and 9 year groups. In Year 5 classrooms there needs to be an increase in integration. Practical experiences need to be explicitly linked or integrated to the concepts explored in non-practical or theory type lessons. It was also found that in the Year 5 learning environments the students have a preference for more open-endedness. Therefore, in the Year 5 classroom learning environment a need for more integration between theory and practical work in science was identified as well as the opportunity for students to explore and design their own practical investigations.

These results may have been gained as Year 5 students are generally taught science by their regular primary school teacher rather than a specialist science teacher (as in the secondary school setting). The results reveal a need for specialist science teachers to be employed in primary schools in order to allow primary school students the opportunity to become independent scientific learners. Many primary school teachers may not link practical experiences to theory or allow students the opportunity to work independently as they may not have the confidence or background in science. Just as music is a specialist area where specialized teachers come in to the primary schools to teach the students, science should also be given this same recognition as there seems to be an increasing decline in student interest in science as well as a decrease in the time spent in the primary classroom investigating science.

In the Year 7 classrooms there was found to be a need for an increase in open-endedness and the Year 7 students would prefer more integration.

Again, the classroom learning environments are generally structured using teacher-centred practical experiences where the students find little relevance or links between the purpose of a practical lesson and that of their theory or knowledge.

This result may have been found because many secondary teachers find that in a laboratory situation there is more “control” in terms of behaviour management when practical lessons are structured in a teacher-lead manner. For example, the method is usually presented and modeled by the teacher for the students to “copy”. The students are not usually given the opportunity to make up their own way of finding out the answer to a problem let alone be given the opportunity to carry out scientific experiments on their own. Obviously, there are safety issues that need to be adhered to when conducting scientific practical lessons, however teachers need to provide students with greater opportunities to make their own discoveries in practical lessons and create clear links between practical and theory lessons.

The SLEI revealed a need for clearer rules in the Year 9 classroom. This could explain the general increase in behaviour management issues at this age as students in Year 9 need guidance especially in regards to the rules of the science laboratory. Student cohesiveness decreases with an increase in age in the actual classroom therefore students in Year 9 need classroom learning environments where they have cohesive relationships with their peers. Increasing student cohesiveness could decrease the “shame” associated with trying in class and participating in activities that are challenging. Teachers need to spend the time with these older students who are young adolescents building relationships that foster a classroom learning environment that is not confronting to them. Activities such as those usually conducted during “peer support” type programs such as learning each others’ names, interests, hobbies, and revealing personal information such as hopes and dreams should be a part of the introduction when a new class is formed at the start of each year.

The SLEI as a measure of classroom learning environments revealed that for all year levels there was no difference about the importance of the material environment.

This finding emphasizes the importance of building relationships rather than having lots of computers as a significant factor in developing effective classroom learning environments. This leads to an increase in student motivation to learn, a decrease in behaviour management issues, a friendly classroom, and an increase in teacher job satisfaction, motivation and quality teaching.

The learning styles of students across the three year levels were measured using the Grid. It was found that the students in Years 5 and 7 liked musical activities. This result may be because students in these year levels may have experience with a musical instrument as part of their curriculum and are familiar with music. This is an important finding as teachers can utilise musical activities when teaching science to students in these year groups.

Years 9 students prefer student-centred activities. This result may have been obtained because students at this age may find teacher-directed lessons boring and uninteresting. All of the students preferred activities with which they had some prior experience or familiarity. This is not surprising as this gives them some confidence to attempt more challenging tasks with less fear of failure.

Students in all year levels liked making posters and disliked performing speeches. Making posters gives students the opportunity to be creative and is an open-ended task. Allowing students the opportunity to make posters in science classes allows freedom of expression, increases motivation, and also allows visual learners the opportunity to remember information and create links when mind maps are created. Posters can be a useful tool or even replacement for the “traditional” writing in an exercise book. Students dislike performing speeches as this can be confronting. Many adults have difficulty speaking in front of their peers. Public speaking is an important aspect of the classroom learning environment, however teachers need to assist students in preparation for performing speeches by allowing them to perform in front of small groups, perform in a group and by guiding students to be creative in preparing presentations to the class to make the experience enjoyable for all.

Gender differences were also explored in this study. The SLEI as a measure of learning environments revealed that female students place greater importance on student cohesiveness, integration, rule clarity, and material environment than do males.

This result indicates that female students may place greater importance on classroom learning as a whole than males. This could be because, in general, classrooms are often constructed in a manner that favours traditionally “female” types of learning. This could be because the majority of teachers (especially in primary schools) are female and tend to teach (whether it be subconsciously or not) in the way in which they themselves prefer to learn. In general, female teachers may find it difficult to understand the way in which male students learn (hand-on rather than writing down notes).

Gender differences were also revealed using the Grid choices of activities as a measure of learning styles. Males prefer activities with no right or wrong answer, activities that they can succeed at, and tend to take the easy options where possible. Males dislike interpersonal activities while females do prefer group work activities.

In summary, the research questions can be answered in the following way:

1. How do the actual and preferred learning environments change across the Years 5, 7 and 9 groups?
    - student cohesiveness decreases with increase in age in the actual classroom;
    - open-endedness needs increasing in the actual classroom in Year 7;
    - integration needs increasing in the actual classroom in Year 5;
    - rule clarity needs improving in the actual classroom in Year 9;
    - Year 5 students prefer more open-endedness; and
    - Year 7 students prefer more integration.

2. How does the preferred learning style change across these three age groups?
    - Years 5, 7 and 9 students prefer making posters;
    - Years 5 and 7 students like musical activities;
    - Year 9 prefer student-centred activities;

- students prefer to select activities where they have some prior experience or familiarity with; and
- students dislike performing speeches.

3. Does gender play a role in:

a. The preferred learning environment of students at these ages? (SLEI)

- female students place greater importance on student cohesiveness, integration, rule clarity, and material environment than do males.

b. The preferred learning style of students at these ages? (Grid)

- males prefer activities with no right or wrong answer;
- males prefer activities that they can succeed at and tend to take the easy options where possible;
- males dislike interpersonal activities; and
- females prefer group work activities.

4. How can actual classroom learning environments be structured to cater for students' preferred learning environment and preferred learning styles across these ages?

- hands on activities;
- opportunities for students to be creative and expressive;
- open endedness;
- clear and structured rules;
- student cohesiveness; and
- relevance.

5.4 RECOMMENDATIONS FOR TEACHERS

Whether its Kolb's Experiential Learning Model which includes all four stages of experience, observation, conceptualisation and experimentation in each lesson or Gardner's eight multiple intelligences, it seems that conducting lessons or providing classroom learning experiences that are rich and varied is the key to producing high quality science education where students' motivation is increased and hence understanding, enjoyment, societal reputation and teacher job satisfaction can then follow on.

In order to implement the strategies discussed in this thesis, a classroom learning environment that fosters initiative and enhances inter-personal skills needs to be developed. Writing topics using Grids and allowing students to select the activities they wish to complete is one method. Students could be placed into groups (as directed by the teacher and changed for each topic throughout the year) and asked to complete 15 activities from the Grid (no more than three from each row and at least one from each column). Student groups then spend the seven or so weeks on the topic with a portfolio of work being presented at the end. This portfolio would then make up the student "notes" on each topic studied throughout each year (as per the Continuum of learning Figure 2.3). In practice, teachers could begin and end with a class "mind map" for each topic. Then teachers could:

- develop a grid for each topic consisting of the activities that are needed to cover the content of the curriculum;
- structure the physical set up of the classroom creatively;
- construct a topic planner based on class timetables; and
- create an assessment guideline for students.

For example, in order to teach a topic in Year 7 (Me and My Home theme) covering the curriculum content of human body in terms of "describe the role of the digestive, circulatory, excretory, skeletal and respiratory systems in maintaining humans as functioning organisms" (NSW Science Years 7 – 10 Syllabus, p. 34.) the following could be created (see Table 5.1):

Table 5.1

Example of Part of a Grid

	1 – Bones	**2 – Joints**	**3 – Respiratory system**
A – Verbal / Linguistic	Design a poster showing the names of the bones in the body	Design a poster showing the three main types of joints	Write a newspaper article describing the process of breathing
B – Logical / Mathematical	Prepare a flowchart outlining the layers of bones	Classify the main joints in the body under the three types	Design an experiment to demonstrate the way oxygen is used by muscles
C – Visual / Spatial	Draw and label the bones in two vertebrate animals	Compare the three main types of joints	Produce a chart showing the function of the lungs
D – Body / Kinaesthetic	Devise a board game titled “Bones” and prepare a manual	Build models of different types of joints	Conduct an experiment to measure changes in breathing rate with exercise
E – Musical / Rhythmical	Write a song about the names of the bones in the human body	Act and choreograph a dance to represent the movement of joints	Produce sound effects for a scene involving an athlete
F – Interpersonal	Interview a person who has broken a bone	Interview a person who is in a wheelchair	Write and record a TV ad that could be used to promote active lifestyles
G – Intrapersonal	Visualise that you have broken your leg. Write a diary about your experiences in a wheelchair	Predict what life would be like without joints in the body	Visualise that you have had to administer CPR. Write a diary about your experiences
H - Naturalistic	Describe the effect on the environment of the various ways of disposing of living things	Describe the types of materials used to in the production of artificial limbs	Describe the environmental costs to society of childhood obesity

For a class consisting of between 25 and 30 students, as is typical in a secondary science class, students could be placed into six groups of four of five in each group. The classroom could be set-up similar to most primary classrooms with different designated areas (see Figure 5.2).

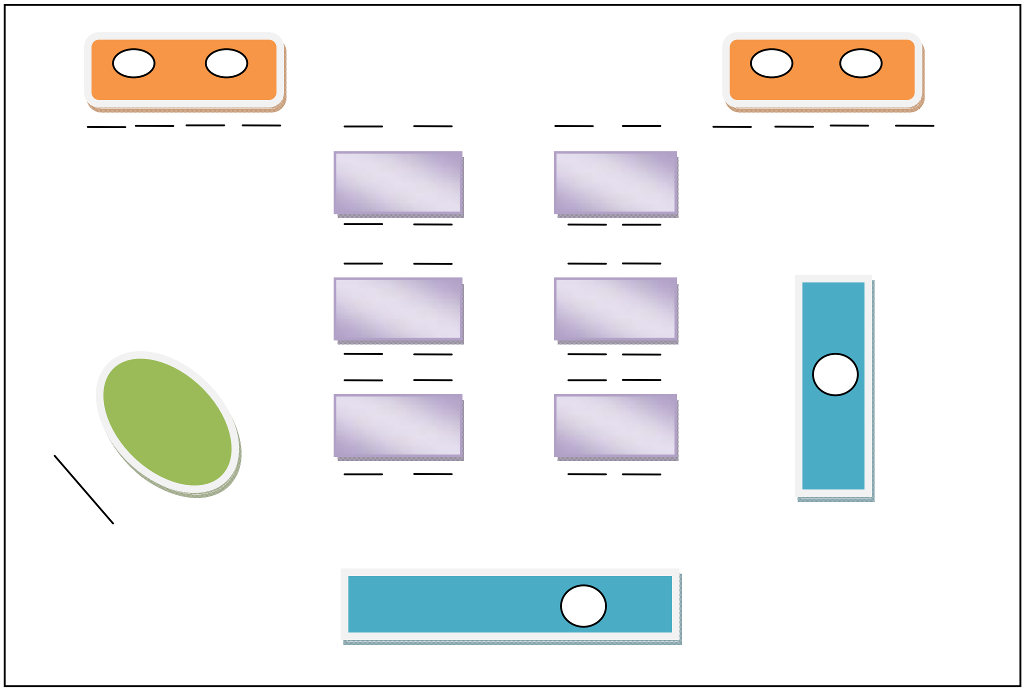


Figure 5.2. Physical set up of the classroom.

The room consists of two computer areas shaded orange (one for a group to use for typing, printing, internet researching and emailing and the other computer area for recording media – sound, music, video with headphones), two "wet" areas shaded blue for experimenting / model building, one "brainstorming" area shaded green with an easel, A3 paper, markers, carpet and cushions and the general "desk" areas shaded purple in the middle with the desks set up in the six groups for general working and to complete any "compulsory" worksheets.

Table 5.2

Example of a Topic Planner

WEEK	MONDAY	TUESDAY	WEDNESDAY	THURSDAY	FRIDAY
1 25 – 1 Apr	Concept Map Introduce Topic	Groups allocated	No class		
2 2 – 8 May			No class		
3 9 – 15 May			No class		OVAL
4 16 – 22 May			No class		
5 23 – 29 May			No class		OVAL
6 30 – 5 Jun			No class		
7 6 – 12 Jun	Presentations	Presentations	No class	Presentations	Teacher feedback Re-visit mind map

The Topic Planner (Table 5.2) could be for a science class that does not have science on a Wednesday. The students could be given this topic planner to try and plan which activities they will complete in which lessons. Two lessons have been allocated to the oval in which the whole class would be going out to the school oval. These two lessons could be utilised by the students by taking out stopwatches to complete the experiment on the effects of exercise on breathing rate, to conduct some mind-mapping outside (take a picnic blanket), conduct interviews, or to film TV ads.

The students would need to be organised for these lessons in advance and would be encouraged to plan the tasks.

In terms of assessment, students' would need to be given some guidelines regarding the presentation and construction of the portfolios. Method of assessment is one area that could be investigated further. Students in this example would be expected to produce a portfolio (in the form of an A4 display folder) containing written material including flow-charts, posters, compulsory worksheets, experiment designs and so on. Students would also need to submit and present to the class any digital material (on a USB) and also any models that had been constructed. A photo of the models could be included in the portfolio and posters could be held up in front of the class and explained verbally, thus reinforcing the content area being covered.

5.5 LIMITATIONS

There are many limitations to embracing an "outside the square" approach to teaching in classrooms in New South Wales schools. In order to create effective classroom learning environments, teachers need time. This limitation is two-fold. The time it takes in planning classroom activities, researching, preparing materials is one factor. The other part is the classroom time spent on the cooperative learning unit of work is time taken out from the teaching time allocated to teach the mandatory content.

Other limitations include the risk of students who are unwilling to participate. Allowing students the opportunity to be creative and involved in their learning poses the risk of increased behaviour management issues if students are not prepared for the change. Teachers may find it "easier" to teach in the traditional "talk and chalk" method which their students' may be familiar with. Peer criticism may also be a limitation to employing cooperative learning strategies in the classroom.

Teachers can be dynamic in creating exciting classroom learning environments by taking on active roles in the writing of syllabus documents. This can lead to curriculum content being adopted that allows for cooperative and creative teaching strategies to become the "normal" teaching and thus eliminating the limitation of taking time out from the mandatory content. That is, by teaching the mandatory content in a creative way.

Teachers can be active in promoting the teaching profession, sharing resources and ideas, engaging in professional development courses, and by conducting interviews and administering questionnaires to ascertain the preferred learning styles and preferred learning environments of their students.

There were limitations encountered in this study. The sample size could have been larger. The number of schools approached was limited to the number of schools in the town. The number of schools who agreed to participate was limited and the way in which the SLEI and Grid were administered was limited to the classroom teachers. Time was another major limitation to the sample size: The time the teachers had available for administering the SLEI and Grid as well as the time for conducting the research.

The SLEI were administered by classroom teachers. There was some concern over the reliability of these data as a high number of the students suffer low literacy levels and because of this poor concentration levels. As the task was probably perceived to be quite difficult there may have been management issues. The common issues were student frustration with long complicated sentences written in small print, lack of understanding of certain terms and short concentration spans. Most of the students in Year 7 would have benefited from one-on-one attention for the SLEI surveys. Again, time was a factor here.

The teachers worked really hard to ensure the SLEI surveys were completed as accurately as possible. This meant reading through the statements and providing clarification and repetition where necessary in order to overcome low literacy levels.

The data gained from asking sample students to select their favourite, easiest, most interesting and most challenging activities and provide reasons why would have been more useful had they been conducted as a verbal interview. This was because some students have low literacy levels and some of the responses were unclear.

Because of lack of time, there were not enough students used in the sample and no students in Year 5 were asked the justification questions.

Year 7 females were asked the incorrect questions (easiest, most challenging, like to do the most, like to do the least) so there was no information for the most interesting. This was a communication breakdown with the teacher. Again, this could be avoided by conducting the questions in a verbal interview/discussion type setting. The data gathered for the Year 7 females were re-ordered as like to do the most for favourite, easiest, no data for most interesting, then most challenging. This was an attempt to overcome the limitation imposed by this small error.

5.6 SIGNIFICANCE

This study has contributed significantly to science education both in theory and in practice. There are many different styles of learning. There is no right or wrong way to teach or to learn – just many different ways. Students become bored in the classroom learning environment when the work is irrelevant and presented in a disjointed way. The gender differences identified in this study revealed that the females (in general) prefer creative activities while the males prefer hands-on activities. This also reiterates the theory that there is a need for visual, body/kinaesthetic, musical and other types of learning in the classroom rather than just the linguistic and mathematical emphasis that is currently placed on curriculum.

In practice, this study has identified ways in which teachers and policy-makers can improve the quality of science education in New South Wales.

This study has shown that practical lessons in science need to be utilised as a tool in learning in the correct manner in order to be effective. That is, practical experiences need to be integrated into the theory lesson as well as be open-ended in order for students to gain maximum relevance and enjoyment from science classes. Student cohesiveness and clear rules need to be fostered especially in Year 9 classes and various activities including posters, music and group-work need to be utilised in the classroom learning environment.

Teachers can use the instruments presented in this study on their own students in order to determine the preferred learning environment and learning styles of their students and thus create activities to suit and increase student interest in science.

Modifying the methods of instruction, presenting activities in a Grid (Table 5.1) and creating a favourable classroom learning environment (Figure 5.1) are some of the ways teachers can use the information gained in this study to enhance and enrich their students learning as well as their own personal and professional development.

Policy-makers can utilise the continuum of learning (Figure 2.3) presented in this study to make changes to the curriculum that can assist teachers develop learning programs that are relevant and interesting for students. The topics based on themes that run across the year levels assists students to see the "big picture" and make meaning from their learning in the science classroom.

Teaching needs to become "fun" for both students and teachers which can lead to improvements in working conditions for teachers which in turn attracts more graduates and raises teaching standards. Improving the science being taught to primary teachers, providing assistance with science within the school, and employing science "specialists" are ways in which the science experiences in primary schools could be improved.

5.7 FINAL COMMENTS

The main factors that will enhance the chances of change occurring in the classroom include time for planning and goal setting as well as support from the school community. Teachers need to be open to try cooperative learning strategies, be organised and creative in their thinking and teachers need to be provided with ongoing support.

This study could be investigated further by administering the SLEI and the Grid choices to a larger sample size. Future research could include teaching a unit using the strategies outlined in this study and conducting pre-tests, post-tests and interviews of students and teachers to ascertain the outcome of using the strategies in the classroom and comparing these with a control class that is taught in the "traditional" manner. Methods of assessing units of work that students' undertake using the strategies outlined in this study is also an area that could be investigated in the future.

From this investigation, formulating classroom learning environments where student-cohesiveness is high and learning activities are varied is paramount for improving student (and hence future generations) interest in science.

> Science is in the curriculum because it *is* relevant and, it should be added, relevant to *people*. Relevance is the very reason for its existence, and it should be the very backbone of science teaching. (Newton, 1988, p. 7 as cited in Jenkins & Pell, 2006).

Teachers of Year 5, Year 7 and Year 9 science students need to think "outside the square" and embrace a style of teaching that provides firm rules as well as a friendly environment. Older students should be exposed to the type of classroom that they experienced in lower primary school – clear and simple rules, fun, exciting, relevant, and memorable. It's time for teachers to "set young minds on fire".

REFERENCES

Aldridge, J. M., Fraser, B. J., Fisher, D. L., & Wood, D. (2002, April). *Assessing students' perceptions of outcomes-focussed, technology-rich learning environments*. Paper presented at the annual meeting of the American Educational Research Association (AERA), New Orleans.

Aldridge, J. M., Fraser, B. J., & Huang, I. T. C. (1999). Investigating classroom environments in Taiwan and Australia with multiple research methods. *Journal of Educational Research, 93*, 48-57.

Aldridge, J. M., Fraser, B. J., Taylor, P. C., & Chen, C. (2000). Constructivist learning environments in a cross national study in Taiwan and Australia. *International Journal of Science Education, 22* (1), 37-55.

Anderman, E. M., & Young, A. J. (1994). Motivation and strategy use in science: Individual differences and classroom effects. *Journal of Research in Science Teaching, 31* (8), 811-831.

Armstrong, T. (1996). *Multiple intelligences*. Retrieved November 4, 2010, from http://www.thomasarmstrong.com/multiple_intelligences.php

Australian Bureau of Statistics (2007). Retrieved March 3, 2011, from www.abs.gov.au

Bailey, B. (2005). *Australian identity and values: A stage 3 unit of work integrating the processes of Bloom's taxonomy and Gardner's multiple intelligences into a Pirozzo 48-grid matrix*. Retrieved February 2, 2011, from http://www.pli.com.au/files/Bronwyn_Bailey_Article.pdf

Best teachers to be financially rewarded. (2011, March 3). *Bigpond News*. Retrieved March 3, 2011, from http://bigpondnews.com/articles/TopStories/2011/05/03/Best_teachers_to_be_financially_rewarded_608100.html

Bogod, L. (1998). *Learning styles explained*. Retrieved February 2, 2011 from http://www.ldpride.net/learningstyles.MI.htm#Multiple%20Intelligences%20Explained

Bonwell, C. (1991). *Active learning: Creating excitement in the classroom*. Retrieved February 24, 2008, from http://www.ntlf.com/html/lib/bib/91-9dig.htm

Bradley, D. (2005, August). *The science practical inventory: A new evaluation instrument for science practical programs.* Paper presented at the Fourth International Conference on Science, Mathematics and Technology Education, Victoria, Canada.

Brock, K., & Cameron, B. (1999). Enlivening political science courses with Kolb's Learning Preference Model. *Political Science and Politics*, *32* (2), 251 – 256.

Brualdi, A. (1996). *Multiple intelligences: Gardner's theory*. Retrieved February 2, 2011 from http://www.springhurst.org/articles/MItheory.htm

Cartnal, R. B., & Diaz, D. P. (1999). Students' learning styles in two classes. *College Teaching, 47*. Retrieved February 24, 2008, from http://www.questia.com/googleScholar.qst

Chandra, V., & Fisher, D. (2009). Students' perceptions of a blended web-based learning environment. *Learning Environment Research, 12* (1), 31-44.

Chandra, V., & Fisher, D. (2006). Assessing the effectiveness of a blended web-based learning environment in an Australian high school. In D. Fisher, & M. S. Khine, (2006). *Contemporary approaches to research on learning environments worldwide* (pp. 461-478). Singapore: World Scientific Publishing Co.

Collins, C., & Yates, L. (2009). Curriculum policy in South Australia since the 1970s: The quest for commonality. *Australian Journal of Education, 53* (2), 125-140.

Cronbach, D. J. (1951). Coefficient alpha and internal structure of tests. *Psychometrika, 16* (3), 297-334.

Darby, J. (2006). *Multiple intelligences and learning styles*. Retrieved February 24, 2008, from http://familiesonline.co.uk/article/articleprint/2416/1/22/

den Brok, P. D., Cakiroglu, J., Taconis, R., & Tekkaya, C. (2008, 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.

De Vellis, R. F. (1991). *Scale development: Theory and applications*. Newbury Park: Sage Publications.

Ebenezer, J. V., & Zoller, U. (1993). Grade 10 Students' perceptions of and attitudes toward science teaching and school science. *Journal of Research in Science Teaching, 30* (2), 175-186.

Ebrahim, A. (2009). *The effect of cooperative learning strategies on elementary students' science achievement and social skills in Kuwait*. Kuwait: Kuwait University.

Ericksen, S. (1984). *The essence of good teaching*. San Francisco: Jossey-Bass.

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., & Khine, M.S. (2006). *Contemporary approaches to research on learning environments worldwide.* Singapore: World Scientific Publishing Co.

Fisher, D. L., & Rickards, T. (1998). Associations between teacher-student interpersonal behavior and student attitude to mathematics. *Mathematics Education Research Journal, 10* (1), 3-15.

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.

Fisher, D. L., Rickards, T., Goh, S. C., & Wong, A. (1997). Perceptions of interpersonal teacher behavior in secondary science classrooms in Singapore and Australia. *Journal of Applied Research in Education, 1*, 3-11.

Fowler, S. (2009). *Identifying multiple intelligences & learning styles*. Retrieved February 2, 2011 from http://fastsmartwebdesign.com/multiple_intelligences_learning_styles.htm

Fraser, B. J. (2002). Learning environments research: Yesterday, today and tomorrow. In S.C. Goh & M.S. Khine (Eds.), *Studies in educational learning environments: An international perspective* (pp.1-25). Singapore: World Scientific Publishing.

Fraser, B. J. (1998a). Science learning environments: Assessment, effects and determinants. In B.J. Fraser & K.G. Tobin (Eds.), *International handbook of science education* (pp. 527-564). 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. (1989). *Assessing and improving classroom environment* (What Research Says, No. 2). Perth: Curtin University of Technology.

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

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

Fraser, B. J., & Lee, S. S. (2008). Science laboratory classroom environments in Korean high schools. *Learning Environments Research, 2009* (12), 67-84.

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

Gallagher, J. J. Implementing teacher change at the school level. In D. F. Treagust, R. Duitt, & B. J. Fraser, (Eds.). (1996). *Improving teaching and learning in science and mathematics* (pp. 222-232). London: Teachers College Press.

Gardner, H. (2003). *Multiple intelligences after twenty years*. Cambridge: Harvard Graduate School of Education.

Gardner, H. (1983). *Frames of mind: The Theory of Multiple Intelligences*. New York: Basic Books.

Guignon, A. (2010). *Multiple Intelligences: A theory for everyone*. Retrieved February 2, 2011 from http://www.educationworld.com/a_curr/curr054.shtml

Haney. J., Lumpe, A., & Czemiak, C. (2003). Constructivist beliefs about the science classroom learning environment: Perspectives from teachers, administrators, parents, community members, and students. *School Science and Mathematics, 103* (8), 366.

Hassan, G., & Fisher, D. (2005, August). *Factors associated with declining interest and motivation in science among secondary and tertiary students in Australia.* Paper presented at the Fourth International Conference on Science, Mathematics and Technology Education, Victoria, Canada.

Hay, P. J. (2009) Students' perceptions of schooling in a senior secondary education system. *Australian Journal of Education, 53* (1), 54-68.

Henderson, D., Fisher, D., & Fraser, B. (1998). Interpersonal behaviour, laboratory learning environments, and student outcomes in senior biology classes. *Journal of Research in Science Teaching, 37* (1), 26-43.

Henderson, D., & Reid, K. (2000, January). *Learning environments in senior secondary science classes*. Paper presented at the Second International Conference on Science, Mathematics and Technology Education, Taipei, Taiwan.

Hofstein, A. (2008, January). *The laboratory in science education: From theory to practice.* Paper presented at the Fifth International Conference on Science, Mathematics and Technology Education, Udon Thani, Thailand.

Hofstein, A., Cohen, I., & Lazarowitz, R. (1996). The learning environment of high school students in chemistry and biology laboratories. *Research in Science & Technological Education, 14* (1), 103-116.

Hofstein, A., Eilks, I., & Bybee, R. (2011). Societal issues and their importance for contemporary science education - A Pedagogical Justification and the State-Of-The-Art in Israel, Germany, and The USA. *International Journal of Science and Mathematics Education, 9* (6), 1459-1483.

Hofstein, A., & Mandler, V. (1985). The use of Lawson's test of formal reasoning in the Israeli science education context. *Journal of Research in Science Teaching, 22* (2), 141-152.

Ingvarson, L. (2010). Recognising accomplished teachers in Australia: Where have we been? Where are we heading? *Australian Journal of Education, 54* (1), 46-71.

Ingvarson, L., & Rowe, K. (2008). Conceptualising and evaluating teacher quality: substantive and methodological issues. *Australian Journal of Education, 52* (1), 5-35.

Jenkins, E. W., & Pell, R. G. (2006) *The Relevance of Science Education Project (ROSE) in England: a summary of findings.* Leeds: University of Leeds.

Jones, M., Howe, A., & Rua, M. (1999). *Gender differences in students' experiences, interests, and attitudes toward science and scientists*. Capel Hill, NC: USA.

Jones, C., Reichard, C. & Mokhtari, K. (2003). Are students' learning styles discipline specific? *Community College Journal of Research and Practice, 27* (5), 363-375.

Kahle, J. (2005, August). *Inside science classrooms with the Constructivist Learning Environment Survey (CLES).* Paper presented at the Fourth International Conference on Science, Mathematics and Technology Education, Victoria, Canada.

Kellner, E., Gullberg, A., Attorps, I., Thoren, I., & Tarneberg, R. (2009). *Prospective teachers' Initial Conceptions About Pupils' Difficulties in Science and mathematics: A Potential Resource in Teacher Education*. Sweden: University of Gayle.

Kempa, R. F., & Diaz, M. M. (1990). Students motivational traits and preferences for different instructional modes in science education – Part 2. *International Journal of Science Education, 12,* 205-216.

Kenneday, G. (2010). *Dubbo college community consultation report*. *Smart Outcomes educational consultancy.* New South Wales: Department of Education Printing Office.

Kerr, C. R. (2005, August). *An investigation of Tasmanian year 11 science students' perceptions of information communication technology-rich learning environments*. Paper presented at the Fourth International Conference on Science, Mathematics and Technology Education, Victoria, Canada.

Kijkosol, D., & Fisher, D. (2008, January). *Laboratory learning environments and attitude to biology classes in Thailand.* Paper presented at the Fifth International Conference on Science, Mathematics and Technology Education, Udon Thani, Thailand.

King, G. (2002). *Cognitive mind mapping*. Retrieved February 2, 2011 from http://www.novamind.com/mind-mapping/cognitive-mind-mapping.php

Klieger, A., & Bar-Yossef, N. (2009). *Professional development of science teachers as a reflection of large-scale assessment*. Israel: Beit Berl Academic College.

Koul, R., & Fisher, D. (2004). Cultural background and students' perceptions of science classroom learning environment and teacher interpersonal behaviour in Jammu, India. *Learning Environments Research, 2005*, (8) 195-211.

Koul, R., Fisher, D., & Shaw, T. (2011). An application of the TROFLEI in secondary-school science classes in New Zealand. *Research in Science & Technological Education*, *29* (2), 147-167.

Koul, R. B., & Zandvliet, D. (2008, January). *Learning environments and environmental education instrument*. Paper presented at the Fifth International

Conference on Science, Mathematics and Technology Education, Udon Thani, Thailand.

Lang, Q. C. (2005). Student perceptions of chemistry laboratory learning environments, student–teacher interactions and attitudes in secondary school gifted education classes in Singapore. *Research in Science Education, 35* (2-3).

Lightburn, M. E., & Fraser, B. J. (2007). Classroom environment and student outcomes among students using anthropometry activities in high-school science. *Research in Science and Technological Education*, *25* (2), 153-166.

Lloyd, D., & Paige, K. (2008, January). *Valued science and mathematics learning in middle schooling: Connecting to students' lived experiences*. Paper presented at the Fifth International Conference on Science, Mathematics and Technology Education, Udon Thani, Thailand.

Lowe, J. P. (2004). *The effect of cooperative group work and assessment on the attitudes of students towards science in New Zealand*. Unpublished doctoral thesis, Curtin University, Australia.

McRobbie, C. J., Fraser, B. J., & Giddings, G. J. (1991). Comparison of personal and class forms of the Science Laboratory Environment Inventory. *Research in Science Education, 1991* (21), 244-252.

Malaguzzi, L. History, ideas and philosophy. In C. Edwards, L. Gandini, & G. Forman, (1998). *The Hundred Languages of Children: The Reggio Emilia Approach* (p. 83). Greenwich: Ablex Publishing.

Miller, K.W. & Davidson, D. (1998). Is thematic integration the best way to reform science and mathematics education? *Science Educator*, *7* (1), 7-12.

Moran, S., Kornhaber, M., & Gardner, H. (2007). Multiple intelligences: building active learners. *Teacher, 177*, 26-30.

Nam, J., Choi, A., & Hand, B. (2010). *Implementation of the Science Writing Heuristic (SWH) approach in 8th Grade science classrooms*. Korea: Pusan National University.

New South Wales Board of Studies. (2007). *Years 7-10 Science Syllabus.* Sydney: Government Printing Office.

New South Wales Department of Education and Training. (2010). *Our middle years learners – engaged, resilient, successful: An educational strategy for Years 5 to 9, 2010 – 2012*. Sydney: Government Printing Office.

New South Wales Department of Education and Training. (2007). *The State Education Research Approval Process (SERAP)* Form k. Sydney: Government Printing Office.

Newby, M., & Fisher, D. L. (1997). An instrument for assessing the learning environment of a computer laboratory. *Journal of Educational Computing Research, 16*, 179-190.

Norusis, M. J. (1993). *SPSS for Windows Base system users Guide Release 6.0*. Chicago, IL.: SPSS Inc.

Nunnally, J. C. (1978). *Psychometric Theory* (2nd ed.). New York: McGraw Hill.

Organisation for Economic Co-Operation and Development. (2005). *Teachers matter: Attracting, developing and retaining effective teachers*. Paris: Author

Orion, N., Hofstein, A. Pinchas, T., & Giddings, G. (1994, March). *The development and validation of an instrument for assessing the learning environment of science outdoor activities*. Paper presented at the National Association for Research in Science Teaching, Anaheim, CA.

Osborne, 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.

Page, S., & Coppedge, G. (2004). Hey, there's a forest in that classroom! *Science and Children, 41* (6), 52.

Pimthong, P., Yutakom, N., Roadrangka, V., Sanguanruang, S., Cowie, B., & Cooper, B. (2009). Teaching and learning about matter in Grade 6 classrooms: A conceptual change approach. *International Journal of Science and Mathematics Education*. Published online February 23, 2011.

Pirozzo, R. (2001). *Improving your children's learning outcomes*. Bridgeman Downs: Pirozzo Consultancy Services.

Prosser, B. (2008). Unfinished but not yet exhausted: A review of Australian Middle Schooling. *Australian Journal of Education, 52* (2), 151-167.

Reid, C., & Fisher, D. (2008, January). *Teacher interpersonal behaviour: It's influence on student motivation in science*. Paper presented at the Fifth International Conference on Science, Mathematics and Technology Education, Udon Thani, Thailand.

Rickards, T. (1999). Teacher-student classroom interactions among science students of different sex and cultural background. *Research in Science Education, 29* (4).

Rodgers, M. P., Cross, D., Sommerfeld Gresalfi, M., Trauth-Nare, A., & Buck, G. (2009). *First year implementation of a project-based learning approach: The need for addressing teachers' orientations in the era of reform*. USA: Indiana University.

Schaller, D. T., (2007). *One size does not fit all: Learning style, play, and on-line interactives*. Retrieved March 16, 2011 from http://www.archimuse.com/mw2007/papers/schaller/schaller.html

Schurr, S. (1996). Balancing act: Student-centred and subject-centred instruction. *Schools in the Middle*, *6* (1), 11-15.

Schuster, D. (2008). Take a planet walk. *Science and Children, 46* (1), 42.

Scott, C. (2010). The enduring appeal of 'learning styles'. *Australian Journal of Education, 54* (1), 5-17.

She, H. (2000). The development of a questionnaire to describe science teacher communication behavior in Taiwan and Australia. *Science Education, 84* (6).

Simpson, R. & Oliver, S. (1985). Attitude toward science and achievement motivation profiles of male and female science students in grades six through ten. *Science Education, 69* (4), 511-526.

Singh, K., Granville, M., & Dika, S. (2002). Mathematics and science achievement: Effects of motivation, interest, and academic engagement. *The Journal of Educational Research, 95* (6), 323-332.

Smith, P. (2004). *Understanding of learning styles among VET practitioners*. Retrieved February 24, 2008, from http://www.avetra.org.au/publications/documents/PA021Smith.pdf

Sullivan, P., Mornane, A., Prain, V., Campbell, C., Deed, C., Drane, S., Faulkner, M., McDonough, A. & Smith, C. (2009). Junior secondary students' perceptions of influences on their engagement with schooling. *Australian Journal of Education*, *53* (2), 176-191.

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

Tuan, H., Chin, C., & Shieh, S. (2005). The development of a questionnaire to measure students' motivation towards science learning. *International Journal of Science Education, 27* (6), 639-654.

Venville, G., Wallace, J., Rennie, L. & Malone, J. (2002). Curriculum integration: Eroding the high ground of science as a school subject? *Studies in Science education, 37*, 43-84.

Venville, G., Wallace, J., Rennie, L & Malone, J. (1999). Building bridges across the disciplines: Learning science through technology. *The Journal of Design and Technology Education, 4* (1), 40-45.

Waldrip, B. G., Fisher, D. L., & Dorman, J. (2007). Identifying exemplary science teachers through students' perceptions of their learning environment. *Learning Environment Research, 2009* (12), 1-13.

Wilcox, D. R., & Sterling, D. R. (2008). Bring the Zoo. *Science and Children, 41* (8), 42.

Wolf, S. J., & Fraser, B. J. (2005, August). *Learning environment and student attitudes and achievement in middle-school science classes using inquiry-based laboratory activities*. Paper presented at the Fourth International Conference on Science, Mathematics and Technology Education, Victoria, Canada.

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

Wubbels, T. (1993). *Teacher-student relationships in science and mathematics classes* (What Research Says, No. 11). Perth: Curtin University of Technology.

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

APPENDICES

Appendix 1 SLEI Actual

Appendix 2 SLEI Preferred

Appendix 3 Grid (Cooperative Learning Unit Natural Events)

Appendix 4 SERAP Approval Letter

Appendix 5 Curtin Approval Letter

Appendix 6 Letter to Principals

Appendix 7 Participant Consent Form

Appendix 8 Participant Information Sheet

Appendix 9 Grid Data

Appendix 1 SLEI Actual

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.

PLEASE CIRCLE:

MALE FEMALE	**YEAR 5 YEAR 7 YEAR 9**	**STUDENT TEACHER**

	*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.	1.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	

For Teacher's Use Only: SC_____ OE____ I____ RC____ ME____

Appendix 2 SLEI Preferred

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.

PLEASE CIRCLE:

MALE FEMALE	**YEAR 5 YEAR 7 YEAR 9**	**STUDENT TEACHER**

	*Remember that you are describing your **preferred** classroom.*	Almost Never	Seldom	Sometimes	Often	Very Often	**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	

For Teacher's Use Only: SC_____ OE____ I____ RC____ ME____

Appendix 3 Grid

Cooperative Learning Unit - NATURAL EVENTS

	1 – Rocks	2 – Fossils	3 – Earthquakes	4 – Volcanoes	5 – Cyclones
A – Verbal / Linguistic	Design a poster showing the layers of the Earth	Design a poster showing the conditions under which fossils form	Design a poster showing the causes and effects of Earthquakes	Design a poster describing volcanoes	Design a poster about cyclones
B – Verbal / Linguistic	Write a speech, story or newspaper article describing the theory of plate tectonics	Write a speech, story or newspaper article about fossils	Write a speech, story or newspaper article about a specific Earthquake that has occurred	Write a speech, story or newspaper article about a specific volcanic eruption	Write a speech, story or newspaper article about a cyclone
C – Logical / Mathematical	Describe the life story of a piece of magma from inside the asthenosphere until it becomes a rock	Prepare a flowchart outlining the process of fossilization	Design an experiment to demonstrate convection currents in a liquid	Classify volcanoes as shield, cinder cone and composite	Predict conditions that would increase the chances / severity of cyclones
D – Visual / Spatial	Draw and label a map of the Earth showing the crustal plates	Create a time line showing the age of the Earth from fossil records	Produce a chart showing the features of P, S, and L waves	Draw the three main types of volcanoes and label the various parts	Compare cyclones to twisters and tornadoes
E – Body / Kinaesthetic	Devise a board game titled “Earth” and prepare a manual	Make cut outs of different types of fossils	Write a TV ad that could be used to warn residents of a possible Earthquake	Build a model of a volcano	Create a play about a cyclone
F – Musical / Rhythmical	Use various rocks as musical instruments	Act and choreograph a dance to represent the process of fossilisation	Produce sound effects for a scene involving an earthquake	Write a song about volcanoes	Compose a musical piece made of instrumental parts to represent a cyclone
G – Interpersonal	In groups, construct a rock collection and label each sample	Design a possible environment for a species that was thought to exist in the past	Interview a person who has been in an Earthquake	Construct an interview for radio of a made up person who survived a volcanic eruption	Construct a TV interview of a made up person who has been in a cyclone
H – Intrapersonal	Predict what will happen to the earth in another 40 million years	Construct a concept map showing various ways of identifying the age of the Earth (eg Radioactive Decay)	Visualise that you have been in an Earthquake. Write a diary about your experiences.	Describe how you would feel if you were in a volcanic eruption	Write a diary or journal entry about what it would be like to be in a cyclone

Adapted from Pirozzo, 2001

Appendix 4 SERAP Approval Letter

PLANNING AND INNOVATION

NEW SOUTH WALES
DEPARTMENT
OF EDUCATION
AND TRAINING

Early Childhood and Primary Education
Secondary Education
Technical and Further Education
Vocational Education and Training
Higher Education
Adult and Community Education

Mrs Linda Pfeiffer
29L Whitewood Road
DUBBO NSW 2830
AUSTRALIA

Dear Mrs Pfeiffer SERAP Number **2007126**

I refer to your application to conduct a research project in NSW government schools entitled *A comparison of the preferred learning styles of Year 5, Year 7 and Year 9 students in Science using the Science Laboratory Environment Inventory (SLEI) and a cooperative learning unit of work based on Multiple Intelligences.*. I am pleased to inform you that your application has been approved. You may now contact the Principals of the nominated schools to seek their participation.

This approval will remain valid until 07 May 2008.

Please note that no researchers or research assistants have been approved to interact with or observe children for the purposes of this research.

You should include a copy of this letter with the documents you send to schools.

I draw your attention to the following requirements for all researchers in NSW government schools:

- School Principals have the right to withdraw the school from the study at any time. The approval of the Principal for the specific method of gathering information for the school must also be sought.
- The privacy of the school and the students is to be protected.
- The participation of teachers and students must be voluntary and must be at the school's convenience.
- Any proposal to publish the outcomes of the study should be discussed with the Research Approvals Officer before publication proceeds.

When your study is completed please forward your report marked to General Manager, Planning and Innovation, Department of Education and Training, GPO Box 33, Sydney, NSW 2001.

Yours sincerely

Dr Christine Ewan
General Manager, Planning and Innovation
16 August 07

• Level 6, 35 Bridge Street • GPO Box 33 • Sydney NSW 2001 Australia •
• *telephone* 02 61 2 9561 8744 • *facsimile* 02 61 2 9561 8941 • www.det.nsw.edu.au •

Appendix 5 Curtin Approval Letter

memorandum

Curtin University of Technology

To	Linda Pfeiffer, SMEC
From	A/Professor Stephan Millett, Executive Officer, Human Research Ethics Committee
Subject	Protocol Approval **RD-12-07**
Date	7 May 2007
Copy	Dr Darrell Fisher SMEC

Office of Research and Development

Human Research Ethics Committee

TELEPHONE 9266 2784
FACSIMILE 9266 3793
EMAIL hrec@curtin.edu.au

Thank you for your "Form C Application for Approval of Research with Minimal Risk (Ethical Requirements)" for the project titled *"A Comparsion Of The Preferred Learning Style Of Year 5 , Year 7 And Year 9 Students In Science"*. On behalf of the Human Research Ethics Committee I am authorised to inform you that the project is approved.

Approval of this project is for a period of twelve months **7 May 2007** to **7 May 2008**.

If at any time during the twelve months changes/amendments occur, or if a serious or unexpected adverse event occurs, please advise me immediately. The approval number for your project is **RD-12-07**. *Please quote this number in any future correspondence.*

pp A/Professor Stephan Millett
Executive Officer
Human Research Ethics Committee

Please Note: The following standard statement must be included in the information sheet to participants:
This study has been approved by the Curtin University Human Research Ethics Committee (Approval Number RD-12-07. If needed, verification of approval can be obtained either by writing to the Curtin University Human Research Ethics Committee, c/- Office of Research and Development, Curtin University of Technology, GPO Box U1987, Perth, 6845 or by telephoning 9266 2784 or hrec@curtin.edu.au

Appendix 6 Letter to Principals

Principal
Dubbo X Public School
Dubbo NSW 2830

Linda Pfeiffer
Dubbo NSW 2830
(02) 6885 4115

linda.pfeiffer@postgrad.curtin.edu.au

Dear Principal,

My name is Linda Pfeiffer and I am currently completing a piece of research for my Doctor of Science Education at Curtin University of Technology. The title of this study is: *A comparison of the preferred learning styles of Year 5, Year 7 and Year 9 students in Science using the Science Laboratory Environment Inventory (SLEI) and a cooperative learning unit of work based on Multiple Intelligences.*

I am seeking permission to conduct this study using some of the students from your school. This would involve Year 5 students:

> **Part A**: completing two surveys (one for actual classroom learning environment and one for preferred classroom learning environment) in regards to their Science lessons and
> **Part B**: selecting preferred classroom activities from a grid.

The teachers of these classes would also be asked to complete the survey for the actual and preferred classroom learning environment. I would envisage the completion of these items would take approximately **30 minutes.**

I wish to conduct the surveys during Term 2 at a time suitable to you. Please find enclosed a Participant Information Sheet and Consent Form for distribution to parents prior to the completion of surveys. Also find enclosed copies of the surveys to be conducted.

I will provide your school with a report of the research findings at the conclusion of this study which is hoped to be by the end of next year. Please contact me at the above phone number or email address.

Thank you for your time.

Linda Pfeiffer

Appendix 7 Participant Consent Form

Curtin University of Technology

A comparison of the preferred learning styles of Year 5, Year 7 and Year 9 students in Science using the Science Laboratory Environment Inventory (SLEI) and a cooperative learning unit of work based on Multiple Intelligences.

CONSENT FORM

- I understand the purpose and procedures of the study.
- I have been provided with the participant information sheet.
- I understand that the procedure itself may not benefit me.
- I understand that my involvement is voluntary and I can withdraw at any time without problem.
- I understand that no personal identifying information like my name and address will be used and that all information will be securely stored for 5 years before being destroyed.
- I have been given the opportunity to ask questions.
- I agree to participate in the study outlined to me.

Name of child: ___________________________ Age: ___________

Signature of child: ___________________________

Name of Parent / Guardian: ____________________

Signature of Parent / Guardian: _________________ Date: ___________

Investigator: ____________________ Signature: ______________

Appendix 8 Participant Information Sheet

Curtin University of Technology

PARTICIPANT INFORMATION SHEET

My name is Linda Pfeiffer and I am currently completing a piece of research for my Doctor of Science Education at Curtin University of Technology.

Purpose of Research

A comparison of the preferred learning styles of Year 5, Year 7 and Year 9 students in Science using the Science Laboratory Environment Inventory (SLEI) and a cooperative learning unit of work based on Multiple Intelligences.

Specifically, the study will investigate:

- How do students' perceptions of, and attitudes to, science change across these three age groups?
- How can the classroom learning environment be modified to cater for students' preferred learning styles?
- How does the preferred learning style change across these three age groups?
- Does gender play a role in the preferred learning style of students at these ages?
- Does teacher gender influence the type of learning style that is most catered for?

Procedure

<u>Part A</u>

(i) Students will complete the SLEI for actual science learning environment and preferred science learning environment. The SLEI consists of 35 statements, 7 for each scale of Student Cohesiveness, Open-Endedness, Integration, Rule Clarity, and Material Environment. The response choices are almost never, seldom, sometimes, often, very often. Examples of statements include:

- "I use the theory from my regular science class sessions during laboratory activities" (Integration)
- "We know the results we are supposed to get before we commence a laboratory activity" (open-endedness)

(ii) SLEI will also be used on the teacher for the actual and preferred science learning environment. If there is a difference between actual and preferred, teacher given opportunity to express reasons why.

<u>Part B</u>

(i) Students will be given a choice of learning activities using a grid. Students will be asked to select (by way of colouring in) 15 tasks to complete in class (hypothetical). They must choose one from each column and no more than three from each row.

(ii) In addition, approximately ten students from each year group will be asked to identify:

1. Which activity would be your favourite? Why?
2. Which activity would be the easiest? Why?
3. Which activity would be the most interesting? Why?
4. Which activity would be the most challenging? Why?

Both Part A and Part B will require students (and teacher) to mark their age and gender on the forms. The differences between the ages, the actual and preferred learning styles, the teachers' perceptions and gender will be compared.

Please note:

- Your involvement in the research is entirely voluntary.
- You have the right to withdraw at any stage without it affecting your rights or my responsibilities.
- Your privacy is greatly respected and any information that could identify you will be removed.
- You will be asked to complete a consent form.
- All information will be stored confidentially with a code at Curtin University of Technology for 5 years. After this time, the information will be destroyed.

If you would like further information about the study, please feel free to contact me on 02 6885 4115 or by email: Linda.Pfeiffer@postgrad.curtin.edu.au. Alternatively, you can contact my supervisor Dr Darrell Fisher at D.Fisher@curtin.edu.au

Thank you very much for your involvement in this research, your participation is greatly appreciated.

"Any fool can know, the point is to understand" (Einstein)

This study has been approved by the Curtin University Human Research Ethics Committee. If needed, verification of approval can be obtained either by writing to the Curtin University Human Research Ethics Committee, c/- Office of Research and Development, Curtin University of Technology, GPO Box U1987, Perth, 6845 or by telephoning 9266 2784 or emailing hrec@curtin.edu.au

Appendix 9 Grid Data

	1 – Rocks			**2 – Fossils**			**3 – Earthquakes**			**4 – Volcanoes**			**5 – Cyclones**		
A – Verbal / Linguistic	Design a poster			Design a poster			Design a poster			Design a poster			Design a poster		
	5	7	9	5	7	9	5	7	9	5	7	9	5	7	9
	M 18 F 15	M 33 F 27	M 30 F 36	M 0 F 8	M 16 F 13	M 14 F 16	M 16 F 15	M 24 F 26	M 26 F 21	M 22 F 16	M 31 F 34	M 25 F 25	M19 F 15	M 41 F 33	M 32 F 35
B – Verbal / Linguistic	Write speech, story or article			Write speech, story			Write speech, story			Write speech, story			Write speech, story		
	5	7	9	5	7	9	5	7	9	5	7	9	5	7	9
	M 3 F 3	M 9 F 5	M 7 F 9	M 13 F 9	M 15 F 14	M 18 F 16	M 6 F 4	M 15 F 10	M 8 F 16	M 10 F 4	M 16 F 8	M 15 F 12	M 7 F 7	M 11 F 18	M 12 F 17
C – Logical / Mathematical	Describe life story of a rock			Prepare a flowchart			Design an experiment			Classify			Predict conditions		
	5	7	9	5	7	9	5	7	9	5	7	9	5	7	9
	M 8 F 8	M17 F 10	M 17 F 15	M 13 F 5	M19 F 19	M 13 F 23	M 21 F 13	M 35 F 27	M 20 F 28	M 9 F 4	M 14 F 9	M 10 F 11	M 12 F 2	M 25 F 10	M 14 F 7
D – Visual / Spatial	Draw and label a map			Create a time line			Produce a chart			Draw			Compare		
	5	7	9	5	7	9	5	7	9	5	7	9	5	7	9
	M 15 F 5	M 21 F 12	M 10 F 26	M 10 F 8	M 11 F 11	M 18 F 16	M 6 F 4	M 12 F 6	M 11 F 7	M 12 F 10	M 27 F 14	M 17 F 26	M 18 F 11	M 29 F 19	M 23 F 24
E – Body / Kinaesthetic	Devise a board game			Make cut outs			Write a TV ad			Build a model			Create a play		
	5	7	9	5	7	9	5	7	9	5	7	9	5	7	9
	M 11 F 14	M 28 F 27	M 20 F 23	M 13 F 13	M 23 F 25	M 23 F 28	M 18 F 8	M 14 F 15	M 15 F 14	M 20 F 8	M 50 F 39	M 30 F 41	M 16 F 17	M 28 F 24	M 15 F 20
F – Musical / Rhythmical	Use musical instruments			Choreograph a dance			Produce sound effects			Write a song			Compose a musical piece		
	5	7	9	5	7	9	5	7	9	5	7	9	5	7	9
	M 18 F 15	M 25 F 30	M 18 F 27	M 7 F 10	M 10 F 13	M 8 F 21	M 13 F 11	M 15 F 13	M 19 F 23	M 10 F 6	M 31 F 19	M 13 F 24	M 1 F 6	M 12 F 8	M 8 F 7
G – Interpersonal	In groups			Design			Interview			Radio interview			TV interview		
	5	7	9	5	7	9	5	7	9	5	7	9	5	7	9
	M 15 F 11	M 27 F 25	M 16 F 31	M 11 F 9	M 27 F 15	M 20 F 24	M 17 F 13	M 28 F 24	M 17 F 28	M 9 F 3	M 13 F 5	M 9 F 9	M 14 F 14	M 19 F 20	M 16 F 18
H – Intrapersonal	Predict			Construct a concept map			Visualise			Describe feelings			Write a diary entry		
	5	7	9	5	7	9	5	7	9	5	7	9	5	7	9
	M 17 F 9	M 38 F 21	M 27 F 18	M 4 F 4	M 10 F 9	M 11 F 13	M 6 F 7	M 15 F 18	M 16 F 21	M 13 F 8	M 29 F 14	M 24 F 20	M 11 F 11	M 16 F 15	M 11 F 29

Key:

- >50%
- 30 – 50%
- < 10%

	YEAR 5 M 34 F 25	YEAR 7 M 61 F 52	YEAR 9 M 53 F 60
>50%	17+ 13+	31+ 26+	27+ 31+
30 – 50%	11+ 8+	20+ 17+	17+ 20+
<10%	<=3 <=3	<=6 <=5	<=5 <=6