Science and Mathematics Education Centre

Gender, Grade-level and Stream Differences in Learning Environment and Student Attitudes in Primary Science Classrooms in Singapore

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DECLARATION

This thesis contains no material which has been accepted for the award of any other degree or diploma in any university. To the best of my knowledge and belief, this thesis contains no material previously published by any person except where due acknowledgement has been made.

Signature:

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ABSTRACT

A major focus of this research was the validity and reliability of a learning environment and attitude questionnaire in primary school classrooms in Singapore. The learning environment scales were chosen from Constructivist Learning Environment Survey (CLES) and What Is Happening In this Class? (WIHIC). The scales to assess the attitudes to science were chosen from the Test of Science Related Attitudes (TOSRA). The study also investigated gender, grade-level and stream differences in learning environment and attitudes to science and also investigated the relationships between attitudes and the learning environment. Data were gathered from 1081 students from 55 different classes in 4 different primary schools in Singapore.

This study is the first in the Singapore context that focused on Gifted Education (GE) pupils and High Ability (HA) pupils in the primary school setting. It is also the first study in Singapore which focused on investigating gender, grade-level and stream differences in learning environment and attitudes to science and associations between students' attitudes to science and their perceptions of the classroom learning environment within the one study.

Factor analysis was conducted for the 70 items in the learning environment and attitude scales based on the CLES, WIHIC and TOSRA. From the original 70 items, 61 items were kept in the same 10-factor structure. The 61 items each had a factor loading of at least 0.40 on its a priori scale and lower than 0.40 on all of the other scales. The 61-item version of the questionnaire containing learning environment scales based on the WIHIC (5 scales with 4−8 items in each) and the CLES (3 scales with 4−5 items in each) and 2 six-item attitude scales based on the TOSRA was accepted. Also the learning environment scales based on the CLES and WIHIC were capable of differentiating significantly between classes, and all learning environment

attitude scales were reliable when used with this sample of elementary-school students in Singapore.

The use of MANOVA and ANOVAs identified the presence of any gender, grade-level, stream, stream-by-gender, grade-by-stream, grade-by-gender and stream-by-gender-by-grade interactions for each scale. The statistically significant findings were:

- significant gender differences for Involvement, Teacher Support, Task Orientation and Cooperation
- significant grade-level differences for Teacher Support, Task Orientation, Cooperation and Enjoyment
- significant stream differences for Involvement, Cooperation and Personal Relevance
- significant stream-by-gender interactions for Task Orientation and Enjoyment
- significant grade-by-stream interactions for Investigation, Student Negotiation, Scientific Inquiry and Enjoyment
- no significant grade-by-gender interaction for any dependent variable
- no significant three-way stream-by-gender-by-grade interaction for any dependent variable.

Simple correlation and multiple regression analyses replicated considerable prior research into associations between student attitudes and the learning environment: improved student attitudes were associated with more emphasis on the aspects of learning environment assessed in this study.

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Chapter 1

INTRODUCTION AND BACKGROUND

1.1 Introduction

In education generally, and in science education specifically, we have seen a myriad of changes in recent times, including a shift from teacher-centred to more student-centred classrooms, the inclusion of computer-assisted learning, cooperative learning, investigative problem-solving and inquiry in science teaching.

Inquiry has been accepted by science educators as the central strategy for teaching and learning science. The nature of lessons have changed appreciably since the time when I was a student, when the science teacher would come into the class and ask us to open the textbook and underline some points, after which she would start writing on the blackboard and we (the students) would copy furiously into our note books. At times, she would show us demostrations of experiments in the front of the class, where we would all crowd around and watch. Very ocassionally, we did an experiment and even then it would involve following a series of steps and not knowing why and what to do. Now the learning environment has changed.

From a researcher's point of view, I was interested in undertanding the psychosocial learning environment that exists in science classrooms now and the attitudes of students towards science. At a more personal level, during the recent years of my teaching career, I have been teaching science to Gifted Education (GE) students and High Ability (HA) students and wondering if these students differ in their perceptions of their science classroom and attitude towards science. Likewise, I was also keen to know if grade-level or gender made a difference to these perceptions, thus leading to the present study.

The foci of my research were to:

- investigate the reliability and validity of a learning environment and attitude questionnaire for primary science classrooms in Singapore,
- investigate the gender, grade-level and stream differences in learning environment and attitudes to science,
- investigate relationships between attitudes and the learning environment.

Data were gathered from 1081 students from 55 different classes in 4 different schools. The students were from grade 4, 5, and 6 and from two streams, Gifted Education (GE) and High Ability (HA).

1.2 Context of Study

This section describes the context of the study, including science education, the education system and the Gifted Education Programme (GEP) in Singapore. This section focuses on Gifted Education (GE) to show the difference between the GE and the normal curriculum that the rest of the students follow.

1.2.1 Science Education in Singapore

Science education in Singapore starts with the primary science curriculum, which is the foundation for various scientific studies at higher levels. The science syllabus is based on the Science Curriculum Framework (Ministry of Education, 2008a) and emphasises the need for a balance between acquisition of science knowledge, process and attitudes.

The Science Curriculum Framework encapsulates that the thrust of science education in Singapore is to prepare students to be effective citizens. As depicted in Figure 1.1, central to the curriculum framework is the inculcation of the spirit of scientific inquiry which is founded on three integral domains of (a) knowledge, understanding and application, (b) skills and processes and (c) ethics and attitudes. These domains are essential to the practice of science. The curriculum is designed to enable students to view the pursuit of science as meaningful and useful. Inquiry is thus grounded in knowledge, issues and questions that relate to the roles played by science in daily life, society and the environment.

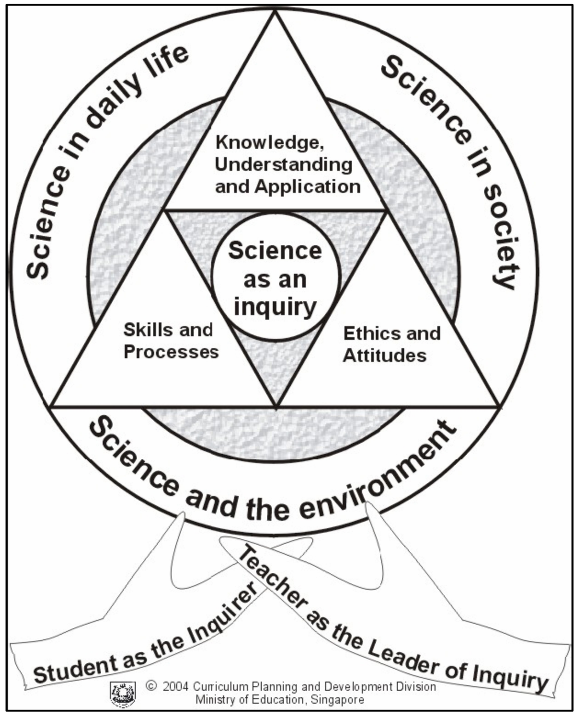

Figure 1.1: Science Curriculum Framework (Source: Ministry of Education, 2008a)

The Primary Science Syllabus aims to:

- provide primary students with experiences which build on their interest in and stimulate their curiosity about their environment.
- provide students with basic scientific terms and concepts to help them understand themselves and the world around them.
- provide students with opportunities to develop skills, habits of mind and attitudes necessary for scientific inquiry.
- prepare students towards using scientific knowledge and methods in making personal decisions.
- help students appreciate how science influences people and the environment. (Ministry of Education, 2008a)

The primary science curriculum is the 'Bible' for mainstream science and GEP science. The planned science curriculum seeks to nurture the student as an inquirer and the teacher as the leader of inquiry in the science classroom. The end goal of the science curriculum is to create students who enjoy science and value science as an important tool in helping them to explore their natural and physical world. The expected role of the teacher, as the leader of inquiry, is to impart the excitement and value of science to the students as they act as facilitators and role models of the inquiry process in the classrooms. The teacher creates a learning environment that encourages and challenges students to develop their sense of inquiry.

Inquiry-based learning can be characterised by the degree of responsibility that students have in posing and responding to questions, designing investigations, and evaluating and communicating their learning (student-directed inquiry) relative to the degree to which the teacher is involved (teacher-guided inquiry). Science lessons are to be structured so that students best benefit from experiences that vary between these two inquiry approaches. The curriculum branch under the Ministry of Education (MOE) encourages teachers to use a variety of strategies to facilitate the inquiry process so as to engage students in meaningful learning experiences and cultivate their interest and curiosity in science.

During inquiry, student social interaction is high and therefore students must work in a risk-free environment (Brewer & Daane, 2002) where they are encouraged to ask questions, share ideas and engage in dialogue. Inquiry requires students to be positively interdependent, so that the benefit to one student benefits the whole group (Colburn, 1998). All students must participate equally and simultaneously to ensure equal opportunities for all students (Dalton & Morocco, 1997; Mastropieri, Scruggs & Boon, 2001).

I feel that such a curriculum would provide opportunities to students for greater student involvement, investigation, task orientation and opportunities to communicate and cooperate. It should also provide greater opportunity for teacher-student interactions that will ultimately result in outcomes such as enjoyment in science lessons and better attitude of the scientific inquiry. Thus my study measured learning environment characteristics such as: Involvement, Teacher Support, Investigation, Task Orientation, Cooperation, Personal Relevance, Uncertainty, Student Negotiation and Attitude scales such as: Scientific Inquiry and Enjoyment using the learning environment and attitude questionnaire designed to measure them.

1.2.2 Education System

The education system in Singapore is structured using a 6:4:2 model with six years of primary education, four years of secondary education and two years of junior college education. The first six years are the formative stage and thus is a critical period in the education of an individual. The education system in Singapore is made up of the following levels:

- Pre-school for children between the ages of 3 to 5 years,
- Kindergarten for children between the ages 5 to 6 years,
- Lower primary (Grade 1 to 3) for children between the ages 7 to 9 years,
- Upper primary (Grade 4 to 6) for children between the ages 10 to 12 years,
- Secondary for children between the ages 13 to 16 years,
- Junior college for children between the ages 17 to 18 years and
- University.

Though primary science is taught as a formal subject from primary three, science education is introduced into the education system from the pre-school ages and is to connect the day-to-day lives of the students.

Being a teacher for the past 15 years in the primary school, I have seen immense changes in education system. The various changes are proposed by the Ministry of Education with the aim to help students to discover their own talents, to make the best of these talents, to realise their full potential, and to develop a passion for learning that lasts through life (Ministry of Education, 2009).

The Gifted Education (GE) Programme, is one such change which was implemented in Singapore in 1984 and is committed to “nurturing gifted individuals to their full potential for the fulfillment of self and betterment of the society" (Ministry of Education, 2008b). According to the Ministry of Education (MOE), Singapore, the rationale for the GE Programme is to ensure that the potential of each student is recognized, nurtured and developed; and to do this it "provides an education of quality and relevance which stimulates individual growth and helps students realise their full potential" (Ministry of Education, 2008b).

1.2.3 The Gifted Education Programme (GEP)

Trained subject teachers are specially deployed by the MOE to teach students in GEP in English, Mathematics, Science, Mother Tongue and Social Studies. The students' academic achievement and attitudes towards learning are monitored closely throughout these three years in the GEP. Cognitive, affective and psychomotor development are equally emphasised in the curriculum (Ministry of Education, 2008b).

Students in GEP also are required to participate in Co-Curriculum Activities (CCA) in areas of sports, uniform groups and/or clubs and societies. This is to promote an all-rounded education in which students' learning potential is maximised. GEP students take school-based tests and assessments which are set specially for them. These test their ability in critical and creative thinking rather than just in knowledge of content alone. There is also continuous assessment based on students' daily work and assignments. GEP students are also prepared for the same national examinations that are taken by students in the mainstream. At the end of Primary 6, GEP students take the Primary School Leaving Examination just like students in the regular stream.

In Singapore, students are identified for the GE based on their performance in the selection tests, which are conducted at the end of Primary 3. The first test, Screening Test, which takes place in August, is open to all Primary 3 students. It comprises two papers, one in English Language and the other in Mathematics. Approximately 4000 students are shortlisted to sit for the Selection Test in October yearly. This second test comprises three papers for English Language, Mathematics and General Ability. Based on the results of this second test, only about 500 students are invited to join the GE Programme in the following year. By going through this tough screening process, students selected for the GE Programme are those with high intellectual ability and potential. Each year, 500 students are selected through the screening process and they are distributed within nine centres, of which my study involved students from four centres.

The selected students in the GE are thus the top 1% of the primary 3 cohort. They are given an enriched curriculum that is pitched to challenge and stretch them. The enriched curriculum is built on the regular curriculum that all other mainstream students are receiving. MOE's rationale for the GE Programme is that the intellectually gifted might not receive a high degree of mental stimulation in the mainstream classroom and thus could become mediocre, indifferent or disruptive in class. The selection process is shown in Figure 1.2.

The Gifted Education (GE) Programme is set up to the advantage of the nation, as Singapore is a small nation and it relies on human resource for its progress and prosperity. These are the educational as well as the socio-political reasons for the need for the GE Programme in Singapore.

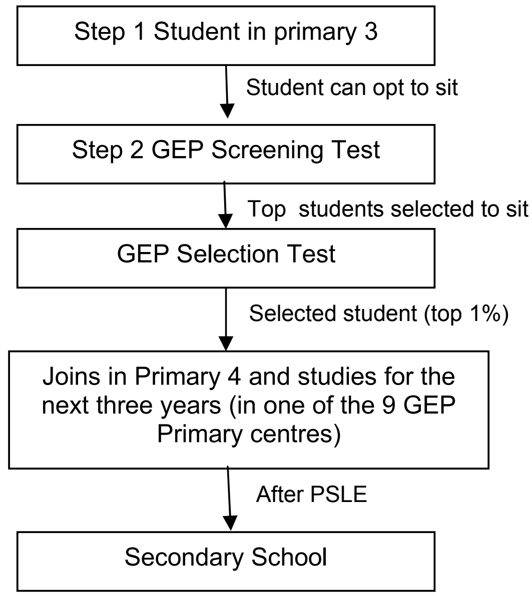

Figure 1.2: Selection/Screening Process of Students for the Gifted Education Programme (Source: Peer, 2009)

Enrichment in the GE Programme is achieved through curriculum differentiation over four areas:

a) Content Enrichment
b) Process Enrichment
c) Product Enrichment
d) Learning Environment.

The GE Programme is set up with an enriched curriculum with the aim to "develop intellectual rigour, humane values and creativity" among gifted youth and to "prepare them for responsible leadership and service to the country and nation" (Ministry of Education, 2008b). My study focuses on the learning environment that the mainstream and GE students are experiencing. The learning environment that the GE students are experiencing is the result of the content, process and product enrichment to which they are exposed.

For the GE students, the GE Branch officers, together with the teachers from the nine centres, plan the enriched curriculum so as to have uniformity within the nine centres. There is however a great autonomy among the teachers as to the activities that they conduct in teaching a certain concept. The main focus is using challenging and inquiry-based approaches that help to engage and challenge GE students. One other aspect to note is that the teachers teaching GE students are not bound to one particular text and refer to various texts and reference materials to teach various concepts and prepare activities.

My study also focused on higher-ability students within the mainstream. In all schools, Higher Ability (HA) students are streamed within the school into one or two classes that are termed the ‘top classes’, with these students also being stretched in order to nurture and develop their potential. The HA students in each school form the top class in the main stream. The percentage that this group forms will be dependent on the cohort of the school. For example, in school A, which has 10 classes with 40 students in each class (a total of 400 students), the HA students will form the top 10% of the cohort. As another example, because School B has 6 classes per level and 40 students per class (total of 240 students), HA students comprise 16.7% of the cohort. However, regardless of the total number of students per school per level, the HA group forms the top one or two classes and they are grouped by their academic performance in the previous year. This thus enables teachers to provide the HA students with greater depth and an enriching curriculum in addition to curriculum provided to all the mainstream classes.

It is a common practice among most schools in Singapore to stretch their HA group of students more than the rest of the mainstream students as these students are doing academically well to be part of the ‘top class’ and also they are able to grasp basic concepts fast, thus enabling teachers to spend time to stretch them further. However, teachers teaching HA students are bound by the activities in the prescribed text that has to be ‘covered’ because “in the end of the year they are sitting for the same exams” and thus there is a “need to make sure that they have gone through all the materials like the other mainstream classes”. Teachers teaching HA students do conduct extra activities to enrich and stretch their students, but are subjected to a time constraint for completing all worksheets and activities that was planned in the

Scheme of Work for that level. They are required to follow the same syllabus as the rest of the classes in the mainstream. Thus, with this restriction of time for the HA students, HA classes have the opportunity to be very varied from being student-centred to teacher-centred.

Relative to the curriculum for HA students, the curriculum for GE students is enriched in content, process and product, whereas the content for HA students is enriched to different level depending on the teacher, school and time available as there is a mainstream syllabus to follow and complete. In terms of the examinations throughout the year, GE students across the nine centres sit for common tests that are set by teachers of the nine centres. The HA students, however, sit for the test that are set at the school level and which is taken by all the mainstream classes in that school. One other difference that is present in most schools between the GE class and HA class is class size. GE classes have an average of 25 students whereas HA classes have around 30 to 40 students depending on the school. (The exact number of students in each of the classes in the different schools in my study is described in Section 3.3.3). These two streams of students (GE and HA) experience a different learning environment and their attitudes towards science could also vary. Thus my study focused on these two groups of students in terms of their perceptions of their learning environment and attitudes towards science. As the GE Programme starts only in grade 4 and continues up to grade 5 and 6, my study compared the GE and HA students from grade 4, 5 and 6.

1.3 Field of Learning Environments

As every student spends approximately 6000 hours in the classroom during his/her primary (Grade 1 to 6) school years, students have a large stake in what happens to them at school and their reactions to and perceptions of their school experiences are significant. Contemporary research on school environments partly owes inspiration to Lewin's (1936) seminal work in non-educational settings, which recognised that both the environment and its interaction with characteristics of the individual are potent determinants of human behaviour. Since then, the notion of person-environment fit has been elucidated in education by Stern (1970), who proposed that the degree of person-environment congruence is related to student outcomes. Also Walberg (1981) has proposed a model of educational productivity in which the educational environment is one of nine determinants of student outcomes. Research specifically on classroom learning environments took off with the work of Walberg (1968) and Moos (1974) after which it spawned many diverse research programs around the world (Fraser, 1994, 1998a, in press).

Several different instruments have been devised for assessing the classroom environment (Fraser, 1998b), including the Learning Environment Inventory (LEI), My Class Inventory (MCI), Questionnaire on Teacher Interaction (QTI), Individualized Classroom Environment Questionnaire (ICEQ), Classroom Environment Scale (CES), Science Laboratory Environment Inventory (SLEI), What Is Happening In this Class? (WIHIC) and Constructivist Learning Environment Survey (CLES). Chapter 2 reviews literature relevant to these learning environment instruments in greater detail.

Learning environments research has not only expanded remarkably on the international scene generally, but Asian researchers specifically have also made important and distinct contributions. Asian researchers have cross-validated the main contemporary learning environment questionnaires that originated in the west and have undertaken careful translations and adaptations for use in the Chinese, Korean, Malay and Indonesian languages. Asian studies have successfully replicated Western research in establishing consistent associations between the learning environment and student outcomes, in using learning environment assessments in evaluation of educational programmes and in identifying determinants of learning environments (Fraser, 2002). The present study draws on the rich resource of diverse, valid, economical and widely-applicable assessment instruments that are available in the field of learning environments (Fraser, 1998b, 1998c).

The learning environment scales for my study were chosen from the CLES and WIHIC questionnaires. The Constructivist Learning Environment Survey (CLES) was designed to enable teachers to monitor the development of learning environments while initiating constructivist approaches to their lessons. The scales in the CLES were developed from the view of critical constructivism (Taylor, 1994), which is based on the notion that the cognitive constructive activity of the learner occurs within and is inhibited by the socio-cultural context. In my study, only three of the five scales were used as they were considered to be relevant: Personal Relevance, Uncertainty and Student Negotiation.

Fraser and McRobbie (1995) developed a learning environment instrument called the What Is Happening In this Class? (WIHIC), which combines modified versions of important scales from a wide range of existing questionnaires with additional scales (equity and constructivism) that accommodate contemporary educational concerns. This questionnaire measures a wide range of dimensions that are important to the daily situations in classrooms. In my study, five of the seven scales from the WIHIC were used as they were considered relevant: Teacher Support, Involvement, Investigation, Cooperation and Task Orientation.

Instruments were needed in my study for assessing students' perceptions of their science classroom environment and their attitudes towards science. Thus, in addition to some scales from the CLES and WIHIC to assess the learning environment, my study also included two scales from Test of Science Related Attitudes (TOSRA) to assess students' attitudes to science.

Thurstone (1928) defined attitude as the sum total of a person's inclinations and feelings, prejudices and biases, preconceived notions, ideas, fears, threats and convictions about any specified topic. Fraser (1978) developed the Test of Science Related Attitudes (TOSRA) to measure seven science-related attitudes among secondary school students. In my study, two scales from the TOSRA were used to measure attitudes, namely, Attitude to Scientific Inquiry and Enjoyment of Science Lessons. For convenience, the eight learning environment scales and two attitude scales were combined to form a single questionnaire that is described in detail later in section 3.4.

1.4 Research Questions

The research questions that were examined in my study are:

Research Question # 1

Are learning environment scales based on the CLES and WIHIC and attitude scales based on TOSRA valid when used with a sample of primary-school science students in Singapore?

Research Question # 2

For primary school science students in Singapore, do students' scores on learning environment and attitude scales vary with:

a) gender,

b) grade-level and

c) stream?

Research Question # 3

Are there associations between students' attitudes to science and their perceptions of classroom learning environment among a sample of primary-school science students in Singapore?

1.5 Significance of this Study

For active learning to occur, the classroom environment must be equally comfortable and enriching for the student and the teacher. Research has shown that classroom environment instruments are useful for various purposes. A primary school student in Singapore spends around 6000 hours in the classroom during his/her primary (Grade 1 to 6) school years. Thus, it seems not only logical but essential to find out about the learning environment. My study gathered data from 1081 students from 55 different classes in 4 different schools. The instrument used to assess students' perceptions of their classroom learning environment included scales based on the Constructivist Learning Environment Survey (CLES), What Is Happening In this Class? (WIHIC) questionnaire and Test Of Science-Related Attitudes (TOSRA).

The first way in which this study is significant is that it involved validating a widely-used learning environment questionnaire in the Singapore primary-school context. Also this was the first time that any learning environment research focused on GE and HA students in the primary-school setting in Singapore.

Another significant contribution of this study was that it investigated gender, grade-level and stream differences in learning environment and attitudes to science, as well as associations between students' attitudes to science and their perceptions of the classroom learning environment. Investigating grade-level and gender differences also was novel in the Singapore context. Though there are various studies that have investigated gender, grade-level or stream differences, so far, no single study has looked into all these differences together. That is why my study investigated all three determinants and their interactions.

This study will furnish teachers and policy makers in Singapore with data regarding the present learning environment in primary GE and HA classes, as well as grade-level and gender differences. These data have the potential to assist teachers in identifying factors that contribute towards creating a positive learning environment that fosters positive attitudes towards science. Thus my research is significant for teachers of high-ability children as it provides potentially-useful information to teachers, researchers and teacher educators.

1.6 Purpose of this Study

The main foci of this research study were to:

- investigate the reliability and validity of a learning environment and attitude questionnaire for primary science classrooms in Singapore
- investigate gender, grade-level and stream differences in learning environment and attitude to science and
- investigate relationships between attitudes and the learning environment.

By reviewing the literature about the various questionnaires available, I chose scales from Constructivist Learning Environment Survey (CLES, Taylor, Fraser, & Fisher, 1997) and the What Is Happening In this Class? (WIHIC, Fraser, Fisher & McRobbie, 1996) to measure students' perceptions of their classroom learning environment. I also included two scales from the Test Of Science-Related Attitudes (TOSRA, Fraser, 1978) to measure students' attitudes towards science. The eight learning environment scales and two attitude scales were combined to form one questionnaire that was used to collect data conveniently. Before the questionnaire could be used, it had to be validated. After validating the questionnaire, data were collected to investigate gender, grade-level and stream differences in learning environment and attitudes to science. Finally, relationships between attitudes and the learning environments were investigated.

1.7 Overview of Chapters in this Thesis

This first chapter outlined the background and significance of this study. The purpose of the study and the research questions were also outlined.

Chapter 2 comprehensively reviews literature on areas related to this study. First, the literature review provides insights into the historical background of learning environments research. Then it provides information about various learning environment instruments found in the literature. Next, it provides information about the development, history and validation of instruments for measuring learning environments. It focuses on two instruments, the CLES and WIHIC, as scales for my study were chosen from these instruments. Chapter 2 also gives an overview of learning environment studies in Singapore, as well as past studies that focused on gender, grade-level and stream differences. Chapter 2 also gives a comprehensive overview of literature devoted to the assessment of students' attitudes.

Chapter 3 describes the research methods, techniques, and instruments used in this study. It also describes the design, sample, and methods of data analysis used for this study.

Chapter 4 presents the results of this study pertinent to the validation of the instruments that were used to assess students' perceptions of their learning environments and attitudes towards science. It also reports grade, gender and stream differences, as well as stream-by-gender, grade-by-stream, grade-by-gender and stream-by-gender-by-grade interactions, for each scale. Finally, results for associations between students' perceptions of their classroom learning environment and their attitudes towards science are reported.

Chapter 5, the final chapter, summarises and discusses all aspects of this study and proposes further research into the factors involved and conclusions based on the data found. Chapter 5 also discusses the limitations and significance of this study and identifies desirable directions for future research.

Chapter 2
LITERATURE REVIEW

2.1 Introduction

Fraser (1998a, 1998c) conceptualised a learning environment as referring to the social, psychological and pedagogical contexts in which learning occurs and which affect student achievement and attitudes. In the 40 years or so since the pioneering use of classroom environment assessments in an evaluation of Harvard Project Physics (Walberg & Anderson, 1968), the field of learning environments has undergone remarkable growth, diversification and internationalisation. Few fields of educational research have such a rich diversity of valid, economical and widely-applicable assessment instruments as does the field of learning environments (Fraser, 1998b, 1998c).

The word ‘environment’ encompasses two main aspects in a classroom context: the physical environment and the human environment. Material characteristics of the classroom, such as furniture, lighting and the layout of the objects in the classroom, comprise the physical environment. The students and the teacher in the classroom and their interactions with each other constitute the human environment or the psychosocial climate of the classroom. Studies have shown that effective learning is related to a positive classroom environment (Brophy & Putnam, 1979). Fraser (1998c, 2001) has mentioned that two advantages of using students’ perceptions of the classroom environment are that, firstly, it describes the class through the eyes of the actual participants and, secondly, it provides data which the observer could miss or consider unimportant. Students in the classroom are in a good position to make judgments about classrooms because they have experienced many different learning environments and have had enough time in a class to form accurate opinions.

A primary school student in Singapore spends around five hours a day in the classroom (excluding recess breaks). With 10 weeks in a school term and four terms a year, a student is spending 6000 hours in the classroom during his/her primary (Grade 1 to 6) school years. Thus, it seems not only logical but essential to obtain information from the student about what they think about their learning environments. A teacher is always interested in creating a positive learning environment and this cannot be achieved unless he/she is first aware of what that environment looks and feels like to students and how they react to it. This is accomplished by studying the students' perceptions of the learning environment, which was the primary aim of my study.

My study also explored the influence of the classroom environment on student attitudes. Thurstone (1928) defined attitude as the sum total of a person's inclination and feelings, prejudice and bias, preconceived notions, ideas, fears, threats and convictions about any specified topic. Mueller (1986) defined attitudes as something that cannot be observed or measured directly but can only be inferred from their consequences. Attitude towards science in the context of my study refers to the way in which students regard science.

My study focused on gender, grade-level and stream differences in learning environment and attitudes to science and the relationships between the learning environment and attitudes to science among Gifted Education (GE) and High-ability (HA) students in primary science classrooms in Singapore.

This chapter reviews literature related to my study under the following sections:

- Historical Background of Learning Environments (Section 2.2)
- Learning Environment Instruments (Section 2.3)
- Research in the Field of Learning Environments (Section 2.4)
- Learning Environment Studies in Singapore (Section 2.5)
- Gender, Grade-level and Stream Differences in Learning Environment (Section 2.6)
- Student Attitudes (Section 2.7)
- Summary of Chapter (Section 2.8).

2.2 Historical Background of Learning Environments

The idea that human environments exist began in the 1930s when Kurt Lewin (1936) recognised that the environment and its interactions with personal characteristics of the individual determine behaviour. Existing research on school environments owes its inspiration to some extent to Lewin's formative work in non-educational settings. The formula, $B = f(P, E)$ was part of the pioneering work of Lewin (1936) and it reflected his acknowledgement that human behaviour (B) within an environment is determined both by the characteristic features of the people (P) in it and by the characteristics of the environment (E) itself.

Following Lewin's work, Murray (1938) proposed a Needs-Press Model in which situational variables in the environment account for a degree of behavioural variance. In 1970, Stern proposed a Person-Environment Congruence Theory, based on Murray's Needs-Press Model, which stated that more congruence between personal needs and environmental press leads to enhanced outcomes. Also, following Murray's Needs-Press Model, Getzels and Thelen (1960) put forward a model for the class as a social system, which suggests that the interaction of personality needs, expectations and the environment predicts behaviours, including student outcomes.

Studies of the learning environment and its effects on student outcomes began in the 1960s, when Herbert Walberg and Rudolf Moos began the early development of learning environment assessment tools which later became the foundation of the field of learning environments as we know it today. The first pioneering study began in 1968 as part of the evaluation activities of Harvard Project Physics (Walberg & Anderson, 1968). Walberg's (1976) view on psychology was that it is a science of mental life and that a key aspect of mental life is perception. He viewed surveying students' perceptions as a valid method for measuring teacher effectiveness, as well as being cost-effective, less time-consuming than classroom observations and an easy way to obtain information via students. In 1981, Walberg proposed a multi-factor psychological theory of educational productivity, which holds that students' learning is a function of three student aptitude variables (age, ability and motivation), two instructional variables (quantity and quality) and four psychosocial environments (home, classroom, peer group and mass media).

Classroom environment assessment was pioneered in an evaluation of Harvard Project Physics that led to the development of an instrument to assess learning environments in physics classrooms. The Learning Environment Inventory (LEI) (Walberg & Anderson, 1968) assesses students' perceptions of the whole-class environment. Anderson and Walberg (1972) investigated students' perceptions of their secondary physics classrooms in terms of the whole-class environment using 61 classes in eight English-speaking schools in Montreal. The study revealed that increasing class size was linearly associated with decreasing cohesiveness and difficulty. Another study by Walberg and Ahlgren (1970) among 144 senior high school physics classes revealed a significant relationship between the set of 14 LEI dimensions and each of the following blocks of predictors: a block of seven student personality traits, a group of 20 student biographical variables, a linear and quadratic class size term combined, the ratio of boys to girls in the class and student general ability.

In 1974, Moos and Trickett developed a series of environment measures which included the Classroom Environment Scale (CES). This instrument is the product of comprehensive research covering perceptual measures of human environments of psychiatric hospital, prisons, university and work areas. The final version has 90 items in nine 10-item scales: Involvement; Affiliation; Teacher Support; Task Orientation; Competition; Order and Organisation; Rule Clarity; Teacher Control; and Innovation. The response format was either True or False. The LEI and CES provided momentum for the study of classroom learning environments and were used for a variety of research purposes and for the development of other instruments (see Fraser, 1994).

Moos (1974) proposed a theoretical framework for human environments, which was the basis for the development of many of the subsequent learning environment instruments. He was interested in the underlying dimensions of social climates, the perceptions of the members of the environment and the well-being of the participants. Moos (1986) designed an instrument, the Work Environment Scale (WES), whose scales are also appropriate for examining the dimensions of school environments. Data gathered through the use of the WES were able to shed light on staff involvement, peer cohesion, supervisor support, autonomy, work pressure, clarity, control, innovation and physical comfort (Moos, 1986). Based on his research on human environments in hospitals, prisons, military establishments, colleges and schools, Moos (1979) proposed three dimensions that characterise all human environments:

- Personal development dimensions which assess personal growth and self-enhancement.
- Relationship dimensions which identify the nature and intensity of personal relationships within the environment and which assess the extent to which people are involved in the environment and support and help each other.
- A system Maintenance and System Change dimension that involve the extent to which the environment is orderly, clear in expectations, is responsive to change and maintains control.

Using Moos' three dimensions, Table 2.1 classifies the individual scales in eight classroom environment instruments that are considered in greater detail in Sections 2.3.2 and 2.3.3. Moos's dimensions guided the choices of scales used in my study.

2.3 Learning Environment Instruments

Since the early 1960s, various learning environments instruments have been created. The various questionnaires are suitable for a variety of grade levels and subject areas and have been widely used in collecting data on perceptions of learning environments.

This section reviews literature about the questionnaires that are currently available for researchers and educators to measure students' learning environment perceptions. Section 2.3.1 provides an overview of the methods used to assess the learning environment. Section 2.3.2 provides an overview of different classroom environment questionnaires. In the following two sections, a more detailed literature review is provided for the two instruments used in this study, with Section 2.3.3 focusing on the development and validation of the Constructivist Learning Environment Survey (CLES) and Section 2.3.4 on the What Is Happening In this Class? (WIHIC).

2.3.1 Methods for Assessing Classroom Environment

Assessing the classroom learning environment provides a valuable source of information for teachers, teacher educators and administrators. Research on learning environment provides useful information for teachers on ways to improve teaching and learning. There are numerous methods which can be used to assess learning environments, including:

- classroom observation
- use of questionnaires
- interviews
- focus-group discussions (Allen & Fraser, 2007; Spinner & Fraser, 2005; Waldrip, Fisher & Dorman, 2009).

Using questionnaires allows us to get the students' perspectives about the classroom environment. Students are able to make judgements about classrooms because they have encountered many different learning environments and have had enough time in a class to form accurate impressions (Fraser, 1998b). The assessment of learning environments and research applications have involved a variety of quantitative and qualitative methods, and an important accomplishment within the field has been the productive combination of quantitative and qualitative research methods (Tobin & Fraser, 1998). Likewise, in my study, questionnaires and focus-group discussions were used.

2.3.2 Overview of a Range of Classroom Environment Questionnaires

Researchers studying classroom environments have used various instruments for collecting data over the years (Fraser, 1998b), including the Learning Environment Inventory (LEI), My Class Inventory (MCI), Classroom Environment Scale (CES), Questionnaire on Teacher Interaction (QTI), Individualized Classroom Environment Questionnaire (ICEQ), Science Laboratory Environment Inventory (SLEI), Constructivist Learning Environment Survey (CLES) and What Is Happening In this Class? (WIHIC).

The rest of this section describes a variety of available instruments, with the two instruments used in this study (CLES and WIHIC) being described in more detail later (Sections 2.3.3 and 2.3.4). Table 2.1 shows an overview of a number of different classroom environment instruments and their scales classified according to Moos' scheme.

Learning Environment Inventory (LEI)

The Learning Environment Inventory (LEI) (Walberg & Anderson, 1968) was developed for an evaluation of Harvard Project Physics, which required an instrument to assess learning environments in physics classrooms. According to Fraser and Walberg (1981), the LEI was the most widely-used perceptual measure of psychosocial environment in science education at the time of their review. The LEI was used to investigate learning environment more closely from the perspective of the students who make up a classroom rather than from the perspective of trained observers. The LEI is an expansion and improvement of the 18-scale Classroom Climate Questionnaire developed by Walberg (1968).

Table 2.1: Overview of Scales in Classroom Environment Instruments

Instrument	Level	Item Per Scale	Scales Classified According to Moos' Scheme: Relationship Dimensions	Personal Development Dimensions	System Maintenance & Change Dimensions
Learning Environment Inventory (LEI)	Secondary	7	Cohesiveness Apathy Friction Favouritism Cliqueness Satisfaction	Speed Difficulty Competitiveness	Diversity Formality Goal Direction Disorganization Material Environment Democracy
Classroom Environment Scale (CES)	Secondary	10	Involvement Affiliation Teacher Support	Task Orientation Competition	Order and Organization Rule Clarity Teacher Control Innovation
My Class Inventory (MCI)	Elementary	6−9	Cohesiveness Friction Satisfaction	Difficulty Competitiveness	
Questionnaire on Teacher Interaction (QTI)	Secondary/ Primary	8−10	Leadership Helping/Friendly Understanding Student Responsibility Uncertain Dissatisfied Admonishing Strict		
Individualised Classroom Environment Questionnaire (ICEQ)	Secondary	10	Personalisation Participation	Independence Investigation	Differentiation
Science Laboratory Environment Inventory (SLEI)	Upper Secondary	7	Cohesiveness	Open-Endedness Integration	Rule Clarity Material Environment
Constructivist Learning Environment Survey (CLES)	Secondary	7	Personal Relevance Uncertainty	Critical Voice Shared Control	Student Negotiation
What Is Happening In this Class? (WIHIC)	Secondary	8	Student Cohesiveness Teacher Support Involvement	Investigation Task Orientation Cooperation	Equity

(adapted from Fraser, 1998a)

The version of the LEI developed in 1968 contained 14 scales, but the 1969 version included 15 scales. The LEI has 15 dimensions of climate which had been identified as being good predictors of learning and which were relevant to social psychological theory at the time (Fraser & Walberg, 1991). This instrument measures student perceptions of 15 classroom climate scales with seven items per scale (a total of 105 items). It has four possible responses on a Likert−type scale: Strongly Disagree, Disagree, Agree and Strongly Agree. The LEI has been used in many studies in which the classroom learning environment served as the dependent variable, with independent variables including sex of the science teacher (Lawrenz & Welch, 1983), teacher personality (Walberg, 1968), class size (Anderson & Walberg, 1972), and wait−time during questioning in science lessons (Cohen, 1977).

LEI scales were also used in studies of associations between student outcomes and classroom environment, thus serving as the independent variable. Outcome measures included academic achievement, attitudes, understanding of the nature of science, and science process skills (Fraser, 1986).

Classroom Environment Scale (CES)

The Classroom Environment Scale (CES) was developed by Moos (1974) and was a result of his research in several human environments. The final version of the Classroom Environment Scale (CES) contains nine scales with 10 items of True−False response format in each scale. The CES was developed to examine the psychosocial environment of school classrooms from the perspective of interaction between participants, including teacher-student and student-student interactions and behaviour exhibited by the teacher (Moos & Trickett, 1974; Trickett & Moos, 1973).

The CES was used to investigate associations between classroom environment and outcome measures such as academic achievement, attitudes (Fraser & Fisher, 1982a, 1982b), absences and grades (Moos &

Moos, 1978), and inquiry skills (Fisher & Fraser, 1983a, 1983b; Fraser & Fisher, 1982a, 1982b).

My Class Inventory (MCI)

The My Class Inventory (MCI) is a simplified form of LEI and is suitable for children aged 8 to 12 years. Though it was developed for use for younger children, it has also been found useful for students in the first year of the junior high school. The MCI contains only five of the LEI's original 15 scales. It has 38 items altogether, with six for Cohesiveness, eight for Friction, nine for Satisfaction, eight for Difficulty and seven for Competitiveness. The LEI was modified to improve comprehension by 8 to 12 year-old children as it took into consideration the language proficiency and attention span among young children and hence the fatigue factor (Fisher & Fraser, 1981; Fraser, Anderson & Walberg, 1982). The MCI has a Yes−No response format.

Initially, the MCI was used in curriculum evaluation studies involving cooperative groups (Talmage, Pascarella, & Ford, 1984), an inservice course on investigative approaches to mathematics teaching (Talmage & Hart, 1977), and comparing special education classes with general education classes in terms of students' perceptions of the learning environment. Several studies involved investigating associations between classroom environment and school attendance (Ellett & Walberg, 1979) and achievement (Talmage & Walberg, 1978). The MCI was used in science classrooms only after Fisher and Fraser (1981) validated it with 2305 seventh grade students in Tasmania. They improved the instrument's validity and reliability by conducting item analysis and removing faulty items.

Many classroom learning environment studies made use of the MCI. For example, Fraser (1984) used the short form of the MCI to compare students' actual and preferred perceptions and teachers' actual and preferred perceptions among 22 Grade 3 classrooms in Sydney, Australia. This study showed that both students and teachers preferred a more favourable classroom environment than the one that they were experiencing, and teachers perceived a more favourable environment than did their students in the same classroom.

Goh and Fraser (1996) used a modified version of the MCI with a three-point response format (Seldom, Sometimes, Most of the Time) in their study of 1512 fifth-grade mathematics students in Singapore. Two statistically significant associations were noted between Cohesion and achievement and between Task Orientation and attitude. In 2002, Majeed et al. investigated the learning environment and its association with student satisfaction among 1565 lower secondary mathematics students in Brunei. This study revealed a satisfactory factor structure for the three-scale version of the MCI, that students generally perceived a positive learning environment in their mathematics classes, and that boys had slightly more positive perceptions than girls.

Sink and Spencer (2005) used the short form of the MCI with 2800 upper elementary students in Washington and attested to the reliability and validity of a revised version with 18 items in four scales (Cohesion, Competitiveness, Friction and Satisfaction). This short form of the MCI can be used to assist counsellors in gauging whether classroom work is fostering a higher level of student satisfaction with the learning environment, building more cohesiveness among students, and reducing the perceived level of classroom friction and competitiveness. When Scott, Fraser and Ledbetter (2008) included student perceptions of classroom environment in evaluating educational alternatives, use of the MCI with 588 3rd to 5th grade students in Texas attested to its validity and reliability. Their study suggested that using science kits was associated with a more positive environment in terms of student satisfaction and cohesiveness.

Questionnaire on Teacher Interaction (QTI)

The Questionnaire on Teacher Interaction (QTI) was developed in the Netherlands to assess student perceptions of eight aspects of teacher interpersonal behaviour, namely, Leadership, Helpful/Friendly, Understanding, Student Responsibility/Freedom, Uncertain, Dissatisfied, Admonishing and Strict behaviour (Crėton, Hermans & Wubbels, 1990; Wubbels & Levy, 1993). It is a unique classroom learning environment instrument because it is the only questionnaire that focuses exclusively on the interpersonal relationship between a teacher and his or her students. It is based upon a theoretical model of proximity (Cooperation−Opposition) and influence (Dominance−Submission). Each item has a five-point frequency response scale ranging from Never to Always. Learning activities are always accompanied by interpersonal interaction and interpersonal sentiments. The reciprocal nature of teacher-student communication makes it a powerful influence on the learning environment and thus on student performance. As the behaviour of both student and teacher influence each other, such interactions are crucial to student learning in the classroom. In the classroom setting, the behaviour of the teacher determines, and is determined by, the students' behaviour (Wubbels, Brekelmans & Hooymayers, 1991).

In the Netherlands, when Wubbels et al. (1991) used the QTI to compare students' and teachers' perceptions, they found that, first, both students and teachers preferred a more positive classroom environment than what was perceived as being actually present and, second, teachers tended to perceive the classroom environment more positively than did their students in the same classroom. Also statistically significant relationships were found between teacher-student interaction and student outcomes. Wubbels and Levy (1993) reported the validity and reliability of the QTI when used in the Netherlands. When the 64-item American version of the QTI was also used with 1606 students and 66 teachers in the USA, its cross-cultural validity and usefulness were confirmed (Wubbels & Levy, 1991). In 1993, Wubbels developed a short 48-item version of the QTI in English to enable school teachers to obtain feedback on their own interpersonal relationships within the classroom.

In studies of relationship between teacher behaviour and student outcomes (Wubbels & Brekelmans, 1998), medium to strong associations were found, but relationships were stronger for affective than for cognitive outcomes. Leadership, helpful/friendly and understanding behaviours were positively related to student outcomes, but uncertain, dissatisfied, and admonishing behaviours were negatively related to outcomes.

Goh and Fraser (1996, 1998) used a modified version of QTI to assess teacher-student interpersonal behaviour and an adapted form of MCI to assess classroom environment among a sample of 1512 students in 39 Grade 5 mathematics classes in Singapore. The 48-item QTI with eight dimensions of teacher behaviour had quite good reliability, with five out of the eight scales (namely, Leadership, Helping/Friendly, Understanding, Dissatisfied and Admonishing) having reliability coefficients above 0.90 for class means.

When Fisher, Henderson and Fraser (1995) used the QTI with 489 Australian students in 28 biology classes in senior high school, the validity and reliability of the QTI were confirmed for students at this level of schooling.

Quek, Wong and Fraser (2005a, 2005b) cross-validated the QTI among 497 10th grade chemistry students in Singapore, reported some sex and stream (gifted vs express) differences in perceptions of teacher-student interaction and established associations between QTI scales and student enjoyment of chemistry lessons.

Scott and Fisher (2004) used a Malay version of QTI together with a scale assessing students' enjoyment of their science lessons among 3104 students in Brunei. Students' perceptions of cooperative behaviours were positively correlated with their cognitive achievement, while submissive behaviours were negatively correlated with their cognitive achievement.

Lee, Fraser and Fisher (2003) also used a translated version of the QTI with 439 high school students in Korea. As well as cross-validating the QTI in the Korean language, associations were found between teacher-student interactions and classroom environment.

Individualised Classroom Environment Questionnaire (ICEQ)

The Individualised Classroom Environment Questionnaire (ICEQ) assesses the dimensions of Personalisation, Participation, Independence and Differentiation (Fraser, 1990; Rentoul & Fraser, 1979). It was the first instrument that is ‘student-centred’ and assesses the environment of individualised, open or inquiry-based classrooms. It measures dimensions that distinguish individualised classrooms from conventional ones. The instrument has a long and short form. The short form can be used to provide a rapid, more economical measure of classroom environment. The final version of the long form contains 50 items altogether, with an equal number of items belonging to each of the five scales. The short form of the ICEQ consists of 25 items divided equally among the five scales, Personalisation, Participation, Independence, Investigation and Differentiation. Each item is responded to on a five-point scale: Almost Never, Seldom, Sometimes, Often and Very Often.

Several studies used the ICEQ to investigate associations between the classroom environment and student outcomes such as inquiry skills (Fraser & Fisher, 1982a, 1982b; Rentoul & Fraser, 1980), attitudes (Asghar and Fraser, 1995; Fraser & Butts, 1982; Fraser & Fisher, 1982b), achievement (Wierstra, 1984) and anxiety (Fraser, Nash & Fisher, 1983).

Science Laboratory Environment Inventory (SLEI)

The Science Laboratory Environment Inventory (SLEI) is suitable for assessing the environment of science laboratory classes at the senior high school or higher education levels (Fraser, Giddings & McRobbie, 1995). The SLEI has five scales (each with seven items) and the five frequency response alternatives are Almost Never, Seldom, Sometimes, Often and Very Often. The five scales of SLEI are Student Cohesiveness, Open-Endedness, Integration, Rule Clarity and Material Environment. The SLEI was the first instrument to have separate class and personal forms. The personal form assesses a student's perceptions of his or her role within the classroom, whereas the class form assesses a student's perceptions of the class as a single entity. The actual or current situation in a science laboratory class is determined using the actual form of the SLEI. This is sometimes compared with what students prefer in an ideal scenario in a science laboratory class with the preferred form. Wording is only slightly altered in the two forms.

The first version of the SLEI for secondary and university science laboratory classes was developed and validated in a large cross-national study that involved 5000 students in six countries: USA, Canada, Australia, England, Isreal, and Nigeria (Fraser & McRobbie, 1995; Fraser & Griffiths, 1992; Fraser & Wilkinson, 1993). The six-country cross-national study was the first research in the learning environments field to analyse the unique instructional setting of science laboratories.

McRobbie and Fraser (1993) used the refined version of the SLEI in Brisbane, Australia, with 1594 senior secondary chemistry students in 92 classes and 52 schools to investigate outcome-laboratory learning environment relationships. In Singapore (Wong & Fraser, 1995, 1996; Wong et al., 1997), a slightly-modified version of the personal form of the SLEI was cross-validated with a total of 1592 tenth grade students and 56 teachers at 28 schools. Another study in Singapore was carried out by Quek et al. (2005) who compared 497 gifted and non-gifted chemistry students' perceptions of their learning environment. All the above studies showed that each SLEI scale displays satisfactory internal consistency reliability when either the student or the class mean was used as the unit of analysis, differentiates between the perceptions of students in different classrooms, and exhibits good factorial validity.

The SLEI was used with a sample of 761 high-school biology students (Lightburn & Fraser, 2007) in USA in evaluating the use of anthropometric activities in terms of student outcomes (achievement and attitudes) and classroom environment (assessed with the Science Laboratory Environment Inventory, SLEI). Data analyses supported the SLEI's factorial validity, internal consistency reliability and ability to differentiate between classrooms. In terms of students' perceptions of the science laboratory environment, there was a statistically significant difference between the two instructional groups only for the scale of Material Environment. The effect size for Material Environment was relatively small (approximately one-sixth of a standard deviation).

In order to investigate the learning environment of senior high school science laboratory classrooms in Korea, the Science Laboratory Environment Inventory (SLEI) was translated into Korean and administered to 439 students (Fraser & Lee, 2009) (99 science-independent stream students, 195 science-oriented stream students and 145 humanities stream students). Data analyses attested to the sound factorial validity and internal consistency reliability of the SLEI, as well as its ability to differentiate between the perceptions of students in different classrooms. Students in the science-independent stream generally perceived their science laboratory classroom environment more favourably than did students in either the humanities or science-oriented stream.

To be able to choose an ideal instrument for answering the research questions in my study, it was important to be familiar with a variety of instruments. This led to choosing scales from the CLES and WIHIC, which are described in Sections 2.3.3 and 2.3.4 below.

2.3.3 Constructivist Learning Environment Survey (CLES)

Meaningful learning, according to the constructive view, is a cognitive process in which individuals make sense of the world in relation to the knowledge which they already have constructed, and this sense-making process involves active negotiation and consensus building. The Constructivist Learning Environment Survey (CLES) was designed to enable teachers to monitor the development of learning environments while implementing constructivist approaches to the lessons. The scales used in the CLES were developed from the view of critical constructivism (Taylor, 1994), which is based on the notion that the cognitive constructive activity of the learner occurs within and is inhibited by the socio-cultural context. The scales of the CLES are Personal Relevance, Shared Control, Critical Voice, Uncertainty, and Student Negotiation.

The Personal Relevance scale measures the connectedness of the curriculum to the learner's out-of-school experiences. This involves the relevance of the environment to students. The Shared Control scale is concerned with learners' ability to articulate their own goals and design a management plan for their achievement. The Critical Voice scale assesses if the learners feel comfortable about voicing their opinions and questions. The Uncertainty scale measures the extent to which opportunities are provided for learners to experience science knowledge as arising from theory-dependent inquiry and involving human experience and values. The Student Negotiation scale assesses to what extent opportunities exist for learners to explain and justify to other learners their newly-developing ideas (Aldridge, Fraser, Taylor & Chen, 2000).

The CLES contains five scales with six items in each scale. There are a total of 30 items with five frequency response alternatives that range from Almost Always to Almost Never. A description and sample item for each scale in the CLES are given in Table 2.2.

Table 2.2: Description and Sample Item for each CLES Scale

Scale	Description	Sample Item
Personal Relevance[a]	Measures to what degree the learning is made relevant to the students' lives.	I learn about the world outside of school.
Scientific Uncertainty[a]	Measures how the students view the nature of scientific knowledge.	I learn that science cannot provide perfect answers to problems.
Critical Voice	Measures to what extent the teacher allows the students to critique their learning activities.	It's okay for me to express my opinion.
Shared Control	Measures to what extent the teacher allows the students to share the control of planning, managing and assessing learning activities, and negotiating social norms.	I help the teacher to plan what I'm going to learn.
Student Negotiation[a]	Measures to what extent the teacher allows students to interact with each other in order to build scientific knowledge.	Other students ask me to explain my ideas.

Adapted from Aldridge, Fraser, Taylor & Chen (2000).
[a] These scales were used in my study.

During the initial stages, Taylor, Fraser and Fisher (1997) encountered several design problems that were identified from students' interviews. For example, students tended to refer to past learning environments instead of the present environment in the science class. Thus the instrument's developers included a phrase at the beginning of each question that read, "In this science class…". As negatively-worded items in CLES caused confusion for students, such items were minimized. Items in CLES were organized into blocks according to their respective scales, because it was found that arranging items in a format that prevented respondents from identifying the scales to which they belonged still didn't keep the respondent from answering in a biased manner. Table 2.3 classifies the scales of the CLES according to the Moos' framework.

In my study, only three of the five scales were used as they were considered to be relevant: Personal Relevance, Uncertainty and Student Negotiation. Critical Voice was not used as it measures to what extent the teacher allows the students to critique their learning activities. Shared Control measures to what extent the teacher allows the students to share the control of planning, managing and assessing learning activities, and negotiating social norms. Having studied in this education system and having been an educator for the past 13 years, I felt that this does not happen much in our education system, and therefore these two scales were omitted.

Table 2.3: Classification of CLES Scales According to Moos' Scheme

Instrument	Scales Classified According to Moos' Scheme		
	Relationship Dimensions	Personal Development Dimensions	System Maintenance and Change Dimensions
Constructivist Learning Environment Survey (CLES)	Personal Relevance[a] Uncertainty[a]	Critical Voice Shared Control	Student Negotiation[a]

[a] Theese scales were used in my study.

In 2005, Nix, Fraser and Ledbetter used the CLES in the United States to study science classes. They evaluated the impact of an innovative teacher development program in school classrooms. Two separate response blocks of 30 items comprising five scales were presented in side-by-side columns to measure students' perceptions on a five-point frequency response scale of the extent to which certain psychosocial factors are prevalent in the science class taught by a teacher who had attended the program (THIS), as well as their perceptions of other science and non-science classes taught by other teachers in the same school (OTHER). Using data collected from 1079 students in 59 classes in north Texas, principal components factor analysis with varimax rotation and Kaiser normalization confirmed the a priori structure of the CLES. The internal consistency reliability, discriminant validity, and the ability to distinguish between different classes and groups also were supported.

Another study that used the CLES was conducted in mathematics classrooms in South Africa. The CLES was used to assess learners' perceptions of the emphasis on constructivism in the classroom environment (Aldridge, Fraser, & Sebela, 2004). This study cross-validated actual and preferred form of the CLES (modified version) with 1864 mathematics students in grades 4–9. Data analysis showed a strong factor structure for both forms of the modified version of the CLES. Scales of the actual and preferred forms of the CLES showed alpha reliability coefficients ranging from 0.56 to 0.90, thus demonstrating good internal consistency reliability for the instrument. The discriminant validity (mean correlation of a scale with other scales) was also calculated for the actual and preferred forms of the modified version of the CLES. The results indicated that each scale of both forms of the modified version of the CLES measures fairly distinct aspects of the classroom learning environment. Additionally, one-way ANOVA results showed that all CLES scales were able to differentiate significantly between students' perceptions in the different mathematics classes.

In a cross-national study between Taiwan and Australia (Aldridge, Fraser, Taylor & Chen, 2000), the CLES was administered to 1,081 Australian and 1,879 Taiwanese high school science students. This study used two versions, one in English and one in Chinese, of the CLES depending on the language of the students. The English and Chinese versions of the CLES were found to be valid and reliable. According to factor analysis results, the internal structure of the English and Chinese versions of the CLES was strong. The alpha reliability coefficients ranged from 0.73 to 0.98 for scales of the English and Chinese versions of the CLES, which demonstrated good internal consistency reliability. One-way ANOVA results indicated that both the English and Chinese versions of the CLES were able to differentiate between science learning environments in 50 Australian classes and 50 Taiwanese classes. This study revealed that both English and Mandarin versions of the CLES were valid and reliable.

In 1999, Kim, Fisher and Fraser used the CLES in a study designed to assess the new curriculum in Korea. They used actual and preferred forms of a Korean version of the CLES among 1083 Grades 10 and 11 science students to reveal a strong factor structure for both forms. The alpha reliability coefficients for all scales of the actual and preferred forms were 0.64 and above. Discriminant validity results showed that each scale of the actual and preferred forms of the CLES in Korean measures a distinct aspect of the classroom learning environment.

Oh and Yager (2004) used a Korean version of the CLES with 136 grade 11 earth science students. In this longitudinal study of the development of constructivist classrooms and students' attitudes, it was found that there were improvements in CLES scores over time and that students' attitudes to science became more positive as their classrooms became more constructivist.

Lee and Fraser (2000) used the CLES to investigate 439 Korean high school students' perceptions of their science classrooms for three streams: humanities, science-oriented and science-independent. All scales of the Korean version had satisfactory internal consistency and it was found that students from the science-independent stream perceived their classroom environments more favourably than did the students in the other two streams.

Harwell, Gunter, Montgomery, Shelton and West (2001) used the CLES in the USA in collaborative action research involving a university and a grade 6 class at a local school. The study monitored the alignment of classroom learning activities with a constructivist viewpoint while integrating technology into the curriculum. Harwell and colleagues reported satisfactory alpha reliability coefficients for all CLES scales for a sample of 60 students, but found no significant changes in student perceptions of the classroom learning environment over the duration of the academic year. Interpretation of results led teachers to construct a new plan of action to bring their classroom learning environments into closer alignment with a constructivist perspective for teaching and learning.

Johnson and McClure (2004) used the CLES for providing insights into the classroom learning environments of beginning science teachers. It was a four-year study of 290 upper-elementary, middle-school, and high-school science teachers and preservice teachers. In the first year of study, they used the 30-item version of the CLES developed by Nix et al. (2005). They then developed a shorter and modified 20-item version containing the same five scales, but with the number of items per scale reduced from six to four.

The new and more economical version also exhibited strong validity and reliability.

In Singapore, Wilks (2000) expanded and modified the CLES for use with 1046 junior college students studying English. The questionnaire displayed good factorial validity and internal consistency reliability and each scale differentiated significantly between the perceptions of students in different classrooms.

A study by Peiro and Fraser (2008) involved the development of modified English and Spanish versions of the CLES and their validation and use among 739 students in Grades K−3 in two schools in Miami, Florida. This study revealed that both the English and Spanish versions of the CLES had a sound factor structure and high internal consistency reliability.

The many studies reviewed above have consistently supported the validity of the CLES in classroom situations from various parts of the world.

2.3.4 What Is Happening In this Class? (WIHIC)

Fraser, Fisher, and McRobbie (1996) developed a learning environment instrument called the What Is Happening In this Class? (WIHIC), which combines the most salient scales from existing questionnaires with additional scales (equity and constructivism) that accommodate contemporary educational concerns. This questionnaire measures a wide range of dimensions that are important in the daily situations in classrooms. It was designed to bring parsimony in the field of learning environments research (Dorman, 2003).

The original instrument consisted of 90 items in nine scales, but a final version has 56 items (Aldridge, Fraser & Huang, 1999) that assess seven classroom environment dimensions: Student Cohesiveness, Teacher Support, Involvement, Investigation, Task Orientation, Cooperation and Equity. The WIHIC is worded to elicit the student's perception of his/her individual role within the classroom, as opposed to the student's perception of the class as a whole. Such personal forms of classroom environment instruments are concordant with a constructivist theory of learning (von Glasersfeld, 1989).

Table 2.4 shows, for each of the seven scales in WIHIC, a scale description and a sample item.

In accordance with Moos' framework, the WIHIC's scales can be classified with Student Cohesiveness, Teacher Support and Involvement as relationship dimensions, Investigation, Task Orientation and Cooperation as personal growth dimensions, and Equity as system maintenance and system change dimension, as shown in Table 2.5.

In my study, five of the seven scales from WIHIC were used as they were considered relevant: Teacher Support, Involvement, Investigation, Cooperation and Task Orientation. Because the scale of Student Cohesiveness is similar to Negotiation scale in CLES, it was omitted. Equity was not a focus of my study and so it was omitted.

Students respond to the WIHIC using a five-point frequency format: Almost Never, Seldom, Sometimes, Often and Almost Always. The items in each scale of the WIHIC assess a common concept and the questionnaire neither uses a cyclic ordering of items nor has any reverse-scored items. Its similarity to the CLES allowed the use of both WIHIC and CLES scales within the same questionnaire in my research.

Table 2.4: Descriptive Information for Seven WIHIC Scales

Scale Name	Scale Description	Sample Item
Student Cohesiveness	The extent to which students know, help and are supportive of one another.	I make friends among students of this class.
Teacher Support[a]	The extent to which the teacher helps, befriends, trusts and is interested in students.	The teacher helps me when I have trouble with the work.
Involvement[a]	The extent to which students have attentive interest, participate in discussions, do additional work and enjoy the class.	I give my opinions during class discussions.
Task Orientation[a]	The extent to which it is important to complete activities planned and to stay on the subject matter.	I know what I am trying to accomplish in this class.
Investigation[a]	The extent to which skills and processes of inquiry and their use in problem solving and investigation are emphasised.	I find out answers to questions by doing investigations.
Cooperation[a]	The extent to which students cooperate rather than compete with one another on learning tasks.	I cooperate with other students when doing assignment work.
Equity	The extent to which students are treated equally by the teacher.	The teacher gives as much attention to my questions as to other students' questions.

Adapted from Aldridge, Fraser & Huang (1999)
[a] These scales were used in my study.

Table 2.5: Classification of WIHIC Scales According to Moos' Scheme

Instrument	Scales Classified According to Moos' scheme		
	Relationship Dimensions	Personal Development Dimensions	System Maintenance and Change Dimensions
What Is Happening In this Class? (WIHIC)	Student Cohesiveness	Investigation[a]	
	Teacher Support[a]	Task Orientation[a]	Equity
	Involvement[a]	Cooperation[a]	

[a] These scales were used in my study.

Zandvliet and Fraser (2004, 2005) used the WIHIC in investigating the effects of educational Internet use in the classroom. The study was conducted both in Australia and Canada using a sample of 1,404 senior high students in 81 classes. Factor analysis strongly supported the a priori seven-scale structure of the WIHIC. Results also showed good internal consistency reliability for all seven scales of the WIHIC. The discriminant validity (mean correlation of one scale with the other scales) demonstrated that the seven WIHIC scales measure distinct, though somewhat overlapping, aspects of the psychosocial environment.

In a study by Allen and Fraser (2007), parents' perceptions were utilised in conjunction with students' perceptions in investigating science classroom learning environments among Grade 4 and 5 students in South Florida. The WIHIC questionnaire was modified for young students and their parents and administered to 520 students and 120 parents. Data analyses supported the WIHIC's factorial validity, internal consistency reliability and ability to differentiate between the perceptions of students in different classrooms. The results showed that both students and parents preferred a more positive classroom environment than the one perceived to be actually present, but effect sizes for actual-preferred differences were larger for parents than for students. Associations were found between some learning environment dimensions (especially task orientation) and student outcomes (especially attitudes). Qualitative methods suggested that students and parents were generally satisfied with the classroom environment, but that students would prefer more investigation while parents would prefer more teacher support.

Dorman (2003) provided support for the validity of a modified 42-item version of the WIHIC using a sample of 3,980 Grade 8, 10 and 12 students in Australia, Canada and the United Kingdom in his cross-validation study. Principal components factor analysis showed that all 42 items of the modified version of the WIHIC had a factor loading of at least 0.40 on their a priori scale and no other scale. In addition, confirmatory factor analysis provided further support for the WIHIC's a priori factor structure across all three countries. Internal consistency reliability analysis revealed Cronbach alpha coefficients ranging from 0.76 to 0.94 for different WIHIC scales in all three countries. Thus, the modified version of the WIHIC was found to be reliable amongst students in Australia, Canada, and the United Kingdom. Results of discriminant validity analyses (mean correlation of a scale with other scales) and one-way ANOVA (ability of the WIHIC to differentiate between students' perceptions in different classes) supported the validity of the modified version of the WIHIC in all three countries. According to Dorman (2003), the WIHIC is a valid measure of classroom environment that has a wide range of applications, especially in Western countries.

Dorman (2008a) conducted another validation of the actual and preferred forms of the WIHIC with a sample of 978 Australian secondary school students who responded to actual and preferred forms of the WIHIC. Separate confirmatory factor analyses for the actual and preferred forms supported the seven-scale a priori structure of the instrument. The use of multitrait-multimethod modelling with the seven scales as traits and the two forms of the instrument as methods supported the WIHIC's construct validity. This research provided strong evidence of the sound psychometric properties of the WIHIC.

Dorman (2008b) conducted another study which involved 978 secondary school students from 63 classes in Queensland who responded to the WIHIC. For each item on the WIHIC, students recorded their perceptions of the actual (or real) and preferred (or ideal) classroom environment. Results revealed that statistically significant differences between actual and preferred environments, and that the gap between actual and preferred environment was smaller for more positive classroom environments.

A study in Singapore by Khoo and Fraser (2008) involving 250 working adults attending courses in five computer education centres supported the validity of a modified version of the WIHIC. A five-factor structure for the modified version of the WIHIC was strongly supported and replicated. The alpha reliability coefficient for each of the five scales of the modified WIHIC ranged from 0.74 to 0.92, suggesting satisfactory reliability. One-way ANOVA results showed that four out of the five scales of the modified WIHIC were able to differentiate significantly between the different classes.

In another study in Singapore, Chionh and Fraser (2009) used the WIHIC questionnaire among 2310 Singaporean Grade 10 students (aged 15 years) in 75 geography and mathematics classes in 38 schools. A seven-scale factor structure was strongly supported and the alpha reliability of each scale was high. Differences between the classroom environments of geography and mathematics classes were small relative to the large differences between students’ actual and preferred classroom environments.

When the WIHIC was used in a two-year science mentoring program for beginning elementary school teachers and their 573 school students in a large, culturally-diverse and ethnically-diverse urban school district in the southeastern United States (Pickett & Fraser, 2009), data analyses supported the sound factorial validity of the WIHIC. At the beginning of the school year, teachers administered a form of the WIHIC that had been modified for use with elementary school students and analyzed the pretest results for their classes. Based on the feedback provided by their students' perceptions of the classroom environment, each teacher planned and implemented a program to address their concerns. The WIHIC was re-administered at the end of the school year so that any pretest-posttest changes in students' perceptions of the learning environment could be identified. Small improvements between pretest and posttest scores were noted for some WIHIC scales

In a study by Wolf and Fraser (2008) in the New York among middle-school physical science students, learning environment and attitude scales were found to be valid and related to each other for a sample of 1,434 students in 71 classes. Analyses strongly supported the factorial validity of the original seven-scale version of the WIHIC and the attitude scale. In terms of classroom environment, students in inquiry classes perceived a statistically significantly greater amount of Student Cohesiveness than did students in the non-inquiry classes.

A cross-validation study (Aldridge, Fraser & Huang, 1999; Aldridge & Fraser, 2000) for an English and Mandarin version of the WIHIC supported the flexibility of this questionnaire when translated into another language. The sample consisted of 1081 Australian students and 1879 Taiwanese students in 50 classes who responded to the WIHIC in English and Chinese version respectively. Analyses supported the WIHIC's factorial validity, internal consistency reliability (alpha coefficient), discriminant validity and ability to differentiate between the perceptions of students in different classrooms.

A large-scale study was conducted by Khine (2002) in Brunei to validate a modified 56-item version of the WIHIC among 1,188 students from 54 science classes in 10 secondary schools. The modified WIHIC showed satisfactory factorial validity and internal consistency, with Cronbach alpha coefficients ranging from 0.78 to 0.94. One-way ANOVA results demonstrated that each scale of the modified WIHIC was able to differentiate significantly ($p<0.01$) between students' perceptions in the different classes.

Koul and Fisher (2005) cross-validated and used a translated version of the WIHIC in India for investigating associations between students' cultural background and their perceptions of their teacher's interpersonal behaviour and classroom learning environment. They administered the WIHIC to a sample of 1021 students from 31 classes in seven co-educational private schools. The reliability coefficients for the different WIHIC scales ranged from 0.58 to 0.83. The eta^2 values ranged from 0.09 to 0.14 and were statistically significant for each scale, indicating that the WIHIC is capable of differentiating significantly between classes. Statistical analyses showed that a Kashmiri group of students perceived their classrooms and teacher interaction more positively than those from the other cultural groups identified in the study.

Research by MacLeod and Fraser (2010) involved the development, translation, validation and application of a modified Arabic version of a modified form of the WIHIC questionnaire. When parallel Arabic and English versions of WIHIC were field tested with a sample of 763 college students in 82 classes, they exhibited sound factorial validity and internal consistency reliability for both its actual and preferred forms. Also the actual form differentiated between the perceptions of students in different classrooms. Comparison of students' scores on actual and preferred forms of the questionnaires revealed that students preferred a more positive classroom environment on all scales. Also, in the United Arab Emirates, Afari, Aldridge, Fraser and Khine (in press) carried out a study using an Arabic translation of the WIHIC with a sample of 352 college students in 33 classes. The Arabic translation exhibited sound factorial validity and internal consistency reliability. Associations were noted between the learning environment and enjoyment and academic efficacy. The study revealed that use of games promoted a positive classroom environment.

In 2010, Fraser, Aldridge and Adolphe carried out a cross−national study of classroom environments in Australia and Indonesia. They used a modified version of WIHIC with a sample of 1161 students (594 students from 18 classes in Indonesia and 567 students from 18 classes in Australia). The factor analysis resulted in a revised version of the instrument comprising 55 items in six scales. The study provided strong support for the factorial validity of both the English-language version of the WIHIC when used in Australia and the Indonesian-language version of the WIHIC when used in Indonesia. The Cronbach alpha reliability coefficients for the six scales, using the individual student as the unit of analysis, were high and ranged from 0.82 to 0.92 for Indonesian students and from 0.78 to 0.89 for Australian students.

Aldridge, Fraser and Ntuli (2009) conducted the first learning environment study at the primary-school level in South Africa. They cross-validated an IsiZulu version of the WIHIC when it was administered to 1077 students in order to determine their preferred and actual classroom environments. Principal components factor analysis followed by varimax rotation confirmed a refined structure for the instrument comprising 19 items in four scales. For the actual form, the Cronbach alpha reliability estimates for different scales ranged from 0.68 to 0.72 using the individual as the unit of analysis and from 0.85 and 0.94 using the class mean as the unit of analysis. For the preferred form, Cronbach alpha reliability estimates for different scales ranged from

0.52 to 0.57 using the individual as the unit of analysis and from 0.86 and 0.88 using the class mean as the unit of analysis.

Sinclair and Fraser (2002) collaborated with three urban middle-school teachers of science in Texas in action research aimed at changing their classroom environments. They used actual and preferred forms of a questionnaire based on the WIHIC as a source of feedback to guide change attempts. Changes occurred on dimensions that the teachers had selected for improvement. This study supports the idea that classroom environments can be improved by teachers who receive feedback, support and training.

Den Brok, Fisher, Rickards and Bull (2006) conducted a study using the WIHIC questionnaire to examine factors that influence Californian students' perceptions of their learning environment. The sample consisted of 665 middle-school science students in 11 Californian schools. It was found that student gender affected students' perceptions, with girls perceiving their learning environments more positively than boys.

In 2010, den Brok, Telli, Cakiroglu, Taconis and Tekkaya used the WIHIC questionnaire to examine how Turkish students perceived their biology classroom environments. Data were gathered from 1474 high school students from four schools. Results indicated that Turkish classrooms were perceived low in terms of Teacher Support and high in terms of Task Orientation.

Kim, Fisher and Fraser (2000) conducted a learning environment study using a Korean translation of the WIHIC with 543 grade 8 students in 12 schools. The Korean translation exhibited sound factorial validity and internal consistency reliability. Associations with environment were noted for attitude scales. The study revealed sex differences in WIHIC scores.

Robinson and Fraser (in press) conducted a study using English and Spanish versions of the WIHIC in Florida among 78 parents and 172 kindergarten science students. Both the English and Spanish versions exhibited sound factorial validity and internal consistency reliability. Associations with environment were noted for achievement and attitudes. The study revealed that, relative to students, parents perceived a more favourable environment but preferred a less favourable environment.

Helding and Fraser (in press) administered English and Spanish versions of the WIHIC in Florida to 924 students in 38 grade 8 and 10 science classes. Both the English and Spanish versions exhibited sound factorial validity and internal consistency reliability. Associations with environment were noted for achievement and attitudes. The study revealed that students of National Board Certified teachers had more favourable classroom environment perceptions.

Aldridge and Fraser (2008) conducted a study that emphasised outcomes-focused learning and the use of ICT in programme delivery. They designed and used the Technology-Rich Outcomes-Focused Learning Environment Inventory (TROFLEI), which incorporated all of the WIHIC's seven scales and includes three other scales: Differentiation, Computer usage and Young Adult Ethos. The study reported strong factorial validity and internal consistency reliability for both the actual and preferred forms of the TROFLEI.

Rita and Martin-Dunlop (2011) assessed the perceptions of 146 gifted and 115 non-gifted high-school biology students and investigated associations between student perceptions and cognitive achievement using the WIHIC. The data revealed that all students preferred a more favourable environment than the one that they were currently experiencing, but gifted students perceived their actual environment more positively than non-gifted students. Teacher Support, Investigation and Equity were all statistically significant independent predictors of student achievement, while Student Cohesiveness had a negative association with achievement.

The many studies reviewed above have investigated and supported the validity of the WIHIC in classroom situations from various parts of the world.

2.4 Research in the Field of Learning Environment

According to Fraser (2007), past research in learning environments falls into six types which are diagrammatically represented in Figure 2. This section reviews these six types of research in order to illustrate the various applications of classroom environment instruments.

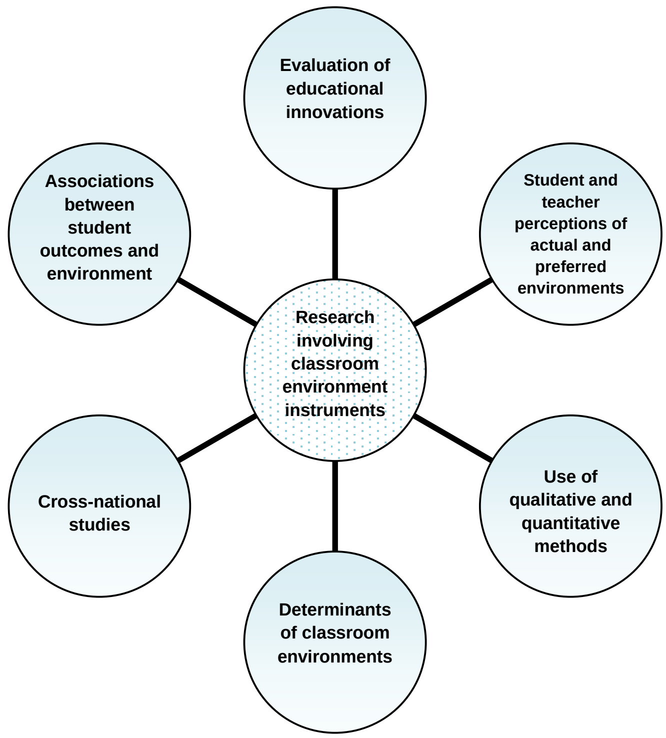

Figure 2.1: Six Types of Research Involving Classroom Environment Instruments

2.4.1 Associations between Student Outcomes and Environment

In past learning environments research, many studies have involved the investigation of associations between students' cognitive and affective learning outcomes and their perceptions of psychosocial characteristics of their classrooms. These studies cover a wide range of environment instruments, student outcomes, school subjects and grade levels (Fraser, in press).

For example, in 2004, Wahyudi and Treagust administered a modified version of the WIHIC to 1400 Indonesian students to assess the classroom learning environment and its associations with student attitudes towards science and national examination scores. The researchers commented that the findings from this study should be used as a starting point for improving science teaching-learning processes in Indonesia.

In 2007, Allen and Fraser investigated parents' and students' perceptions among Grade 4 and 5 students in science classroom learning environments in South Florida using the WIHIC questionnaire. The results showed that both students and parents preferred a more positive classroom environment than the one perceived to be actually present, but effect sizes for actual-preferred differences were larger for parents than for students. Associations were found between some learning environment dimensions (especially task orientation) and student outcomes (especially attitudes).

Fraser (2002) noted that many Asian researchers have undertaken various studies of associations between student outcomes and students' perceptions of their classroom learning environment using a wide range of environment instruments, student outcomes, school subjects, and grade levels. The questionnaires involved in the studies were not only in the English language, but also in various Asian languages.

For example, Khine (2001) conducted a study in Brunei among 1,188 students from 54 secondary science classes. The WIHIC and Test of Science Related Attitudes (TOSRA) were administered to science students to gather their perceptions of the classroom learning environment and their attitudes towards science. Strong associations were found between the students' perceptions of their learning environment and their attitudes to science.

A Malay translation of the QTI was administered to 3,104 primary school students to investigate associations between the science classroom environment and students' enjoyment of science lessons. Strong associations were found between students' perceptions of the learning environment and their enjoyment of science lessons (Scott & Fisher, 2004).

In a study in Singapore, Quek, Wong and Fraser (2005a, 2005b) investigated associations between teacher-student interactions and students' attitudes towards chemistry among 497 tenth grade students from three independent schools in Singapore. Associations were found between the interpersonal behaviour of chemistry teachers and students' enjoyment of their chemistry lessons.

In another study in Singapore, Goh and Fraser (1998) examined two aspects of classroom learning environment (interpersonal teacher behaviour and classroom climate) and their associations with affective and cognitive outcomes among primary mathematics students. Data from a random sample of 1512 boys and girls from government primary schools were subjected to a series of correlational analyses (simple, multiple and canonical correlation) and multilevel (hierarchical linear model) analyses, using two levels of analysis (the student and the class). The results were fairly similar (in both patterns of significance and the direction of relationships) for the different types of statistical analysis. In particular, better achievement and student attitudes were found in classes with an emphasis on more teacher Leadership, Helping/Friendly and Understanding behaviours and less Uncertain behaviour, and also in classes showing more Cohesion and less Friction.

In another Singaporean study by Chionh and Fraser (2009), which involved the use of the WIHIC questionnaire among 2310 Grade 10 students (aged 15 years) in 75 geography and mathematics classes in 38 schools, an investigation of associations between classroom environment and several student outcomes revealed that better examination scores were found in classrooms with more student Cohesiveness, whereas self-esteem and attitudes were more favourable in classrooms with more Teacher Support, Task Orientation and Equity. Differences between the classroom environments of geography and mathematics classes were small relative to the large differences between students' actual and preferred classroom environments.

Another Asian study of associations between student outcomes and their perceptions of the classroom learning environment was conducted in Singapore among 1,592 Grade 10 chemistry students in 56 classes in 28 randomly-selected coeducational government schools (Wong & Fraser, 1996). Students' perceptions of their chemistry laboratory learning environment were assessed using the Chemistry Laboratory Environment Inventory (CLEI), which is a modified version of the Science Laboratory Environment Inventory (SLEI). The Questionnaire on Chemistry-related Attitudes (QOCRA), a modified form of the Test of Science-Related Attitudes (TOSRA), was used to assess students' attitudes to chemistry. Environment-attitude associations were explored using three methods of correlational analysis (simple, multiple and canonical) and two units of statistical analysis (the individual and the class mean). Statistically significant associations were found between the nature of the chemistry laboratory classroom environment and the students' attitudinal outcomes.

One of the objectives of my study was to investigate associations between student attitudes and their perceptions of the classroom learning environment.

2.4.2 Evaluation of Educational Innovations

Classroom environment instruments can be used in the evaluation of educational innovations. Learning environment dimensions have been included in evaluations of the implementation and effectiveness of educational innovations in the Western and Eastern parts of the world in various subject areas and at different grade levels. That is, these studies have involved evaluating educational innovations and new curricula in terms of their impact on transforming the classroom learning environment.

In Singapore, the What Is Happening In this Class? (WIHIC) was administered to 250 adult learners in 23 classes to evaluate adult computer application courses in terms of students' perceptions of their classroom learning environment (Khoo & Fraser, 2008). In this study, it was found that most students perceived high levels of involvement, teacher support, task orientation and equity in their classroom learning environment, although the effectiveness of the course differed according to the age and sex of students. In another study in Singapore, the Geography Classroom Environment Inventory (GCEI) was used to evaluate a computer-assisted learning program among geography students at the secondary-school level (Fraser & Teh, 1994). An experimental group (students who were using the computer-assisted learning program) and a control group (students who were not using the computer-assisted learning program) responded to the GCEI, an achievement test, and an attitudinal survey to determine the effectiveness of the computer-assisted learning program in terms of improving students' perceptions of the geography learning environment, attitudes towards geography, and academic achievement. The findings showed that the students who used the computer-assisted learning program had much higher scores for classroom environment, achievement, and attitudes scales than did the students in the control group who were not taught with the computer-assisted learning program.

In the USA, several studies have involved evaluating educational innovations. For instance, in Florida, Spinner and Fraser (2005) evaluated the effectiveness of the Class Banking System (CBS), an innovative mathematics program, with a sample of Grade 5 students. The students responded to actual and preferred forms of the Individualised Classroom Environment Questionnaire (ICEQ), the actual form of the Constructivist Learning Environment Survey (CLES), the Test Of Mathematics-Related Attitudes (TOMRA) and conceptual map tests. The study participants were divided into two groups, an experimental group (taught using the CBS program) and a control group (taught without the CBS intervention). Selected scales from the ICEQ, CLES, TOMRA and a conceptual map test were administered as pretests and posttests to determine if the CBS was effective in improving students' perceptions of their classroom learning environment, their attitudes towards mathematics and their conceptual understanding in mathematics. It was found that the experimental group (taught with the CBS program) typically had higher posttest scores for classroom environment, attitudes and achievement than did the control group. To augment the quantitative findings, qualitative data were collected in the form of classroom observations and student interviews. The qualitative data supported the effectiveness of the CBS in improving elementary mathematics students' attitudes towards mathematics, perceptions of the classroom learning environment and conceptual development.

Several other studies in the USA are noteworthy for their use of learning environment dimensions as criteria of effectiveness in evaluating educational programs. In Texas, Nix, Fraser and Ledbetter (2005) reported use of the CLES in an evaluation of an innovative teacher development program involving the teachers' 1079 students in 59 classes. In California, Ogbuehi and Fraser (2007) used scales from the CLES and WIHIC with 661 middle-school students in 22 classes as part of an evaluation of innovative teaching strategies in mathematics. Also in California, Martin-Dunlop and Fraser (2008) used scales from the SLEI and WIHIC in an evaluation of an innovative science course involving 525 elementary prospective teachers. In 2007, Lightburn and Fraser validated the SLEI with 761 high-school biology students and evaluated the effectiveness of using anthropometry activities in science lessons among a subsample of 158 of these students.

Mink and Fraser (2005) conducted a one-year study of 120 fifth-grade students whose teachers participated in a program entitled Project SMILE (Science and Mathematics Integrated with Literary Experiences). The purpose of the study with the elementary students was to determine the extent to which the classroom implementation of Project SMILE positively influenced the classroom environment and student attitudes toward reading, writing and mathematics. The implementation of SMILE was found to have a positive impact on the students of the teachers who participated in the inservice program, in that student attitudes to mathematics and reading improved and there was congruence between students' actual and preferred classroom environment on the scales of satisfaction and difficulty. As well, prior research was replicated in that students' satisfaction was greater in classrooms with a more positive learning environment, especially in terms of student cohesiveness.

In a study by Wolf and Fraser (2008) in the United States, inquiry and non-inquiry laboratory teaching were compared in terms of students' perceptions of the classroom learning environment, attitudes toward science, and achievement among middle-school physical science students. Learning environment and attitude scales were found to be valid and related to each other for a sample of 1,434 students in 71 classes. Factor analyses strongly supported the factorial validity of the original seven-scale version of the WIHIC and the attitude scale. For a subsample of 165 students in 8 classes, inquiry instruction promoted more student cohesiveness than non-inquiry instruction (effect size of one-third of a standard deviation), and inquiry-based laboratory activities were found to be differentially effective for male and female students. In terms of classroom environment, students in inquiry classes perceived a statistically significantly greater amount of Student Cohesiveness than did students in the non-inquiry classes (effect size=0.36 standard deviations).

The studies reviewed above have shown that learning environment assessments have provided useful process criteria in the evaluation of educational innovations.

2.4.3 Differences between Student and Teacher Perceptions of Actual and Preferred Environment

Various educational researchers have used learning environment instruments in investigating differences between students and teachers in their perceptions of the same actual classroom environment. Likewise, there have been studies of differences between the actual environment and that preferred by students or teachers. The preferred forms are concerned with goals and value orientations and measure perceptions of the classroom environment ideally liked or preferred (Fraser & Walberg, 1991). The item wording is almost the same for both actual and preferred forms, but there are slightly different instructions given for answering the forms. Students are instructed to rate what their class is actually like for the actual form and what they would prefer it to be like for a preferred form.

For example, a study by Fisher and Fraser (1983a, 1983b) used the ICEQ with a sample of 116 classes for comparing student actual and preferred scores and a subsample of 56 teachers of these classes for contrasting teachers' and students' scores. Students preferred a more positive classroom environment than was actually present for all five ICEQ dimensions. The teachers perceived a more positive classroom environment than did their students in the same classroom on four of the ICEQ's dimensions.

Another study conducted by MacLeod and Fraser (2010) involved using the WIHIC with a sample of 763 college students in 82 classes in Dubai. Comparison of students' scores on actual and preferred forms of the questionnaires revealed that students preferred a more positive classroom environment on all scales.

For a sample of 978 secondary school students from 63 classes in Queensland responding to the WIHIC, Dorman (2008) reported statistically significant differences between actual and preferred environments, and that the gap between actual and preferred environment was smaller for more positive classroom environments.

In a study by Allen and Fraser (2007), parents' perceptions were utilised in conjunction with students' perceptions in investigating science classroom learning environments among Grade 4 and 5 students in South Florida. Both students and parents preferred a more positive classroom environment than the one perceived to be actually present, but effect sizes for actual-preferred differences were larger for parents than for students.

Hofstein, Cohen and Lazarowitz (1996) compared the actual and preferred environments of biology and chemistry laboratories for male and female eleventh-grade students in Israel. When comparing actual and preferred laboratory environments, Israeli chemistry students scored higher on the scales of Integration and Organization than biology students. Overall, both biology and chemistry students preferred a more favourable learning environment on all scales than what they were actually experiencing.

The studies reviewed above have shown that students usually prefer a more positive classroom environment than is actually present, and that teachers typically perceive a more positive classroom environment than their students. Other studies of differences between perceptions of actual and preferred environment have been conducted in classrooms in the USA (Moos, 1979), The Netherlands (Wubbels, Brekelmans & Hooymayers, 1991), Australia (Fraser & McRobbie, 1995) and Singapore (Wong & Fraser, 1996).

2.4.4 Use of Qualitative and Quantitative Methods

Now with mixed methods becoming more popular in educational research, qualitative methods have been combined with quantitative methods in studies of the learning environment. Though the use of questionnaires has led to many insights into learning environments through the students' eyes, the field also includes many fine studies that have used qualitative or interpretative methods (Fraser, 1998b), and considerable progress has been made in combining qualitative and quantitative methods in learning environment research (Fraser & Tobin, 1991; Tobin & Fraser, 1998). Examples of studies that highlight the benefits of combining qualitative and quantitative methods in learning environment research include research on exemplary science teachers (Fraser & Tobin, 1989), a study of higher-level learning (Tobin, Kahle & Fraser, 1990), and an interpretative study of a teacher-researcher teaching science in a challenging school setting (Fraser, 1999).

For example, Aldridge, Laugksch and Fraser (2006) carried out a study to developed and validated an instrument that can be used to assess students' perceptions of their learning environment as a means of monitoring and guiding changes towards outcomes-based education in South Africa. In the first phase, data collected from 2638 Grade 8 science students from 50 classes in 50 schools in the Limpopo Province of South Africa were analysed to provide evidence about the reliability and validity of the new instrument. In the second phase, two qualitative case studies were used to investigate whether profiles of class mean scores on the new instrument could provide an accurate and ‘trustworthy’ description of the learning environment of individual science classes.

When Allen and Fraser (2007) investigated parents’ and students’ perceptions among Grade 4 and 5 students in science classroom learning environments in South Florida using the WIHIC questionnaire, associations were found between some learning environment dimensions (especially task orientation) and student outcomes (especially attitudes). Qualitative methods used in this study suggested that students and parents were generally satisfied with the classroom environment, but that students would prefer more investigation while parents would prefer more teacher support.

Another study conducted in Florida involved evaluating the effectiveness of the Class Banking System (CBS), an innovative mathematics program, with a sample of Grade 5 students (Spinner & Fraser, 2005). To augment quantitative findings, qualitative data were collected in the form of classroom observations and student interviews. The qualitative data supported the effectiveness of the CBS in improving elementary mathematics students’ attitudes towards mathematics, perceptions of the classroom learning environment, and conceptual development.

Aldridge and Fraser (2000) conducted a cross-national study of classroom environments in Taiwan and Australia using mixed methodologies from different paradigms in exploring the nature of classroom learning environments. They used the WIHIC questionnaire to measure students’ perception of their classroom environment, a scale based on TOSRA to assess students’ satisfaction in terms of enjoyment, interest and how much they look forward to science classes. The sample involved 1081 Grade 8 and 9 general science students from 50 classes in 25 schools in Western Australia and 1879 Grades 7–9 students from 50 classes in 25 schools in Taiwan. It was found that Australian students consistently perceived their environments more favourably than did Taiwanese students. Students in Taiwan, however, reported significantly more positive attitudes towards science than did students in Australia. Prompted by the above findings, the researchers further examined students' perceptions in each country using classroom observations, interviews with teachers and students, and narrative stories written by the researchers. Three important points emerged after gathering the qualitative data. Firstly, whilst the classroom environments are different in the two countries, the questionnaire scores did not necessarily reflect fully the overall quality of education. Secondly, when interpreting the data for scales of the WIHIC questionnaire, consideration needed to be given to whether the scales reflect what is considered to be educationally important in the countries and cultures from which the data were collected. Finally, researchers felt that comparisons of quantitative data from different countries should be made with caution because there were some items that students in one country interpreted slightly differently from students in another country.

Fraser (2002) noted that the use of quantitative methods has tended to dominate Asian research into the learning environments. This can be considered to be a gap that the present study could begin to fill. Thus my study used qualitative and quantitative methods in investigating learning environments.

2.4.5 Determinants of Classroom Environment

Classroom environment dimensions have been used as criterion variables in research designed to identify how the classroom environment varies with factors such as class size, teacher personality, grade-level, subject taught and type of school (Fraser, 1994). For example, in a study by Hofstein, Cohen and Lazarowitz (1996), actual and preferred environments of biology and chemistry laboratories were compared for male and female eleventh-grade students in Israel. Gender differences were found in perceptions of actual biology learning environment, but not of actual chemistry environment. Girls rated their actual biology classes more favourably than boys on Teacher Supportiveness, Involvement, and Student Cohesiveness, but the opposite was true for Open-Endedness.

In Singapore, Goh and Fraser (1998) used the QTI and MCI with 1512 students to detect gender differences in mathematics achievement in favour of boys, but girls generally viewed the classroom environment more favourably than did boys. In another study by Quek, Wong and Fraser (2005a, 2005b), teacher-student interactions and perceptions of the laboratory learning environment were investigated among 497 gifted and non-gifted secondary-school students in Singapore. Gender differences were found in actual and preferred chemistry laboratory classroom environments and teacher-student interactions. Stream (gifted versus non-gifted) differences were found in actual and preferred chemistry laboratory classroom environments and teacher-student interactions.

In another study by Owens and Straton (1980), it was found that girls preferred more competition than boys. However, Byrne, Hattie and Fraser (1986) found that boys preferred more friction, competitiveness and differentiation, while girls preferred more teacher structure, personalisation and participation than did boys. Rickards (2003) also found differences between male and female students' perceptions of teacher interpersonal behaviour: females typically perceived their teachers more positively than males, with males perceiving their teachers as more uncertain, dissatisfied, admonishing and strict.

Lee, Fraser and Fisher (2003) and Fraser and Lee (2009) used translated versions of QTI and SLEI, respectively, to investigate 439 Korean high school students' perceptions of their science classrooms from three streams: humanities, science-oriented and science-independent. All scales of the Korean version had satisfactory factorial validity and internal consistency reliability and it was found that students from the science-independent stream perceived their classroom environments more favourably than did the students in the other two streams.

Chionh and Fraser (2009) cross-validated a version of WIHIC with a group of geography and mathematics students in Singapore. They investigated differences in perceptions of their geography and mathematics classroom environments among 2310 Secondary Four (Grade 10) students of the Express/Special Course in 75 randomly-selected classes from 38 randomly-selected schools. A comparison of geography and mathematics samples revealed that both groups of students had almost similar general perceptions of their learning environments.

In Singapore, no previous study has involved investigating stream and grade-level differences in the primary science classroom environments. Thus, this was a gap that my study filled by investigating gender, grade-level and stream differences in learning environment and attitudes.

2.4.6 Cross-National Studies

Fraser (2007) said that educational research that crosses national boundaries offers much promise for generating new insights as there is usually greater variation in variables of interest in a sample drawn from multiple countries and the taken-for-granted familiar educational practices of one country can be questioned and made 'strange' when exposed to research which involves more than one country. Studies bringing together data from different countries can be found in learning environment research.

A cross-national study (Aldridge, Fraser, Taylor & Chen, 2000; Aldridge & Fraser, 2000) involved 1081 Australian students and 1879 Taiwanese students and it revealed differences between Taiwanese and Australian classrooms. The students responded to either an English or a Chinese version of the CLES or WIHIC. Australian students consistently perceived their classroom environments more favourably than did students in Taiwan on all scales but, in contrast, Taiwanese students had a more positive attitude towards their science classes.

In another study, Fraser, Giddings and McRobbie (1992) investigated the science laboratory classroom environments in a number of schools in six countries (Australia, USA, Canada, England, Israel and Nigeria). The sample consisted of 3727 students from 198 classes in schools and of 1720 students from 71 university classes. Data from the six-country sample provided strong evidence that science laboratory classes around the world are dominated by closed-ended activities. The study also showed that the females held more favourable perceptions than males and that there were statistically significant associations between attitudinal outcomes and laboratory environment dimensions.

In a study conducted in Australia and Canada, Zandvliet and Fraser (2004, 2005) used the WIHIC in investigating the effects of educational Internet use in the classroom using a sample of 1,404 senior high students in 81 classes. This study combined the investigation of the physical and psychosocial environments featured within these ‘technological settings’, as well as interactions among the selected physical and psychosocial factors in influencing students’ satisfaction with their learning in these settings.

Dorman (2003) carried out a cross-national study involving high-school mathematics students from Australia, the UK and Canada. The WIHIC questionnaire was validated cross-nationally using a sample of 3980 high school students. The study used multi-sample analyses within structural equation modelling to substantiate invariant factor structures for three grouping variables: country, grade level and student gender. This study supported the wide international applicability of the WIHIC as a valid measure of classroom psychosocial environment.

Researchers from Singapore and Australia have also carried out a cross-national study of secondary science classes (Fisher, Goh, Wong & Rickards, 1997). The QTI was administered to students and teachers from a sample of 20 classes from 10 schools in each of Australia and Singapore. Australian teachers were perceived as giving more responsibility and freedom to their students than was the case for the Singapore sample, whereas teachers in Singapore were perceived as being stricter than their Australian counterparts.

Fraser, Aldridge and Adolphe (2010) carried out a cross-national study of classroom environments in Australia and Indonesia. They used a modified version of WIHIC with a sample of 1161 students (594 students from 18 classes in Indonesia and 567 students from 18 classes in Australia). The study revealed some differences between countries and between sexes in students' perceptions of their classroom environment. For some scales (Involvement and Investigation), Indonesian students perceived their learning environments significantly more positively than did Australian students. However, for some other scales (Task Orientation and Equity), Australian students had significantly more positive perceptions of their classroom environment than their Indonesian counterparts. The study also identified a statistically significant country-by-sex interaction for one learning environment scale, namely, Student Cohesiveness.

2.5 Learning Environment Studies in Singapore

The study of learning environments has attracted considerable interest in Singapore as part of educational research. Teachers and parents in Singapore are concerned that students are given every possible opportunity to excel both in and out of the classroom and that their potential is nurtured. Thus achievement tends to drive much of the learning that takes place in schools. With the great amount of time that the students spend in classrooms (1000 hours per academic year), the nature of classroom environment is likely to have an impact on students' motivation and learning. Every classroom is a dynamic learning environment with different and unique students and teachers, from different backgrounds and with different experiences, interacting together in order to experience and make sense of the immense learning opportunities available to all. Every teacher is managing a classroom from two levels, namely, the teaching and learning process and the classroom environment in which learning takes place (Goh, 2005). A positive classroom climate is needed for effective learning (Emmer, Evertson & Anderson, 1980). This highlights the importance for the study of the learning environment.

In Singapore, associations between learning outcomes and classroom learning environments were found in chemistry classes (Wong & Fraser, 1995), geography classes (Teh & Fraser, 1995a) and mathematics classes (Goh, Young & Fraser, 1995). Teh and Fraser (1995b) extended research on classroom environment to computer-assisted learning (CAL) classes in geography in an investigation of associations between student outcomes and classroom environment. The sample consisted of 671 high school geography students in 24 classes in 12 randomly-chosen schools in Singapore. The Geography Classroom Environment Inventory was developed to assess Gender Equity, Investigation, Innovation and Resource Adequacy in CAL geography classes. Student outcomes encompassed an achievement and an attitude measure. The nature of the CAL geography classroom environment accounted for appreciable proportions of the variance in both cognitive and affective outcomes beyond that attributable to student background characteristics.

Wong and Fraser (1995) modified and field tested the SLEI and validated it with a sample of 1,592 Grade 10 chemistry students in Singapore. Quek, Wong and Fraser (2005a, 2005b) investigated teacher-student interactions and student attitudes towards chemistry among 497 gifted and non-gifted secondary-school students in Singapore. Stream (gifted versus non-gifted) and gender differences were found in actual and preferred chemistry laboratory classroom environments and teacher-student interactions. Quek, Wong and Fraser (2005b) showed that students whose teachers were directive (i.e., those who provided a well-structured and task-orientated learning environment) and tolerant/authoritative (i.e., those who provided a pleasant, well-structured environment and who had a good relationship with students) showed the greatest cognitive and affective gains. The lowest student gains were associated with teachers who were uncertain/aggressive (i.e., those who offered an aggressive kind of disorder) and uncertain/tolerant.

Another study was undertaken at the primary-school level in Singapore into mathematics classrooms in 13 government co-educational elementary schools (Goh & Fraser, 1998, 2000). A sample of 1512 students in 39 mathematics classes was used to explore two aspects of the learning environment, namely, interpersonal teacher behaviour and classroom climate, using the Questionnaire on Teacher Interaction/Primary (QTI/Primary) and the My Class Inventory (MCI), respectively. Student-teacher relationships and classroom climate were significantly related to students' achievement and attitudes towards learning. This study also showed that teacher leadership and being understanding, helpful and friendly are positive behaviours that teachers should demonstrate in primary-school classrooms. It also showed that classroom environments were conducive to learning when there was a high degree of cohesion and little friction among students.

Pang (1999) used a case study to explore the impact of a co-operative learning environment on underachievers in a Primary 4 classroom. Underachieving students responded positively with more active participation in class activities, increased confidence and self-esteem and better relationships with peers.

Khoo and Fraser (2008) used a learning environment instrument among 250 adults to evaluate courses in five computer education centres in Singapore. Factor analysis supported a five-factor structure for the learning environment questionnaire. In this study, students perceived their learning environments favourably in terms of the levels of Trainer Support, Task Orientation, and Equity. Student Satisfaction varied between the sexes and between students of different ages.

Chionh and Fraser (2009) used the WIHIC questionnaire among 2310 Singaporean Grade 10 students (aged 15 years) in 75 geography and mathematics classes in 38 schools. A seven-scale factor structure was strongly supported and the alpha reliability of each scale was high. An investigation of associations between classroom environment and several student outcomes revealed that better examination scores were found in classrooms with more student cohesiveness, whereas self-esteem and attitudes were more favourable in classrooms with more teacher support, task orientation and equity.

Table 2.6: Summary of Learning Environment Studies in Singapore

Reference(s), Year	Subject, grade	Sample(s)	Instrument
Wong & Fraser, 1995	Chemistry, Grade 10	1592 students	Science Laboratory Environment Inventory (SLEI)
Teh & Fraser, 1995a, 1995b	Geography, Secondary	671 high school students in 24 classes	Geography Classroom Environment Inventory
Goh, Young & Fraser, 1995 Goh & Fraser, 1998, 2000	Mathematics, Primary 5	1512 students	Questionnaire on Teacher Interaction (QTI primary)
Pang, 1999	Underachievers, Primary 4	Underachievers, primary 4 classroom	Case study
Quek, Wong & Fraser, 2005a, 2005b	Chemistry, Secondary	497 gifted and non-gifted students	Chemistry Laboratory Environment Inventory (CLEI), Questionnaire on Teacher Interaction (QTI)
Khoo & Fraser, 2008	Computer education centres	250 adults	What Is Happening In this Class? (WIHIC)
Chionh & Fraser, 2009	Geography and mathematics, Grade 10	2310 students	What Is Happening In this Class? (WIHIC)
Chua, Wong & Chen, 2011	Chinese, secondary	Chinese language, 1460 secondary three students	Chinese Language Classroom Environment Inventory (CLCEI)

Chua, Wong and Chen (2011) used the Chinese Language Classroom Environment Inventory (CLCEI) to investigate the nature of Chinese Language classroom environments in Singapore secondary schools. The investigation was carried out using a sample of 1460 secondary three students from 50 Chinese language classes. Although both the Chinese Language teachers and the students perceived their present classroom learning environments positively, they would like improvements in all the six dimensions of classroom learning environment under investigation. Also teachers perceived a more positive classroom learning environment than their students in the same class. In addition, female students perceived their actual and preferred classroom environments more positively than their male counterparts. The various learning environment studies in Singapore are tabulated in Table 2.6.

With reference to various studies conducted in classrooms, it is apparent that the learning environment is a critical factor in the learning process. The learning environment includes all of the elements within a classroom, including the interactions between the teacher and students and the classroom climate. Favourable classroom environments support students' sense of wanting to learn and thus are important in improving learning outcomes. Because to date there has been no previous study into stream, grade-level and gender differences in the learning environment in primary schools in Singapore, my study filled this gap.

2.6 Gender, Grade-level and Stream Differences in Learning Environment

As my study involved the investigation of gender, grade-level and stream differences, this section is focused on research specifically into these differences.

Gender Differences

Students' perceptions of the classroom environment have been used as criterion variables in the investigation of differences between perceptions of the classroom environment held by girls and boys. For example, in a study by Hofstein et al. (1996), actual and preferred environments of biology and chemistry laboratories were compared for male and female eleventh-grade students in Israel. Gender differences were found in the actual biology learning environment, but not in the actual chemistry environment. Girls rated their actual biology classes more favourably than did boys on the scales of Teacher Support, Involvement, and Student Cohesiveness, but the opposite was true for Open-Endedness. Greater gender differences were found with the preferred form than with the actual form. For the preferred chemistry environment, mean scores for Open-Endedness were higher for boys than for girls and, for the preferred biology environment, girls' mean scores for seven of the eight scales (except Open-Endedness) were higher.

In Singapore, Goh and Fraser (1998) used the QTI and MCI with 1512 students in investigating gender differences in mathematics achievement in favour of boys, but girls generally viewed the classroom environment more favourably than did boys. In another study by Quek, Wong and Fraser (2005), teacher-student interactions and student attitudes towards chemistry were investigated among 497 gifted and non-gifted secondary-school students in Singapore. Gender differences were found in actual and preferred chemistry laboratory classroom environments and teacher-student interactions. Khoo and Fraser (2008) used a modified version of the WIHIC to measure classroom environment in their evaluation of adult computer courses. Males perceived significantly greater involvement, while females perceived significantly higher levels of equity.

When gender-related differences in perceptions of the learning environment were explored in Korea, Kim, Fisher and Fraser (2000) found that boys perceived more teacher support, involvement, investigation, task orientation and equity than did girls. Owens and Straton (1980) found that girls preferred more competition than boys. However, in another study (Byrne, Hattie & Fraser, 1986), boys preferred more friction, competitiveness and differentiation while girls preferred more teacher structure, personalisation and participation than did boys. Thus promoting positive student attitudes is an essential element in encouraging increased participation of females in science and science-related subjects (Henderson, Fisher & Fraser, 2000). Rickards (2003) found that females typically perceive their teachers more positively than males, with males perceiving their teachers as more uncertain, dissatisfied, admonishing and strict.

In 2006, Morrell and Lederman (1998) found that, among 5th, 7th and 10th graders, females were slightly more positive about school than males. No gender differences were found with respect to classroom attitudes, and fifth graders had significantly more positive attitudes than students in the higher grades.

Stream Differences

In a study by Quek, Wong and Fraser (2005a, 2005b), teacher-student interactions and student attitudes towards chemistry were investigated among 497 gifted and non-gifted secondary-school students in Singapore. Stream (gifted versus non-gifted) differences were found in actual and preferred chemistry laboratory classroom environments and teacher-student interactions.

In another study, Lee, Fraser and Fisher (2003) and Fraser and Lee (2009) used the QTI and SLEI to investigate 439 Korean high school students' perceptions of their science classrooms from three streams: humanities, science-oriented and science-independent. All scales of the Korean version had satisfactory internal consistency and it was found that students from the science-independent stream perceived their classroom environments more favourably than did the students in the other two streams.

Grade-level Differences

In 1999, Kim, Fisher and Fraser investigated the extent to which a new general science curriculum, reflecting a constructivist view, had influenced the classroom learning environment in Grade 10 science. The CLES was administered to 1083 students and 24 science teachers in 12 different schools. One class of Grade 10 and one class of Grade 11 were sampled at each school. Grade-level differences in students' perceptions of their learning environment were explored using a one-way MANOVA with the set of CLES scales as dependent variables. Grade 10 students perceived their environment as more constructivist for most scales except uncertainty, and differences were statistically significant for the three scales of personal relevance, shared control and student negotiation.

In 1975, a study by Randhawa and Michayluk involving 96 classrooms and the use of the LEI revealed that, relative to Grade 11 classes, Grade 8 classes were perceived as having a better material environment and greater diversity, formality, speed, friction, goal direction, favouritism, apathy, cliqueness, satisfaction, disorganization and competitiveness. Likewise, in another study involving use of 10 of the LEI's scales with a sample of 1121 science and mathematics classes in 15 states in the USA, Welch (1979) found that, relative to senior high-school students, junior high-school students perceived their classes as less difficult, satisfying and democratic, with more disorganization, diversity, formality, friction, cliqueness and favouritism.

In 2007, Castillo investigated grade-level, gender and ethnic differences in the attitudes and learning environment perceptions of high-school mathematics students. The study revealed noteworthy grade-level differences in that there was an increase in scores for Student Cohesiveness, Attitude to Inquiry, and Equity between Grades 9 and 10. There was decline in the scores for Teacher Support, Task Orientation, and Student Self-Efficacy between Grades 9 and 10.

Although there are various studies that have investigated gender, grade-level or stream differences, so far, no one study has investigated all of these determinants together. That is why I investigated all three determinants and their interactions.

2.7 Student Attitudes

Because the objectives of this study included investigating determinants of students' attitudes as well as associations between classroom environment and students' attitudes, literature related to assessment of students' attitude is reviewed in this section. Attitude is a non-observable psychological construct that can only be inferred from behaviour, and so there is no unanimous agreement on any one definition of attitude. Thurstone (1928) defined attitude as the sum total of a person's inclinations and feelings, prejudices and biases, preconceived notions, ideas, fears, threats and convictions about any specified topic. Krathwohl, Bloom and Masia (1964) developed a taxonomy in which various affective behaviours were placed along a hierarchical continuum: receiving or attending; responding; valuing; organization; and characterization by a value or value complex. Klopfer (1971, 1976) further developed a structure for the affective domain specifically related to science education to include four categories: events in the natural world (refers to a question of awareness and an emotive response to experiences that requires no formal study); activities (focuses on students participation in activities related to science); science (refers to the nature of science as a means of knowing about the world); and inquiry (refers to scientific inquiry process).

Two main categories related to attitudes concerned with science education are attitudes towards science and scientific attitudes (Gardner, 1975). Gardner defines attitudes towards science as a learned disposition to evaluate in certain ways objects, people, actions, situations or propositions involved in learning science. The 'learned disposition' refers to the way in which students regard science, such as interesting, boring, dull or exciting. The term 'scientific attitudes', on the other hand, are defined as desirable attributes of scientists in professional work and could be categorised as interests, adjustments, appreciation and values.

In some countries, it is possible to find trends of decreasing interest in science subjects in secondary schools by analysing the number of students choosing science subjects (Greenfield, 1996). Recently, greater attention has been given to affective variables, particularly attitudes, in educational research, possibly because affective variables are as important as cognitive variables in influencing learning and other outcomes (Koballa, 1988). The central attribute of the attitude concept is its evaluative quality – like or dislike (Shrigley, Koballa & Simpson, 1988), including terms such as interest, enjoyment and satisfaction (Gardner & Gauld, 1990) and even curiosity, confidence and perseverance (Shulman & Tamir, 1972). Shrigley (1983) states that it is generally agreed that attitude is not innate, but learned as part of culture. Klopfer (1976) alleviated the problems caused by the multiple meanings attached to the term attitude to science by developing six categories of conceptually-different attitudinal aims: manifestation of favourable attitudes to science and scientists; acceptance of scientific enquiry as a way of thought; adoption of scientific attitudes; enjoyment of science learning experiences; development of interest in science and science-related activities; and development of interest in pursuing a career in science.

Fraser (1978) developed the Test of Science Related Attitudes (TOSRA) to measure seven science-related attitudes among secondary school students. The TOSRA consists of 70 items, which are spread equally between seven distinct scales. Each scale contains 10 items, with the responses based on a five-point Likert scale ranging from Strongly Agree to Strongly Disagree. The names of the TOSRA scales are: Social Implications of Science, Normality of Scientists, Attitude to Science Inquiry, Adoption of Science Attitudes, Enjoyment of Science Lessons, Leisure Interest in Science and Career Interest in Science. In my study, two scales from the TOSRA was used to measure attitudes, namely, Attitude to Scientific Inquiry and Enjoyment of Science Lessons.

TOSRA was carefully developed, extensively field-tested and found to be highly reliable. For example, in 1982, Fraser and Butts studied 546 year 9 girls and 712 year 7 students in 23 classes in Australia. Likewise, Wong and Fraser (1996) investigated environment-attitude associations for 1592 tenth grade chemistry students in Singapore using the SLEI and three of the seven TOSRA scales. All the samples yielded high internal consistency reliability and satisfactory discriminant validity for TOSRA scales.

Past research has shown that, in order to improve student attitudes and achievement, it is desirable to create learning environments that emphasise the characteristics found to be positively associated with student outcomes (Brekelmans, Wubbels & Creton, 1990). Research has also revealed that students' willingness to learn results in positive attitudes and is closely related to teachers' method of teaching (Kounin, 1970).

Kim, Fisher and Fraser (1999) investigated the extent to which a new general science curriculum, reflecting a constructivist view, had influenced the classroom learning environment in Grade 10 science by administering the CLES to 1083 students and 24 science teachers in 12 different schools in Korea. One class of Grade 10 and one class of Grade 11 were sampled at each school. Associations between the five CLES scales and students' attitudes towards their science class were examined using multiple regression analysis involving the whole set of the CLES scales, in addition to a simple correlation analysis, to provide a more conservative test of associations between each CLES scale and attitude when all other CLES scales were mutually controlled. Students' perceptions showed a statistically significant relationship with their attitudes for the scales of Personal Relevance, Shared Control and Student Negotiation for Grade 11.

Also, in Singapore, Wong and Fraser (1996) investigated associations between students' perceptions of their chemistry laboratory classroom environment and their attitudes towards chemistry, using a sample of 1592 final-year secondary school chemistry students in 56 classes in 28 randomly-selected coeducational government schools. They used the Questionnaire on

Chemistry-Related Attitudes (QOCRA), a modified form of the TOSRA, to assess students' attitudes to chemistry. Significant associations were found between the nature of the chemistry laboratory classroom environment and the students' attitudinal outcomes.

McRobbie and Fraser (1993) used the SLEI in Australia with 1594 senior secondary chemistry students in 92 classes and 52 schools in investigating relationships between student outcomes and the laboratory learning environment. In addition, a subsample of 596 students also completed a Likert-style questionnaire assessing chemistry-related attitudes that was a blend of items from TOSRA and also included some new items. The attitude questionnaire was used to investigate associations between attitudinal outcomes and the laboratory learning environment. A strong and consistent attitude-learning environment association was found between SLEI and attitude scales. Open-Endedness had a significant negative correlation with the attitude scale of Normality of Chemists, suggesting that attempting to increase the number of open-ended activities in the science laboratory can backfire by inadvertently and adversely affecting students' attitudes.

In another study (Fisher, Henderson, & Fraser, 1997; Henderson, Fisher, & Fraser, 2000) in Australia investigating biology laboratory classrooms and attitudes towards science with 489 senior secondary students in 28 classes, students completed the SLEI, the QTI, two scales from TOSRA, a written examination and several practical skills tests. Associations were strongest between learning environment and attitudes, rather than between learning environment and either cognitive achievement or practical performance. Another interesting finding was that students with more than one science laboratory class had more favourable learning environment perceptions and attitude scores.

In 2010, Fraser, Aldridge and Adolphe reported a cross-national study of learning environments and attitudes to science. The results attested the internal consistency reliability and empirical independence of the TOSRA scales for both the Indonesian and Australian versions. Associations between students' perceptions of the classroom environment and their attitudes to science were investigated for a sample of 1161 students (594 from Indonesia and 567 from Australia). There were statistically significant associations for most attitude-environment relationship except for Attitude to Scientific Inquiry and Equity for the Australian sample and between Career Interest in Science and Student Cohesiveness for both the Indonesian and Australian samples.

A study in Singapore (Wong & Fraser, 1996; Wong et al., 1997) cross-validated a slightly-modified version of the SLEI. In addition, a 30-item, three-scale Questionnaire of Chemistry-Related Attitudes (QOCRA), a modification of TOSRA, was used. A total of 1592 tenth grade students and 56 teachers at 28 schools in Singapore were involved. Preferred scores were slightly higher than actual scores, females viewed the laboratory environment slightly more favorably than did males (except for Open-Endedness), and there were positive associations between learning environment and attitudinal outcomes (again, except for Open-Endedness).

For my study, only two of the constructs from TOSRA (Enjoyment of Science Lessons and Attitude to Scientific Inquiry) were used to assess attitudes. For more information about the attitude scales used in my study, refer to Section 3.4.2.

2.8 Summary of Chapter

This literature review chapter encompassed some historical background to the learning environment field and traced its trajectory since the time when Kurt Lewin (1936) recognised that the environment and its interactions determine human behaviour. Murray followed this in 1938 and proposed a Needs-Press Model. The journey continues with Walberg and Moos in the 1960s as they developed tools for assessing the learning environment. Classroom environment assessment was pioneered in an evaluation of Harvard Project Physics by Walberg and Anderson (1968) and in programmatic research by Moos and Trickett (1974). Various researchers subsequently created different instruments.

Section 2.3 reviewed questionnaires that are currently available for researchers and educators for measuring students' learning environment perceptions, including the Learning Environment Inventory (LEI), My Class Inventory (MCI), Classroom Environment Scale (CES), Questionnaire on Teacher Interaction (QTI), Individualised Classroom Environment Questionnaire (ICEQ), Science Laboratory Environment Inventory (SLEI), Constructivist Learning Environment Survey (CLES) and What Is Happening In this Class? (WIHIC).

The chapter then focused specifically on the CLES and WIHIC, as these were the two learning environment instruments from which scales were chosen for use in my study, including their validity and various studies that have used them. The studies reviewed consistently supported the validity of the CLES and WIHIC in classroom situations in various parts of the world.

The next section focused on various studies from the field of learning environments, including research undertaken in Singapore. The research reviewed showed that the study of learning environments has attracted considerable interest among educational researchers internationally. These studies validated various learning environment instruments and established consistent associations between student outcomes and classroom learning environments. The literature reviewed in this section revealed a gap that my study filled in that there were no previous studies conducted among gifted students in primary science classrooms.

Next the chapter focused on past learning environment studies involving gender, grade-level and stream differences. This review of research showed that there have been no previous studies in Singapore that investigated all three determinants of gender, grade-level and stream and their interactions, as in my study.

The chapter next reviewed literature on student attitudes and how the Test of Science Related Attitudes (TOSRA) had been used in various prior studies. The studies reviewed also had explored associations between classroom environment and students' attitudes.

The literature showed that student' perceptions of their learning environment and their attitudes to a subject vary with various factors such as gender, grade-level, subject, etc. My study investigated: reliability and validity of learning environment and attitude questionnaires; grade-level (grade 4, 5 and 6), stream (GE, HA) and gender (male, female) differences in learning environment perceptions and attitudes to science; and interrelationships between student attitudes and the learning environment. The scales for assessing learning environment in this study were Involvement, Teacher Support, Investigation, Task Orientation, Cooperation, Personal Relevance, Uncertainty and Student Negotiation, and the attitude scales selected were Attitude to Scientific Inquiry and Enjoyment of Science Lessons. Figure 2.4 provides a schematic model of my study. The lines illustrate possible associations.

The next chapter describes the research methods used in the present study, including detailed information about the research objectives, design of the study, sample, instruments used and methods of data collection and analysis.

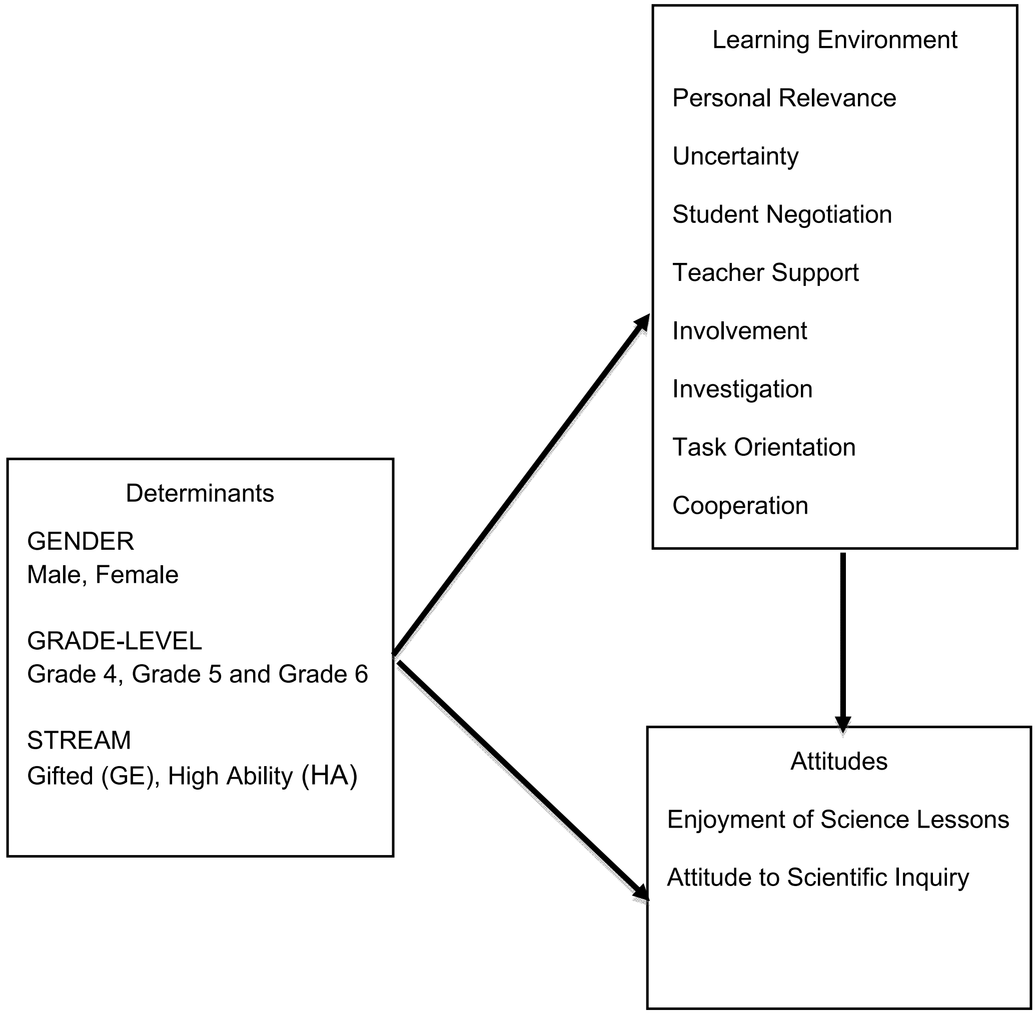

Figure 2.2: Schematic Model of Study

Chapter 3
METHODOLOGY

3.1 Introduction

Whereas chapter 2 presented a review of literature relevant to my study, this chapter describes the methodology used in investigating my research questions. This chapter includes identification and description of sample, procedures for gathering the data, and how the data were analyzed. The various sections in this chapter are:

- Objectives of the study (Section 3.2)
- Selection of the sample (Section 3.3)
- Instruments used in study (Section 3.4)
- Piloting the questionnaire (Section 3.5)
- Data analysis procedures (Section 3.6)
- Summary of chapter (Section 3.7).

3.2 Objectives of Study

This section recapitulates the objectives of this study and the research questions. The main foci of this research study was to investigate:

- the reliability and validity of a questionnaire assessing learning environment and attitudes in primary science classrooms in Singapore,
- the gender, grade-level and stream differences in learning environment and attitudes to science and
- relationships between attitudes and the learning environment.

After reviewing literature about various questionnaires available, I chose scales from Constructivist Learning Environment Survey (CLES, Taylor, Fraser, & Fisher, 1997) and the What Is Happening In this Class? (WIHIC, Fraser, Fisher & McRobbie, 1996) to measure students' perceptions of their classroom learning environment. I also included two scales from the Test Of Science-Related Attitudes (TOSRA, Fraser, 1978) to measure students' attitudes towards science. For convenience during data collection, the eight learning environment scales and two attitude scales were combined to form one questionnaire. Before the questionnaire could be used for testing the other research questions in the study, first, it had to be validated, which involved in answering the first research question:

> *Research Question # 1*
>
> *Are learning environment scales based on the CLES and WIHIC and attitude scales based on TOSRA valid when used with a sample of primary-school science students in Singapore?*

After validating the questionnaire, in order to investigate the gender, grade-level and stream differences in learning environment and attitudes to science, research question 2 was answered:

> *Research Question # 2*
>
> *For primary school science students in Singapore, do students' scores on learning environment and attitude scales vary with:*
>
> *a) gender,*
>
> *b) grade-level and*
>
> *c) stream?*

Finally, investigating relationships between attitudes and the learning environments gave rise to research question 3:

> *Research Question # 3*
>
> *Are there associations between students' attitudes to science and their perceptions of classroom learning environment among a sample of primary-school science students in Singapore?*

3.3 Background and Selection of Sample

As my study involved GE students (Gifted Education) and HA students (High Ability), my first task and constraint was getting access to the GE students because there were only 9 primary schools in Singapore which have the Gifted Education programme. Once I got access to these schools, I intended to use HA pupils in the same school. Of the 9 GE centres in Singapore, three had to be eliminated as they were single-gender schools. I was thus left with six GE schools. From each school, I intended to use all GE students in Grade 4, 5 and 6 and one or two HA classes per grade-level in order to have equal sample sizes from both streams. As stated in Section 2.2.2, GE students belong to the top 1% of the cohort and they are found within these 9 schools. The next few sections describe the process of getting access to the sample, the problems faced and finally an overview of the sample used for the study.

3.3.1 Process

My first step was to write to the Data Administration Centre, Ministry of Education, to request approval to collect data from schools. For this, I needed to provide information about the schools that I intended to approach, the number of students from whom I need to collect the data, and the questionnaire I would be using in the study. This took me around two to three months to complete. Once I got the approval, my next step was to approach the schools.

I wrote to the principals of the six schools (Appendix 1) via email to ask them for permission to collect data. One principal immediately replied that her school would not be able to participate in the research as teachers were involved in a few other projects, it was a busy time in her school and she did not want to stress her teachers. When one other school principal did not reply, I sent her another letter, but she then replied that she would not be able to participate. Finally, I was only able to get favourable replies from four schools.

Once I had received a favourable reply from each school, the Principal appointed a liaison person with whom I kept in touch throughout the data collection. This liaison person was a great help to me, as I only needed to communicate with him/her regarding the whole process and he/she helped me to pass information to the rest of the teachers. From each of the four schools, all GE classes in Grade 4, 5 and 6 had to participate in this study. For the HA classes, each school gave one or two classes per grade level. This depended on the school, with some schools only designating one class as a HA class, while another designated two classes as the HA class. How the designation of HA classes was done depended a lot on the school and the cohort of students that they had per year. However it was done, still the schools had one or two designated HA classes.

Once I got in touch with the liaison person, he/she told me the number of students in the classes that were designated to participate in this study. I then had to print adequate copies of:

- Information Sheet for Teacher (Refer Appendix 2)
- Information Sheet for Student and Consent Form (Refer Appendix 3)
- Information Sheet for Parents and Consent Form (Refer Appendix 4)
- Questionnaire.

Only one copy of the Information Sheet for the Teacher was printed for each class. For the Information Sheet and Consent Form for student and parents, one copy per student was printed and sent to the schools.

Using the Information Sheet, I informed the participants about the purpose of the study and the confidentiality involved. For the parents and students, I asked for their consent to participate in the study. Before I could collect data, I needed permission from each student and his/her parent. Data were only collected from students who consented to participate in the study.

The liaison person decided the exact date for distribution of the questionnaire within the school. The liaison person also decided a date and time so that the students would not be disturbed while completing the questionnaire and that this would cause minimal disruption to their curriculum. The time and date for all the schools was within the same time period, that is, at the end of the academic year, after the school examinations. Such a time was chosen so that the teachers did not feel that they were losing out in their curriculum time when they spent time responding to this survey. The liaison person communicated with the teacher to first give out the Information Sheets and Consent Forms for parents and students and to collect them before the day assigned to give out the questionnaire.

Of the four schools participating in the study, students from one school were selected for a focus-group interview. The teacher randomly chose four students per stream per grade level for the interview. Of these four students, two were males and two were females. Thus a total of 24 students (3 grade levels x 2 streams x 4 students) were chosen to attend a focus-group interview that was recorded and transcribed for later use. These students were given Information Sheets and Consent Forms (See Appendix 5) that included information about attending an interview.

3.3.2 Problems Faced

The researcher, teacher and liaison person faced various problems during the process. Throughout the school year, teachers are always busy, and having been a teacher myself for the past 15 years, I can safely say there is no time period within the year when teachers are free and that would be a suitable time to conduct the study because the liaison teachers felt that different teachers were busy at different times, she found it difficult to come up with one date for doing the survey in her school. They communicated this with me by email or during my telephone conversations and face-to-face informal meetings with them. They also found it difficult to keep pushing teachers to give out the information sheet and collect them, so that they could confirm the number of participants. Thus, when it came to deciding on a date to conduct the survey, we decided that, as long as all classes at the same grade level completed the survey on the same day it was acceptable. It was also acceptable if different grade levels completed the survey on different days within the same week. Although some schools took some time to provide me with the number of students, I finally managed to get the numbers and print the consent forms and questionnaires.

For the teachers, the problems that they faced were in the distribution and collection of the consent forms. Some teachers gave me feedback suggesting that I should just ask consent from the students only, as this would make the process easier for them. They mentioned that, if only pupils had to sign the consent forms, then they would just give the consent form, ask pupils to read and sign in class, and then answer the questionnaire and complete the study. This would have reduced the time wasted in chasing the students for consent form. The teachers also felt that, as I had the MOE's approval, there was no need to ask for parent approval.

The problem associated with giving the Parent Consent form was that, in the Singapore context, parents are not used to being asked for consent when surveys are undertaken in school as long as the Principal approves. Therefore some parents were confused as to why they were asked for approval. Some parents telephoned me to ask, for example:

> *What will you do with the information?*
>
> *Can you give me the questions before I sign this.*
>
> *Why did you choose my son's class and school? What is your criterion? Why this school? How many schools are participating?*
>
> *Who will see the results?*

The problem that I, the researcher, faced was the non-return of consent forms. This occurred because the child was forgetful and did not return the consent form, or because the parent did not give consent, or because the teacher did not chase the pupil for the consent forms. Thus, eventually, I did not get all pupils in the classes to complete the questionnaire. For some classes, I realised later that I had only half the class completing the questionnaire. Thus my sample size was reduced. However, it was still acceptable because, at the planning stages, I had only targeted in collecting data from three schools. I had written to six schools asking permission to participate, hoping to get at least 50% acceptance. I got acceptance from four schools that agreed to participate. However, if all students in the classes took part in the survey, the sample size would have been larger.

Another reason for the reduction in the sample size was that, because Grade 6 was the final year for this group of students, they had many end-of-year programmes in their respective schools. Thus, even during curriculum time, students participating in concerts and shows were using the time to practice. Thus, when the questionnaire was distributed, some students were not in the classroom and the teacher giving out the questionnaire just left them out. Thus, in all four schools, the number of Grade 6 students completing the questionnaire was less than for the other grades (as seen in Table 3.1).

3.3.3 Sample for the Study

Data were gathered from 1081 students from 55 different classes in four different schools. Table 3.1 provides detailed information about the sample.

Table 3.1: Information about the Sample

Group	Sample Size				
	School 1	School 2	School 3	School 4	Total
Gender Subgroup					
Males	154	150	141	220	665
Females	100	82	76	158	416
Total	254	232	217	378	1081
Grade Subgroup					
Grade 4	78	85	82	149	394
Grade 5	99	89	87	126	401
Grade 6	77	58	48	103	286
Total	254	232	217	378	1081
Stream Subgroup					
GE	125	89	127	228	569
HA	129	143	90	150	512
Total	254	232	217	378	1081

Students for the interview came from school 1. The teachers from school 1 chose four students per grade level per stream. Focus-group interviews were conducted separately per grade per stream. Thus six interviews were conducted. Each interview session involved four students, two boys and two girls.

3.4 Instruments Used in the Study

Classroom learning environments have been assessed and investigated using numerous instruments that have been extensively validated. These instruments were previously described in Chapter 2. After examining various instruments available for assessing classroom learning environments, I selected some scales from CLES and WIHIC to assess the learning environment and scales from TOSRA to assess attitudes to science. This decision was based on reviewing the literature, convenience, established validity and consultation with my research supervisor.

3.4.1 Learning Environment Scales

The Constructivist Learning Environment Survey (CLES) was designed to enable teachers to monitor the development of learning environments that involve constructivist approaches to the lessons (Taylor, 1994) (see section 2.3.3). Because the Singapore Primary Science Curriculum is promoting constructivist approaches, scales from CLES were chosen for my study. Literature reviewing (see Section 2.3.3) showed that the CLES was found to be valid and reliable when used with 739 grade K−3 students in Florida (Peiro & Fraser, 2008), 1864 grades 4–9 mathematics students in South Africa (Aldridge, Fraser & Sebela, 2004), 1079 students in science classes in the United Sates (Nix et al., 2005), 1081 Australian and 1879 Taiwanese high school science students (Aldridge, et al., 2000), 1046 junior college students in Singapore (Wilks, 2000) and 1083 Korean high school science students (Kim et al., 1999).

Of the five scales in the CLES, only three were chosen, namely, Personal Relevance, Uncertainty and Student Negotiation, as they were considered relevant to my study. The Personal Relevance scale measures the connectedness of the curriculum to the learner's out-of-school experiences. This involves the relevance of the environment to the students. The Uncertainty scale measures the extent to which opportunities are provided for the learners to experience science knowledge as arising from theory-dependent inquiry and involving human experience and values. The Student

Negotiation scale assesses to what extent opportunities exist for learners to explain and justify to other learners their newly-developing ideas.

Fraser, Fisher and McRobbie (1996) developed a learning environment instrument called the What Is Happening In this Class? (WIHIC) (see Section 2.3.4). This questionnaire measures a wide range of dimensions that are important to the daily situations in classrooms. The WIHIC is worded to elicit the student’s perception of his/her individual role within the classroom, as opposed to the student’s perception of the class as a whole. Literature reviewing (see Section 2.3.4) showed that the WIHIC was valid and reliable when used with 250 working adults attending courses in five computer education centres in Singapore (Khoo & Fraser, 2008), 520 students and 120 parents in South Florida (Allen & Fraser, 2007), 1404 high school students in Australia and Canada (Zandvliet & Fraser, 2005) and 3980 Grade 8, 10 and 12 students in Australia, Canada and the United Kingdom (Dorman, 2003).

Five of the seven scales from WIHIC were selected as they were considered to be relevant to my study. They are Teacher Support, Involvement, Investigation, Cooperation and Task Orientation. The Teacher Support scale measures the extent to which the teacher helps, befriends, trusts and is interested in students. The Involvement scale measures the extent to which students have attentive interest, participate in discussions, do additional work and enjoy the class. The Investigation scale measures the extent to which skills and processes of inquiry and their use in problem solving and investigation are emphasised. The Cooperation scale measures the extent to which students cooperate rather than compete with one another on learning tasks. The Task Orientation scale measures the extent to which it is important to complete activities planned and to stay on the subject matter.

The study of learning environments has a theoretical base in the work of Moos (1979). On the basis of extensive empirical research, Moos concluded that such environments could be described in terms of three general categories: the Relationship dimension, the Personal Development dimension and the System Maintenance and Change dimension (see Section

2.2). In accordance with this framework, the CLES's and WIHIC's scales can be classified as shown in Table 3.2.

Table 3.2: Scales from Two Learning Environment Instruments Classified According to Moos' Scheme

Instrument	Author & Date Developed	Items per Scale	Scales Classified According to Moos' Scheme		
			Relationship Dimensions	Personal Development Dimensions	System Maintenance & Change Dimensions
Constructivist Learning Environment Survey (CLES)	Taylor & Fraser (1991)	6	Personal Relevance [a] Uncertainty	Critical Voice	Student Negotiation [a] Shared Control
What Is Happening In this Class? (WIHIC)	Fraser, McRobbie, & Fisher (1996)	8	Student Cohesiveness Teacher Support [a] Involvement [a]	Investigation [a] Task Orientation [a] Cooperation [a]	Equity

[a] These scales were used in my study.

As the different scales were chosen for the questionnaire, I made sure that all three dimensions of Moos's scheme were represented. The scales used in my study, that are identified in bold in Table 3.2, provide coverage of all three dimensions of Moos.

3.4.2 Attitudes to Science

Fraser (1978) developed the TOSRA to measure seven science-related attitudes among secondary school students (see section 2.7). The TOSRA consists of 70 items, which are spread equally between seven distinct scales. Each scale contains 10 items, with the responses based on a five-point Likert scale ranging from Strongly Agree to Strongly Disagree. For my study, only two of the constructs (Enjoyment of Science Lessons and Attitude of Scientific Inquiry) were used as they were considered to be relevant to the study.

Literature review (see Section 2.7) showed that the TOSRA was valid and reliable when used with 1161 students from Indonesia and Australia (Fraser et al., 2010), 1592 tenth grade students in Singapore (Wong & Fraser, 1996), 1594 senior secondary students in Australia (McRobbie & Fraser, 1993) and 546 year 9 girls and 712 year 7 students in Australia (Fraser & Butts, 1982).

For each scale in the original TOSRA, there are five positively-worded and five negatively-worded statements. As the scales measuring attitude were going to be placed in the same questionnaire as the learning environment scales (see Section 3.3.3), the negatively-phrased statements were removed as both the learning environment questionnaires (CLES and WIHIC) did not have negatively-phrased statements. Another reason for removing the statements was to avoid lengthening the instrument. With the removal, each of the attitude scales had five statements. Because the scales from CLES and WIHIC had eight or six items per scale, one extra item was added to each attitude scale to increase the total number of items to six.

For the scale of Attitude to Scientific Inquiry, the extra item that was included was: "I would prefer to learn scientific facts by doing an experiment than to find out from others." For the scale Enjoyment of Science Lessons, the extra item that was included was: "I would enjoy school more if there were more science lessons."

3.4.3 Putting Together the Questionnaire

After the selection, development and modification of the eight learning environment scales and two attitude scales, they were then placed into a single questionnaire. There were constraints in that students were reluctant to complete questionnaires that are considered overly long and also they do not like to complete many questionnaires. Thus the eight learning environment scales and two attitude scales were combined to form one questionnaire with a common set of instructions at the front (Refer Appendix 6). In order to have a similar format, the phrase "In my science class…" was placed at the top of the page for the questionnaire and the statements were all scored using a five-point frequency scale consisting of Almost Never=1, Seldom=2, Sometimes=3, Often=4 and Almost Always=5.

3.5 Piloting the Questionnaire

The questionnaire was piloted with a class of 40 Grade 4 students to ensure if the wording of the questions were suitable for grade 4 to 6 students in Singapore. The students were told they were going to complete a questionnaire and were asked to indicate with an 'x', any part or sentence about which they were unclear. They were told not to ask their friends if they were unsure and that they would be given time after the completion of the questionnaire to indicate any part of the survey or question about which they were unclear. The time taken for all the students to complete the survey was also taken note of.

The maximum time taken by the students to complete the survey was 20 minutes. Therefore, when requesting time from the schools for the completion of the questionnaire during my main study, I requested for 40 to 45 minutes, so that I could be sure that there was enough time for students to complete the questionnaire and for the logistics of distributing and collecting the questionnaire.

I also observed the students as they were completing the questionnaire and noted places where students pondered and spent a considerable amount of time or did something that was not required. There were four areas of concern as observed by me or as indicated by the students.

Firstly, some confusion was associated with the directions to students given on the first page of the questionnaire. The initial questionnaire had as part of the instructions:

Circle

1 if the statement applies Almost Never
2 if the statement applies Seldom
3 if the statement applies Sometimes
4 if the statement applies Often
5 if the statement applies Almost Always.

Students seemed to ponder at the word ‘Circle’ and even tried to circle the numbers below the word. As a result of my observation, after the questionnaire had been completed, I asked the pupils to identify the cause for the delay. They stated that the word ‘Circle’ confused them as they did not know what to circle. Thus I decided to move this option behind the example and reworded the instructions.

Secondly, during discussion after completion of the questionnaire, some students said they were confused with the sentence: “If you selected ‘Often’, then you would circle number 4 on the right hand side”. Therefore, I decided that the practice example should look similar to the questionnaire.

Thirdly, during the pilot testing of the questionnaire, many students had placed ‘x’ beside statements 9, 10, 26 and 46 to indicate that these statements were confusing and they were not sure what the statement meant. I asked those who understood it to explain in their own words. I asked the pupils who did not understand whether they understood their friends’ explanation. I also reworded the question and asked them if the rewording made the statement clearer. Using the other students’ explanation and my own input, the wording for the statements was changed as shown in Table 3.

Table 3.3: Changes Made to the Questionnaire

Statement number	Original statement	New statement
9	The teacher takes a personal interest in me.	My teacher is interested in my well-being/ welfare.
10	The teacher goes out of his/her way to help me.	The teacher makes an extra effort to help me.
26	I do as much as I set out to do.	I do what I plan to do.
46	What I learn has nothing to do with my out-of-school.	What I learn in this class has nothing to do with what I do outside school.

Lastly, because some students left out the last page of the questionnaire, I decided to include the words “Go to next page…” and “End of questionnaire”.

With the changes completed, the questionnaire was ready to be administered to the sample (refer Appendix 6). When distributing the questionnaire, for logistical purposes and to make the respondents feel that they were answering one questionnaire rather than having to complete two questionnaires, items from the attitude scales were included in the same questionnaire as the items from the learning environment scales. The combined questionnaire thus had a common set of directions and response alternatives (a five-point frequency response scale).

3.6 Data Collection and Analysis

My study involved a combination of qualitative and quantitative methods to collect different kinds of data from different sources in order to provide useful information that could help with understanding and explaining the phenomenon more completely and answering the three research questions stated in Section 3.2.

Quantitative research methods are based on the collection and analysis of numerical data, usually obtained from questionnaires, tests and other formal paper-and-pencil instruments. Whereas qualitative research methods are based on the collection and analysis of non-numerical data, such as observation, interview and focus group discussions (Gay & Airasian, 2003). Quantitative tools provide results obtained from the research population and qualitative tools can validate the quantitative tools as well as contribute to a better understanding of the research environment (Orion, Dubowski & Dodick, 2000). Each research method has different advantages, limitations and purposes. In the study of classroom learning environment, some studies have combined quantitative and qualitative methods (Aldridge, Fraser & Huang, 1999; Tobin & Fraser, 1998).

3.6.1 Quantitative Data Collection

Quantitative data were collected with a questionnaire containing eight learning environment scales based on the CLES and WIHIC and two attitude scales based on TOSRA. The questionnaires were administered to students from four primary schools in Singapore. After the questionnaire had been administered, each student’s responses were checked. For a few students who had left one page blank, their data were omitted and the rest of the student responses (1081 students) were entered into a database using the Microsoft Excel software. After entry, the responses keyed in were double-checked to ensure accuracy.

The responses of Almost Never, Seldom, Sometimes, Often, and Almost Always were entered as 1, 2, 3, 4 and 5, respectively, into the database. Other important information such as questionnaire number, class number and grade-level were also entered directly from the questionnaires into the database. Information such as school, gender and stream were coded (e.g. 1 for male and 2 for female) and entered directly from the questionnaire. The data was then transferred to statistical analysis software, SPSS, to carry out the analyses.

3.6.2 Quantitative Data Analysis

The data were then statistically analysed to answer the research questions listed in Section 3.2. To answer the first research question concerning the reliability and validity of the questionnaire in primary science classrooms in Singapore, various analyses were conducted. To examine the internal structure of the 70 items of the learning environment and attitude scales, the data were subjected to principal axis factoring with varimax rotation and Kaiser normalisation. Factor analysis was conducted to check whether removing any of the items would improve the factorial validity of the instrument. Any item that had a factor loading of 0.40 or above with its a priori scale and below 0.40 with each of the other scales was retained. This led to the deletion of 9 items.

To check whether every item in each learning environment and attitude scales assesses a similar construct, the internal consistency reliability was calculated. The Cronbach alpha coefficient was calculated using two units of analysis (individual and class mean) as the index of scale of internal consistency.

One-way ANOVA was used to determine the ability of each learning environment scale to differentiate significantly between the perceptions of the students from the different classrooms. The eta^2 statistic, which is a measure of the degree of association between class membership and the dependent variable for each of the learning environment scales, was calculated.

After validating the questionnaire, in order to investigate gender, grade-level and stream differences in learning environment and attitude to science, and answer research question 2, a three-way multivariate analysis of variance (MANOVA) was conducted. The MANOVA results provided important information about the statistical significance of differences between groups.

Because the MANOVA produced statistically significant results using Wilks' lambda criterion, the three-way univariate ANOVA was interpreted seperately for each main effect (gender, grade level and stream) and each interaction. Results indicate if there were any statistically significant differences between genders, grade levels and streams for each dependent variable. The MANOVA and ANOVAs also are able to identify the presence of any stream-by-gender, grade-by-stream, grade-by-gender and stream-by-gender-by-grade interactions for each scale.

It was also essential to determine the magnitude of these differences and their educational importance by calculating effect sizes (the difference between means expressed in standard deviation units). To determine the effect size for a scale, the difference between the mean of the groups was divided by the pooled standard deviation. Thus the effect size for each learning environment and attitude scale was also calculated. According to Cohen (1977), effect sizes can range from small (0.10) to medium (0.25) to large (0.40).

To answer the third research question concerning whether or not associations exist between students' perceptions of their classroom learning environment and their attitudes toward science, simple correlation and multiple regression analyses were performed at two units of analysis (individual and class mean). The simple correlation (r) describes the bivariate association between each of the seven learning environment scales and each attitude outcome. The multiple correlation (R) describes the relationship between an attitudinal outcome and the set of learning environment scales. The standardised regression weight (β) describes the association between a particular learning environment scale and an outcome when all other learning environment scales are mutuallycontrolled.

The results of all the statistical analyses are reported in Section 4.2 (results for Research Question #1), Section 4.3 (results for Research Question #2), and Section 4.4 (results for Research Question #3).

3.6.3 Qualitative Data Analysis

The main data-collection method employed in my study involved the administration of questionnaires to assess students' attitudes and perceptions of classroom learning environment. In addition, as recommended by Tobin and Fraser (1998), I incorporated a minor qualitative data-collection component based on interviews with a small number of participating students. Although valuable, the qualitative component was small enough to represent a limitation of this study. The qualitative component helped to triangulate the data obtained from the questionnaire. Interview questions were based on the constructs of the questionnaire, so that quantitative and qualitative data could be combined to enhance understanding of the learning environment and attitude constructs.

Qualitative data were collected in the form of interviews. The sample for the qualitative data collection consisted of four students per grade level per stream. Students were interviewed to get their perspectives about their science classrooms. The interviews were conducted in a group setting, which included the four interviewees and me. The interviewees were made to feel comfortable during the entire process, and they were told that their responses would remain anonymous. A video recorder was used to tape the interviews in order to ensure that all conversations were captured and to make it easier when analysing the data later.

As recommended by Patton (1990), careful steps were taken during the interview process to enhance the validity of the findings. The interviews were conducted in a quiet area. The location was an air-conditioned classroom that contained comfortable seating and lighting. The office was remote enough from the rest of the school so that there would be minimal disturbances from movement and noise of students outside. To ensure that interviewees felt comfortable and at ease when sharing their views and opinions (Patton, 1990), I listened actively to their conversations and allowed them to comment freely without agreeing or disagreeing with respondents. I maintained an open and comfortable atmosphere by using positive nonverbal cues such as using non-intimidating body posture and having eye contact at all times (Anderson & Arsenault, 1998). Also, as recommended by Mathison (1998), the various interviews took place at different times and dates to increase validity.

The student interviews were video recorded and transcribed. During transcription, each student was identified with respect to gender, stream and grade level.

3.7 Summary of Methodology

The methodology of my research study was discussed in this chapter. Section 3.2 recapitulated the objectives of this study and the research questions. Section 3.3 described the process, identified problems faced in the selection of the sample and provided detailed information about the sample. Section 3.4 discussed the scales used in the study and how the questionnaire was put together. Section 3.5 described how the questionnaire was piloted and the changes made to the original questionnaire based upon feedback obtained during piloting. Finally, Section 3.6 described the methods of data collection and analysis.

The first objective of my research was to validate the instrument that was used to gather data. The total student sample in my study consisted of 1081 students from 55 different classes in 4 different primary schools in Singapore. The instrument included learning environment scales based on the CLES and the WIHIC questionnaires, as well attitude scales based on the TOSRA. Modifications were made to some of the items and minor adjustments were made to the format of the response scales (see Appendix 6 to view the questionnaire about My Science Class).

In order to investigate the validity of the questionnaire, the data gathered were statistically analyzed in terms of factor structure, internal consistency reliability and ability to differentiate between classrooms. The same data collected during the validation of the instruments were used to answer the other research question concerning the gender, grade-level and stream differences in learning environments and attitudes to science.

Finally, the same data were statistically analyzed using simple correlation and multiple regression analyses to determine whether associations exist between students' perceptions of the classroom learning environment and their attitudes towards science. The results of all these analyses are reported in Chapter 4. As a minor component of my study, supplementary qualitative data also were collected via interviews with students. The next chapter reports the results of my study.

Chapter 4

RESULTS AND ANALYSES

4.1 Introduction

The main aims of this research study were to:

- investigate the reliability and validity of a learning environment and attitude questionnaire when used in primary science classrooms in Singapore
- investigate gender, grade-level, and stream differences in learning environment and students' attitudes to science
- investigate relationships between students' attitudes and the learning environment.

Data were gathered from 1081 students from 55 different classes in 4 different schools. The instrument used to assess students' perceptions of their classroom learning environment included scales based on the Constructivist Learning Environment Survey (CLES) and the What Is Happening In this Class? (WIHIC) questionnaire. To assess students' attitudes towards science, two attitude scales were based on the Test Of Science Related Attitudes (TOSRA).

The instrument was first checked for its validity and reliability using the data gathered from the 1081 primary school students. The data were then used to investigate gender, grade-level and stream differences in learning environment and students' attitudes to science, as well as associations between students' attitudes to science and their perceptions of the classroom learning environment. All data collected from the student sample were statistically analysed to answer the research questions of my study, and the results are reported in this chapter under different sections. Section 4.2 reports the the results for the validity and reliability of the learning environment scales based on the CLES and WIHIC and attitude scales based on the TOSRA. Section 4.3 reports gender, grade-level and stream differences in the learning environment and attitudes to science and the interaction effects among gender, grade-level, and stream. Section 4.4 reports associations between students' perceptions of classroom learning environment and attitudes to science.

4.2 Validity and Reliability of Learning Environment and Attitude Scales

To measure students' perceptions of their classroom learning environment, I selected scales from two widely-applicable learning environment questionnaires: the Constructivist Learning Environment Survey (CLES, Taylor, 1994) and the What Is Happening In this Class? (WIHIC, Fraser, Fisher & McRobbie, 1996). To measure students' attitudes towards science, two scales were chosen from the Test Of Science Related Attitudes (TOSRA, Fraser, 1978).

The WIHIC is a combination of modified versions of important scales taken from historically-important learning environment questionnaires. The WIHIC is the most widely-used learning environment questionnaire and it has been widely applied to a variety of contexts, subject areas and grade levels. The original version and/or modified versions of the WIHIC have been used in numerous studies conducted in the United States (Allen & Fraser, 2007; Ogbuehi & Fraser, 2007) and also have been translated into other languages, thus enabling researchers to use either the original English version or modified versions of the questionnaire in their studies in Brunei (Khine, 2002) and Korea (Kim, Fisher & Fraser, 1999). Cross-national studies using the WIHIC have been possible due to the flexible nature of the questionnaire. For instance, the WIHIC has been cross-validated between nations such as England, Canada and Australia (Dorman, 2003), Taiwan and Australia (Aldridge & Fraser, 2000), Canada and Australia (Zandvliet & Fraser, 2004) and Indonesia and Australia (Fraser, Aldridge & Adolphe, 2010). For further information about the development and validation of the WIHIC, refer to Sections 2.3.4 and 3.4.1.

For this study, five of the seven original scales of the WIHIC were chosen: Involvement, Teacher Support, Investigation, Task Orientation and Cooperation. As the Primary Science Syllabus in Singapore aims to provide students with opportunities to develop skills, habits of mind and attitudes necessary for scientific inquiry and prepare students towards using scientific knowledge and methods in making personal decisions (Ministry of Education, 2008b), these scales were applicable to this study.

According to Fraser (1998b), the CLES is useful for assessing the degree to which the science classroom environment is consistent with a constructivist epistemology. This aspect of the CLES was appealing for this study because the primary science curriculum (Ministry of Education, 2008b) seeks to nurture the student as an inquirer and the teacher as the leader of inquiry. For this, a constructivist classroom would be ideal. Another feature of the CLES is that its original version, as well as shortened, translated and/or modified versions, have been found to be valid and reliable when used in small-scale and large-scale studies in different parts of the world such as Australia (Taylor, Fraser & Fisher, 1997), Korea (Kim, Fisher & Fraser, 1999), South Africa (Aldridge, Fraser & Sebela, 2004) and the United States (Nix, Fraser & Ledbetter, 2005; Peiro & Fraser, 2005; Spinner & Fraser, 2005). A cross-national study conducted with secondary-school students involving Taiwan and Australia (Aldridge, Fraser, Taylor & Chen, 2000) also found the CLES to be valid and reliable. Refer to Sections 2.3.3 and 3.4.1 for more information about the development and validation of the CLES.

Three scales (namely, Personal Relevance, Uncertainty, and Student Negotiation) from the CLES's five original scales were chosen for this study. These three scales were relevant to this study because the curriculum branch under MOE encourages teachers to use a variety of strategies to facilitate the inquiry process and engage students in meaningful learning experiences when teaching science.

The Test Of Science Related Attitudes (TOSRA) was originally designed to measure seven distinct attitudes among students in the secondary grades (Fraser, 1978). The original, modified or translated versions of the TOSRA have been used and cross-validated in various learning environment studies conducted around the world at a variety of grade levels and in various subject areas in Australia (Fraser & Butts, 1982; Fraser & Fisher, 1982a; McRobbie & Fraser, 1993), Singapore (Wong & Fraser 1996), the United States (Martin-Dunlop & Fraser, 2008), Korea (Kim, Fisher & Fraser, 1999), Indonesia and Australia (Fraser, Aldridge & Adolphe, 2010) and Brunei (Scott & Fisher, 2004).

In my study, I used only two of the seven original scales of the TOSRA, namely, Attitude to Scientific Inquiry and the Enjoyment of Science Lessons. Items that were negatively phrased and reverse scored were removed and one new item per scale was added so that each scale has 6 positively-worded items. For more information about the development of the attitude scale, refer to Section 3.4.2. These scales were chosen as the Primary Science Syllabus in Singapore aims to provide primary students with experiences which build on their interest and curiosity and to develop students who enjoy and value science (Ministry of Education, 2008a).

For convenience in administering these scales, they were included in a single questionnaire. For more information about the creation of the questionnaire, including the modifications made to the CLES, WIHIC and TOSRA scales, refer to Section 3.4. The final version of the instrument can be viewed in Appendix 6.

Data were collected from 1081 students from 4 different primary schools. The students were from Grades 4, 5 and 6 and from two streams, Gifted Education (GE) and High Ability (HA). The data were used to investigate the reliability and validity of the questionnaire to answer the first research question:

Research Question # 1

Are learning environment scales based on the CLES and WIHIC and attitude scales based on TOSRA valid when used with a sample of primary-school science students in Singapore?

The statistical analyses used to answer Research Question #1 included factor structure (Section 4.2.1) and internal consistency reliability (Section 4.2.2) for the learning environment scales based on the CLES and WIHIC and the attitude scales based on the TOSRA. A one-way ANOVA was also used to determine the ability of each learning environment scale to differentiate between the perceptions of students in the different science classrooms (Section 4.2.3).

4.2.1 Factor Structure of Learning Environment Scales Based on the CLES and WIHIC and Attitude Scales Based on the TOSRA

Principal axis factor analysis with varimax rotation with Kaiser normalisation was conducted for the 70 items in the learning environment and attitude scales based on the CLES, WIHIC and TOSRA in order to check whether removing any of those items would improve the internal consistency reliability and/or factorial validity of the scales. The criteria used to retain an item were that it must have a factor loading of 0.40 or above with its a priori scale and below 0.40 with each of the other scales. There were a total of nine items that did not meet these criteria and therefore were removed. Items 3, 6, 7, 8 and 18 were removed from the WIHIC scales and Items 46, 47, 53 and 54 were removed from the CLES scales. All the items from the Scientific Inquiry and Enjoyment scales from the TOSRA were retained. From the original 70 items, 61 items were kept in the same 10-factor structure: Involvement (IN), Teacher Support (TS), Investigation (IV), Task Orientation (TO), Cooperation (CO), Personal Relevance (PR), Uncertainty ((UN), Student Negotiation (SN), Scientific Inquiry (SI) and Enjoyment (EJ).

Table 4.1: Factor Analysis Results for Learning Environment and Attitude Questionnaire

	Factor Loadings									
Item No	IN	TS	IV	TO	CO	PR	UN	SN	SI	EJ
1	0.62									
2	0.76									
4	0.48									
5	0.49									
9		0.66								
10		0.74								
11		0.73								
12		0.67								
13		0.64								
14		0.69								
15		0.56								
16		0.46								
17			0.58							
19			0.65							
20			0.43							
21			0.69							
22			0.70							
23			0.71							
24			0.57							
25				0.51						
26				0.50						
27				0.45						
28				0.58						
29				0.62						
30				0.58						
31				0.65						
32				0.52						
33					0.64					
34					0.52					
35					0.66					
36					0.64					
37					0.61					
38					0.75					
39					0.69					
40					0.58					
41						0.52				
42						0.48				
43						0.50				
44						0.72				
45						0.61				
48							0.60			
49							0.67			
50							0.61			
51							0.60			
52							0.54			
55								0.61		
56								0.64		
57								0.68		
58								0.64		
59									0.70	
60									0.78	
61									0.79	
62									0.82	
63									0.76	
64									0.75	
65										0.70
66										0.78
67										0.75
68										0.81
69										0.84
70										0.78
% Variance	27.92	5.48	5.22	4.62	3.47	3.24	2.68	2.27	2.05	1.95
Eigenvalue	19.54	3.84	3.65	3.23	2.43	2.27	1.87	1.59	1.43	1.36

N = 1081 students in 55 classes.

Principal axis factoring with varimax rotation and Kaiser normalisation.

Factor loadings less than 0.40 have been omitted from the table.

Items 3, 6, 7, 8, and 18 were removed from the WIHIC scales and Items 46, 47, 53, and 54 were removed from the CLES scales.

For the remaining 61 items, Table 4.1 shows that the a priori structure of the instrument comprising 8 learning environment scales and two attitude scales was confirmed. The factor loadings, percentage of variance, and eigenvalue for the 10 scales are reported in Table 4.1. The refined 61-item version of the questionnaire consisted of 10 scales based on the WIHIC (5 scales with 4−8 items in each), CLES (3 scales with 4−5 items in each) and TOSRA (2 scales with 6 items in each).

The percentage of variance ranged from 1.95% to 27.92% for the 10 different scales, summing to a total of 58.9% (see Table 4.1). The eigenvalues for the 10 different scales range from 1.36 to 19.54. The factor analysis results reported in this section strongly support the factor structure of the refined 61-item questionnaire and attest to the independence of factor scores on the 10 scales consisting of eight learning environment scales based on the WIHIC and CLES and attitude scales based on the TOSRA.

4.2.2 Internal Consistency Reliability of Learning Environment and Attitude Scales

To check whether every item in each of the 10 scales assesses a similar construct, the internal consistency reliability was used. The index of scale internal consistency used was the Cronbach alpha coefficient. Table 4.2 shows the Cronbach alpha coefficient for each of the 10 scales (namely, five scales based on the WIHIC, three scales based on the CLES, and two attitude scales based on the TOSRA) using two units of analysis (individual and class mean). When using the individual student scores as the unit of analysis, the alpha coefficient for the 10 different scales ranged from 0.77 to 0.94. When using the class mean as the unit of analysis, the alpha coefficient for the 10 different scales were higher and ranged from 0.77 to 0.98 (see Table 4.2). The highest alpha reliability was obtained for the Enjoyment scale and the lowest for the scale Uncertainty.

Overall, the results reported in this section suggest that the learning environment scales based on the CLES and WIHIC and the attitude scales based on the TOSRA were reliable when used with this sample of elementary school students in Singapore.

Table 4.2: Average Item Mean, Average Item Standard Deviation, Internal Consistency Reliability (Cronbach Alpha Coefficient) and Ability to Differentiate between Classrooms (ANOVA Results) for Learning Environment and Attitude Scales

Scale	No of Items	Unit of Analysis	Average Item Mean	Average Item SD	Alpha Reliability	Anova Eta²
Learning Environment						
Involvement	4	Individual	3.22	0.79	0.79	0.12*
		Class Mean	3.24	0.27	0.87	
Teacher Support	8	Individual	3.37	0.86	0.89	0.13*
		Class Mean	3.39	0.33	0.94	
Investigation	7	Individual	3.05	0.86	0.88	0.09*
		Class Mean	3.06	0.26	0.91	
Task Orientation	8	Individual	4.05	0.68	0.86	0.13*
		Class Mean	4.05	0.24	0.91	
Cooperation	8	Individual	3.83	0.75	0.90	0.11*
		Class Mean	3.85	0.25	0.93	
Personal Relevance	5	Individual	3.81	0.80	0.84	0.08*
		Class Mean	3.84	0.23	0.89	
Uncertainty	5	Individual	3.71	0.82	0.77	0.06**
		Class Mean	3.72	0.21	0.77	
Student Negotiation	4	Individual	3.26	0.91	0.86	0.09*
		Class Mean	3.28	0.29	0.91	
Attitudes						
Inquiry	6	Individual	3.74	1.02	0.91	
		Class Mean	3.72	0.28	0.93	
Enjoyment	6	Individual	3.62	1.08	0.94	
		Class Mean	3.63	0.49	0.98	

**p*< 0.05, ***p*<0.01

N=1081 in 55 classes

Eta² is the ratio of between to total sums of square and represents the proportion of variance accounted for by class membership

Item means and standard deviations were computed to portray the nature of the science learning environment. The relatively high mean scores for all scales (see Table 4.2) suggest a positive classroom environment, with the mean scores ranging between 3.05 and 4.05. The standard deviation for all the scales was less than 1.08, suggesting that there was limited diversity in students' perceptions. Generally, students perceived a positive science classroom learning environment.

The CLES scales used in my study (namely, Personal Relevance, Uncertainty and Student Negotiation) were also found to have satisfactory internal consistency reliability in past learning environment studies. In one study conducted in California (Ogbuehi & Fraser, 2007), CLES scales were found to be reliable, with alpha reliabilities ranging from 0.71 to 0.84 using the individual as unit of analysis. In addition, scales from the CLES displayed satisfactory internal consistency reliability in other studies conducted with students in Korea (Kim et al., 1999), Australia and Taiwan (Aldridge et al., 2000), South Africa (Aldridge, Fraser & Sebela, 2004) and the United States (Dryden & Fraser, 1996, 1998; Johnson & McClure, 2004; Nix et al., 2005; Peiro & Fraser, 2008).

The WIHIC scales used in my study (namely, Teacher Support, Involvement, Investigation, Task Orientation and Cooperation) were also found to have satisfactory internal consistency reliability in past learning environment studies. In a study in South Florida (Allen & Fraser, 2007), scales of the WIHIC were reliable when used with a group of Grade 4 and 5 students, with alpha reliabilities ranging from 0.67 to 0.86. Other studies in which the WIHIC displayed satisfactory internal consistency reliability were conducted with students in Singapore (Khoo & Fraser, 2008; Chionh & Fraser, 2009), Australia (Dorman, 2008), the United States (Wolf & Fraser, 2008), India (Koul & Fisher, 2005), Australia, Canada and United Kingdom (Dorman, 2003), Australia and Canada (Zandvliet & Fraser, 2004, 2005) and Australia and Indonesia (Fraser, Aldridge & Adolphe, 2010).

Original, modified and/or translated versions of the TOSRA have been found to have satisfactory internal consistency reliability in a variety of research studies conducted in Australia (McRobbie & Fraser, 1993), Brunei (Scott & Fisher, 2004), Singapore (Wong & Fraser, 1996; Wong et al., 1997), Taiwan and Australia (Aldridge, Fraser & Huang, 1999), Indonesia and Australia (Fraser, Aldridge & Adolphe, 2010) and the USA (Martin-Dunlop & Fraser, 2008). Thus, the results of my study replicate those of past research involving the TOSRA.

4.2.3 Ability of the Learning Environment Scales to Differentiate between Classrooms

One-way ANOVA was used to determine the ability of each learning environment scale to differentiate significantly between the perceptions of science students from the different classrooms. For each ANOVA, scores on one of the learning environment scales constituted the dependent variable and class membership was the independent variable. ANOVA results for each of the eight learning environment scales (Involvement, Teacher Support, Investigation, Task Orientation, Cooperation, Personal Relevance, Uncertainty and Student Negotiation) are reported in Table 4.2 for the sample of 1081 students in 55 classes. The eta² statistic, which is a measure of the degree of association between class membership and the dependent variable for each of the learning environment scales, ranged from 0.06 to 0.13 and was statistically significant (p<0.05) for each scale (see Table 4.2). Overall, the ANOVA results provide further evidence that the learning environment scales based on the WIHIC and CLES were valid when used with my sample in Singapore.

My results replicate past research indicating that scales from the CLES and WIHIC are able to differentiate significantly (p<0.05) between students' perceptions in different classrooms in Australia and Taiwan (Aldridge et al., 2000), South Africa (Aldridge et al., 2004), Australia (Dorman, 2008) and the United States (Ogbuehi & Fraser, 2007, Wolf & Fraser, 2008).

4.3 Gender, Grade-level and Stream Differences in Learning Environment and Attitudes to Science

Once the relliability and validity of the instrument were established, the data were then used for the second purpose of my study, which was to investigate gender (male, female), grade-level (Grades 4, 5 and 6) and stream (GE and HA) differences in the learning environment and attitudes to science. The relevant research question is:

Research Question # 2

For primary school science students in Singapore, do students' scores on learning environment and attitude scales vary with:

d) gender (Section 4.3.1)

e) grade level (Section 4.3.2)

f) stream (Section 4.3.3)?

The analyses reported in this section involved differences between the groups (gender, grade level or stream) for the whole sample. A three-way multivariate analysis of variance (MANOVA) was conducted with the learning environment and attitude scales as the dependent variables and with gender, grade-level and stream as the three independent variables. Because the MANOVA produced statistically significant results using Wilks' lambda criterion, the three-way univariate ANOVA (gender, grade level and stream) was interpreted separately for each dependent variable. Results indicated whether there were any statistically significant differences between genders, grade levels and streams on each dependent variable. Table 4.3 provides the three-way ANOVA results for each of the 10 learning environment and attitude scales. The MANOVA and ANOVAs also identified the presence of any stream-by-gender, grade-by-stream, grade-by-gender and stream-by-gender-by-grade interactions for each scale. An overview of Table 4.3 reveals the following statistically significant findings (which are discussed in detail in subsequent sections):

- significant gender differences for Involvement, Teacher Support, Task Orientation and Cooperation (see Section 4.3.1),
- significant grade-level differences for Teacher Support, Task Orientation, Cooperation and Enjoyment (see Section 4.3.2),
- significant stream differences for Involvement, Cooperation and Personal Relevance (see Section 4.3.3),
- significant stream-by-gender interactions for Task Orientation and Enjoyment (see Section 4.3.4),

- significant grade-by-stream interactions for Investigation, Student Negotiation, Scientific Inquiry and Enjoyment (see Section 4.3.5),
- no significant grade-by-gender interaction for any dependent variable (see Section 4.3.6),
- no significant three-way stream-by-gender-by-grade interaction for any dependent variable (see Section 4.3.7).

Table 4.3 shows the *F* values and the eta^2 values of the scales for gender, grade-level and stream differences and their interactions. *F* ratios show the statistical significance of gender, grade-level or stream differences and their interactions for each scale, as discussed in the following sections. Eta^2 indicates the effect size in terms of the proportion of variance in a dependent variable explained by an independent variable.

4.3.1 Gender Differences in Learning Environment and Attitudes to Science

For the sample of 1081 students in 55 classes, there were 665 (61.5%) male students and 416 (38.5%) female students. In this section, analyses for gender differences in learning environment and attitudes to science are reported.

Table 4.4 reports the average item mean, average item standard deviation and difference between male and female students in scores on each environment and attitude scale. The *F* ratios in Table 4.4 show the statistical significance of gender differences for each scale and they are taken from the three-way ANOVA results in Table 4.3.

Table 4.3: Three-way ANOVA Results (F and Eta^2) for Gender, Grade-level and Stream Differences for Learning Environment and Attitude Scales

Scale	Three-way ANOVA Results													
	Gender		Grade		Stream		StreamxGender		GradexStream		GradexGender		StreamxGenderxGrade	
	F	Eta^2	F	Eta^2	F	Eta^2	F	Eta^2	F	Eta^2	F	Eta^2	F	Eta^2
Learning Environment														
Involvement	17.39**	0.02	0.69	0.00	3.05*	0.00	1.78	0.00	1.76	0.00	0.83	0.00	2.45	0.00
Teacher Support	4.36*	0.00	9.06**	0.01	0.01	0.00	2.04	0.00	1.52	0.00	1.81	0.00	1.45	0.00
Investigation	2.36	0.00	0.08	0.00	0.25	0.00	0.03	0.00	3.80*	0.00	2.26	0.00	0.75	0.00
Task Orientation	12.26**	0.01	9.57**	0.02	0.93	0.00	3.56*	0.00	2.85	0.00	0.07	0.00	2.40	0.00
Cooperation	15.29**	0.01	3.59*	0.00	2.95*	0.00	0.18	0.00	0.49	0.00	0.85	0.00	0.01	0.00
Personal Relevance	1.31	0.00	2.47	0.00	7.17**	0.01	2.65	0.00	0.20	0.00	0.31	0.00	2.07	0.00
Uncertainty	0.16	0.00	0.48	0.00	0.10	0.00	2.79	0.00	1.73	0.00	1.12	0.00	2.39	0.00
Student Negotiation	0.03	0.00	2.82	0.00	1.75	0.00	0.35	0.00	4.75**	0.01	1.02	0.00	2.38	0.00
Attitudes														
Inquiry	1.49	0.00	1.48	0.00	0.07	0.00	1.91	0.00	4.09**	0.00	0.46	0.00	0.00	0.00
Enjoyment	1.24	0.00	7.26**	0.01	1.02	0.00	6.15*	0.00	4.69**	0.01	2.40	0.00	2.23	0.00

$*p < 0.05$, $**p < 0.01$

Sample size=1081 students in 55 classes

Eta^2 represents the proportion of variance in a dependent variable explained by an independent variable.

Table 4.4 shows that the *F* ratio was statistically significant ($p<0.05$) for the four learning environment scales of Involvement, Teacher Support, Task Orientation and Cooperation. To allow simple comparison of the average scores on the different scales, the average item mean (scale mean divided by the number of items in that scale) and average item standard deviation for each learning environment and attitude scale are reported in Table 4.4 for male and female students.

Table 4.4: Average Item Mean, Average Item Standard Deviation and Difference between Genders (ANOVA Result and Effect Size) for Each Learning Environment and Attitude Scale

Scale	Average Item Mean		Average Item SD		Difference	
	Male	Female	Male	Female	*F*	Effect Size
Learning Environment						
Involvement	3.31	3.08	0.78	0.80	17.39**	0.29
Teacher Support	3.32	3.44	0.86	0.85	4.36*	-0.14
Investigation	3.08	3.01	0.86	0.87	2.36	0.08
Task Orientation	3.98	4.14	0.70	0.65	12.26**	-0.23
Cooperation	3.75	3.96	0.77	0.71	15.29**	-0.28
Personal Relevance	3.82	3.80	0.81	0.79	1.31	0.02
Uncertainty	3.72	3.71	0.82	0.82	0.16	0.01
Student Negotiation	3.26	3.25	0.93	0.88	0.03	0.01
Attitudes						
Inquiry	3.70	3.79	1.05	0.97	1.49	-0.08
Enjoyment	3.64	3.58	1.11	1.03	1.24	0.05

*$p< 0.05$, **$p<0.01$
Sample size= 665 (males) and 416 (females)

The effect size, which is the difference between the means of the two gender groups divided by the pooled standard deviation, was also calculated for each learning environment and attitude scale (see Table 4.4). According to Cohen (1988), effect sizes range from small (0.10) to medium (0.25) to large (0.40). The effect sizes displayed in Table 4.4 are consistent with the ANOVA results in that the magnitudes of the differences between males and females for the four scales for which gender differences were statistically significant (namely, Involvement, Teacher Support, Task Orientation and Cooperation) were modest (ranging from 0.14 to 0.29 standard deviations). These magnitudes suggest that the differences between the males and females are of modest educational significance.

Figure 4.1 graphically illustrates the differences between male and female students in terms of mean scores on each learning environment and attitude scale. It shows that males had higher means than females for the majority of scales. However, for the four scales that showed a statistically significant difference, females scored higher than males on three of the scales. Figure 4.1 graphically shows that the male students perceived higher levels of Involvement (mean = 3.31) in their classroom environment than their female counterparts (mean = 3.08), but that females perceived higher levels of Teacher Support, Task Orientation and Cooperation than their male counterparts.

Because the presence of interactions can confound the interpretation of main effects, and because there were some statistically significant interactions involving gender (Table 4.3), my discussion of gender results in this section is revisited below in Section 4.3.5.

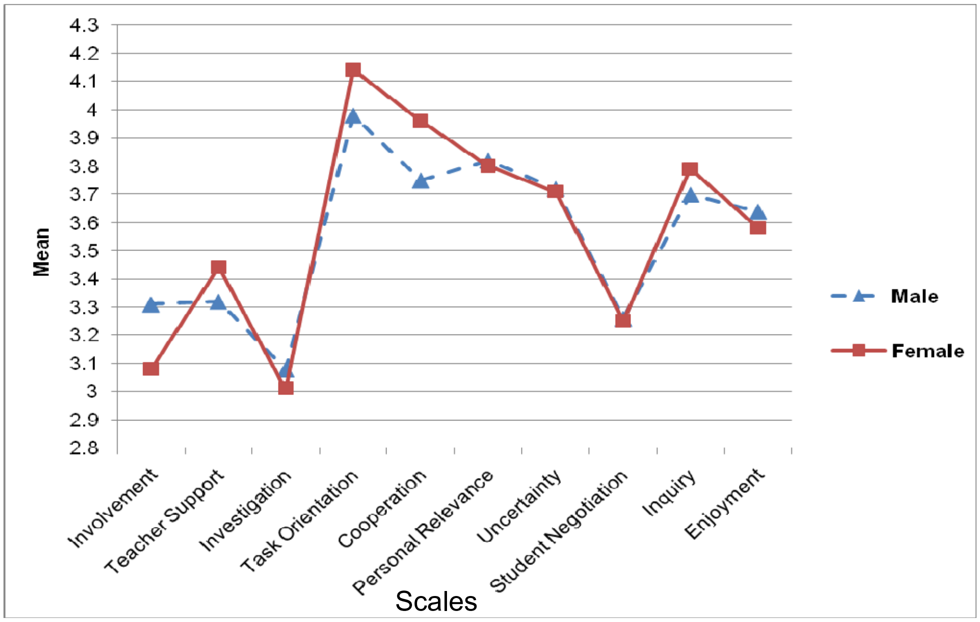

Figure 4.1: Male and Female Students' Mean Scores for Learning Environment and Attitude Scales

4.3.2 Grade-Level Differences in Learning Environment and Attitudes to Science

For the sample of 1081 students taken from 55 classes, there were 394 (36.4%) Grade 4 students, 401 (37.1%) Grade 5 students and 286 (26.5%) Grade 6 students. In this section, grade-level differences in learning environment and attitudes to science are reported.

The ANOVA results reported in Table 4.3 show the statistical significance of grade-level differences. As reported in Table 4.3, grade-level differences were statistically significant ($p<0.05$) for three of the eight learning environment scales (namely, Teacher Support, Task Orientation and Cooperation) and one attitude scale (Enjoyment). The F values from Table 4.3 are reported in Table 4.5, along with the average item mean (scale mean divided by the number of items in that scale) and average item standard deviation for each learning environment and attitude scale for each of the three grade levels. An inspection of means for the scales for which grade-level differences were statistically significant (namely, Teacher Support, Task Orientation, Cooperation and Enjoyment) revealed that Grade 6 students had the highest mean for the three learning environment scales and Grade 4 students had the highest mean for the attitude scale. The eta² values for the three scales for which grade-level differences were statistically significant was only 0.01, suggesting that relatively little variance in scores on these scales was attributable to grade level.

Table 4.5: Average Item Mean, Average Item Standard Deviation and Difference between Grade Levels (ANOVA Result and Effect Size) for Each Learning Environment and Attitude Scale

Scale	Average Item Mean			Average Item SD			Difference	
	Grade			Grade			*F*	Eta²
	4	5	6	4	5	6		
Learning Environment								
Involvement	3.21	3.21	3.26	0.82	0.80	0.76	0.69	0.00
Teacher Support	3.36	3.26	3.54	0.87	0.86	0.81	9.06**	0.01
Investigation	3.03	3.07	3.04	0.85	0.87	0.88	0.08	0.00
Task Orientation	4.09	3.93	4.12	0.69	0.72	0.62	9.57**	0.01
Cooperation	3.80	3.80	3.93	0.79	0.77	0.68	3.59*	0.01
Personal Relevance	3.84	3.77	3.85	0.82	0.82	0.76	2.47	0.00
Uncertainty	3.69	3.70	3.76	0.81	0.82	0.84	0.48	0.00
Student Negotiation	3.28	3.19	3.32	0.95	0.95	0.79	2.82	0.00
Attitudes								
Inquiry	3.78	3.75	3.65	0.99	1.04	1.04	1.48	0.00
Enjoyment	3.75	3.55	3.53	1.06	1.10	1.07	7.26**	0.01

Sample size = 394 (Grade 4), 401 (Grade 5) and 286 (Grade 6)
*p <0.05, **p<0.01

Figure 4.2 graphically demonstrates the differences between Grade 4, 5 and 6 in terms of mean scores on each learning environment and attitude scale. A pattern that is evident is that Grade 6 students had higher scores for Teacher Support (mean = 3.54) and Cooperation (mean = 3.93) than students in either Grade 4 or 5. The lowest score for Teacher Support (mean = 3.26) was for Grade 5 students whereas, for Cooperation, Grade 4 and 5 students had similar scores (mean = 3.80). For Task Orientation, Grade 6 students had the highest score (mean = 4.12) and Grade 5 students had the lowest score (mean = 3.93). For Enjoyment, Grade 4 students had the highest score (mean = 3.75) and Grade 5 and 6 students had lower but similar scores (mean = 3.55 and 3.53) (see Table 4.5 and Figure 4.2).

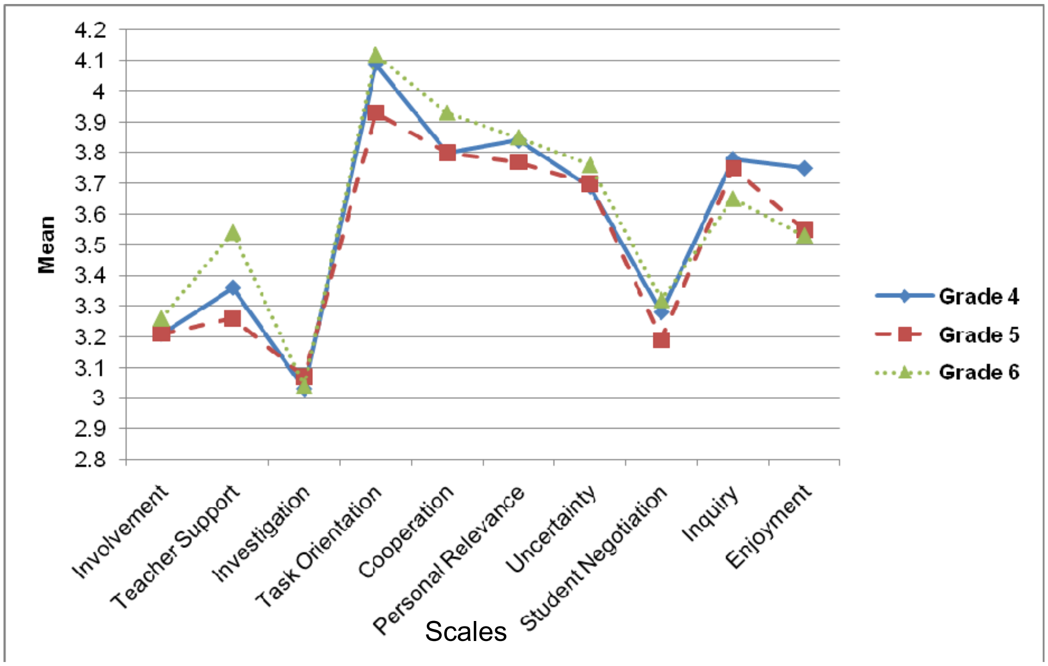

Figure 4.2: Grade 4, 5 and 6 Students' Mean Scores for Learning Environment and Attitude Scales

Because the presence of interactions confounds the interpretation of main effects, and because there were some statistically significant interactions involving grade level (Table 4.3), my discussion of grade-level results in this Section is revisited below in Section 4.3.4.

4.3.3 Stream Differences in Learning Environment and Attitudes to Science

For the sample of 1081 students in 55 classes, there were 569 (52.6%) students in the GE (Gifted Education) stream and 512 (47.4%) students in the HA (High Ability) stream. In this section, stream differences between GE students and HA students in learning environment and attitude scores are reported (see Table 4.6). *F* ratios from three-way ANOVAs (reported previously in Table 4.3 and reproduced in Table 4.6) show that stream differences were statistically significant (p<0.05) for three out of the eight learning environment scales (namely, Involvement, Cooperation and

Personal Relevance). For the attitude scales, there was no statistically significant difference between streams.

Table 4.6: Average Item Mean, Average Item Standard Deviation and Difference between Streams (ANOVA Result and Effect Size) for Each Learning Environment and Attitude Scale

Scale	Average Item Mean		Average Item SD		Difference	
	GE	HA	GE	HA	*F*	Effect Size
Learning Environment						
Involvement	3.28	3.16	0.78	0.81	3.05*	0.15
Teacher Support	3.35	3.39	0.84	0.87	0.01	-0.04
Investigation	3.04	3.06	0.85	0.88	0.25	-0.02
Task Orientation	3.99	4.10	0.68	0.68	0.93	-0.16
Cooperation	3.78	3.90	0.74	0.77	2.95*	-0.15
Personal Relevance	3.75	3.89	0.82	0.78	7.17**	-0.17
Uncertainty	3.70	3.73	0.82	0.82	0.10	-0.03
Student Negotiation	3.29	3.22	0.89	0.94	1.75	0.07
Attitudes						
Inquiry	3.70	3.78	1.05	1.00	0.07	-0.07
Enjoyment	3.56	3.69	1.10	1.06	1.02	-0.12

$^*p < 0.05$, $^{**}p < 0.01$
Sample size= 569 (GE) and 512 (HA)

The effect size, which is the difference between the means of the two groups divided by the pooled standard deviation, for each learning environment and attitude scale was also calculated (see Table 4.6). These effect sizes confirm the ANOVA results in that the magnitudes of the differences between the two streams (GE and HA) for the three environment scales for which differences were statistically significant (namely, Involvement, Cooperation and Personal Relevance) were small and ranged from only 0.15 to 0.17 standard deviations. According to Cohen (1988), effect sizes range from small (0.10) to medium (0.25) to large (0.40). Therefore the effect sizes reported in Table 4.6 suggest a small degree of educational importance for the differences between the GE and HA streams.

To allow simple comparison of the average scores on the different scales, the average item mean (scale mean divided by the number of items in that scale) and average item standard deviation for each learning environment and attitude scale are reported in Table 4.6 for GE and HA students. GE students perceived higher levels of Involvement (mean = 3.28) in their classroom environments than their HA counterparts (mean = 3.16), but HA pupils perceived higher levels of Cooperation and Personal Relevance than their GE counterparts.

Furthermore, Figure 4.3 graphically demonstrates these differences between the two streams in terms of mean scores on each learning environment and attitude scale. A pattern that is evident is that the HA students had higher scores than their GE counterparts for most scales (see Table 4.6 and Figure 4.3).

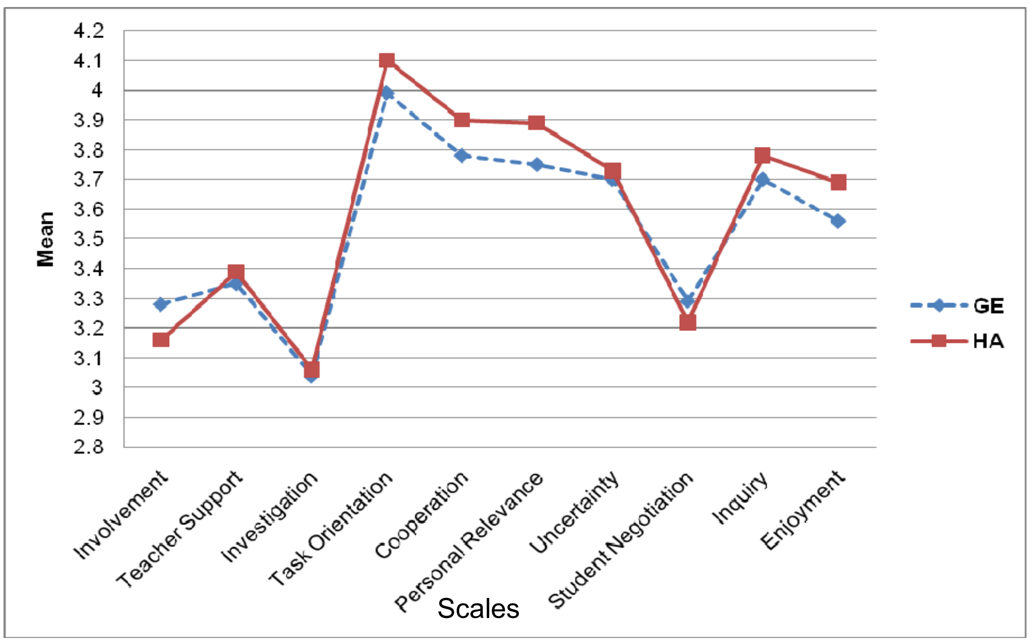

Figure 4.3: GE and HA Students' Mean Scores for Learning Environment and Attitude Scales

Although the magnitudes for between-stream differences are small, Figure 4.3 and Table 4.6 show a consistent pattern in terms of the direction of the differences. It is interesting to note that, of the 10 scales, HA students scored a higher mean than the GE students for 8 scales. Statistically significant stream differences were found between gifted and the high-ability students, with the HA students having higher scores for Cooperation and Personal Relevance.

Because the presence of interactions confounds the interpretation of main effects, and because there were some statistically significant interactions involving stream (Table 4.3), my discussion of stream results in this Section is revisited below in Sections 4.3.4 and 4.3.5.

4.3.4 Stream-by-Gender Interactions for Learning Environment and Attitudes to Science

This section involves examining the interactions between stream and gender for each learning environment and attitude scale. The results of the three-way ANOVAs in Table 4.3 show that the scales for which the stream-by-gender interaction was statistically significant were Task Orientation and Enjoyment. Furthermore, because a significant main effect for gender and stream also occurred for Task Orientation (see Tables 4.3 and 4.4), it is important to revisit the interpretation of the main effects.

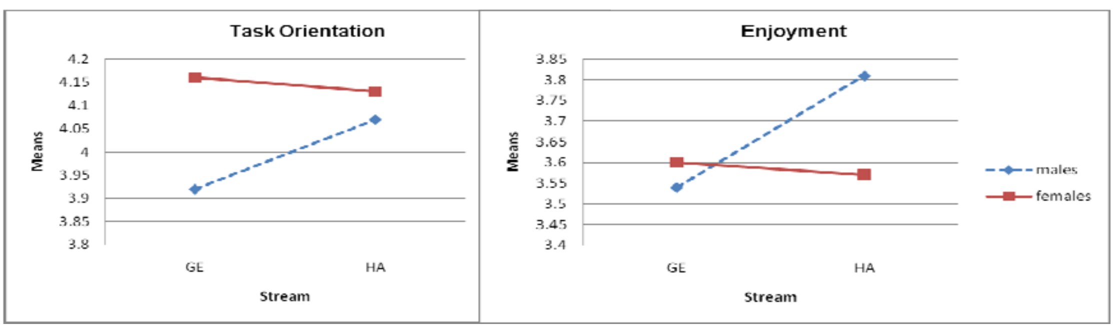

Figure 4.4: Gender-by-Stream Interactions for Learning Environment and Attitude Scales

The interpretation of both the significant gender effect and the significant gender-by-stream interaction for Task Orientation and Enjoyment is illustrated graphically in Figure 4.4. This figure shows the mean Task Orientation scores obtained by four groups, namely, GE males, GE females, HA males and HA females. For male students, Task Orientation scores were higher for the HA students than GE students. Whereas, for female students, Task Orientation scores were higher for GE students than HA students.

Likewise, for male students, Enjoyment scores were higher for HA students than GE students. For female students, the Enjoyment scores for GE students were slightly higher than the HA students.

Figure 4.4 clearly shows that my earlier interpretation of the gender effect (i.e. the females having higher Task Orientation scores than the males) is too simple and now needs to be moderated in the presence of the gender-by-stream interaction. Figure 4.4 shows that the interpretation of this interaction is that females had higher Task Orientation scores than males only in the GE stream, but that gender differences were negligible in the HA stream.

The presence of a significant gender-by-stream interactoin suggests that my previous interpretation of there being no gender diffrerences and no stream differences overall in Enjoyment is oversimplified. Figure 4.4 shows that, although there was a negligible gender difference in Enjoyment in the GE stream, enjoyment in the HA stream was higher for males than females.

4.3.5 Grade-level-by-Stream Interactions for Learning Environment and Attitudes to Science

This section reports interactions between grade-level and stream for each learning environment and attitude scale. The three-way MANOVA/ANOVA identified that the interaction between grade-level and stream (see Table 4.3) was statistically significant for Investigation, Student Negotiation, Attitude to Scientific Inquiry and Enjoyment. In order to interpret these four grade-level-by-stream interactions, the graphs in Figure 4.5 were constructed to depict the six means for the different combinations of grade level (Grades 4, 5 and 6) and stream (GE and HA).

For Grade 4 students, HA scores were lower than GE scores for Investigation, Student Negotiation and Scientific Inquiry. However, for Enjoyment, HA and GE scores were comparable. For Grade 5 students, HA scores were higher than GE scores for all four scales. For Grade 6 students, HA scores were lower than GE scores for the three scales of Student

Negotiation, Scientific Inquiry and Enjoyment. However, HA scores were higher than GE scores for Investigation (as shown in Figure 4.5).

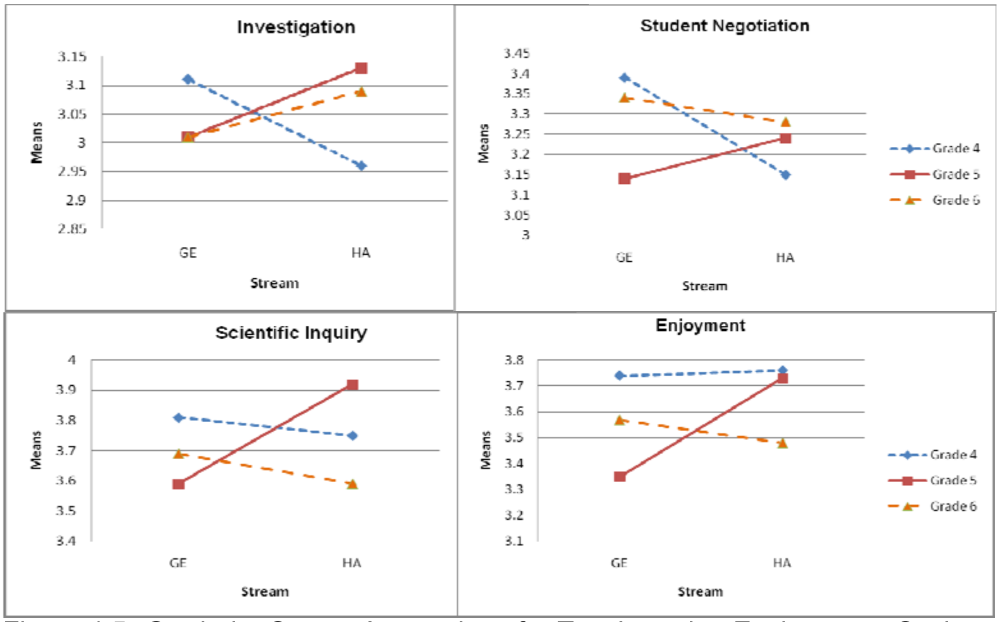

Figure 4.5: Grade-by-Stream Interactions for Two Learning Environment Scales and Two Attitude Scales

Figure 4.5 clearly shows that my earlier interpretation of the grade-level effect (i.e. the Grade 4 students scored highest for Enjoyment and Grade 6 students scored lowest for Enjoyment) is too simple and now needs to be moderated because of the presence of the grade-by-stream interaction. The interpretation of this interaction is that the Grade 4 students had the highest mean for all three grade levels. However, HA students in Grade 5 had higher scores for Enjoyment than HA students in Grade 6, whereas GE students in Grade 5 had lower scores than HA students in Grade 6.

The eta² values (reported in Table 4.3) were only 0.01 for these interactions, suggesting that relatively little variance in the scores on these scales was attributable to stream-by-gender interactions.

4.3.6 Grade-by-Gender Interactions for Learning Environment and Attitudes to Science

The MANOVA and ANOVA results for the interaction between grade-level and gender in Table 4.3 show that this interaction was statistically nonsignificant for every learning environment and attitude scale.

4.3.7 Grade-by-Stream-by-Gender Interactions for Learning Environment and Attitudes to Science

The MANOVA or ANOVA results reported in Table 4.3 for the three-way interaction of stream, gender and grade-level indicate that this interaction was statistically nonsignificant for every learning environment and attitude scale.

4.4 Associations between Learning Environment and Attitudes to Science

The data gathered from 1081 primary school science students who responded to the questionnaire containing scales based on the CLES, WIHIC and TOSRA were statistically analyzed to determine associations between students' perceptions of their classroom learning environment and their attitudes toward science. The relevant research question answered in this section is:

> *Research Question # 3*
>
> *Are there associations between students' attitudes to science and their perceptions of classroom learning environment among a sample of primary-school science students in Singapore?*

To answer this question, associations between the learning environment and student attitude scales were explored using simple correlation and multiple regression analyses and are reported in Table 4.7. The simple correlation (*r*) describes the bivariate association between each of the seven learning environment scales and each attitude outcome. The multiple correlation (*R*) describes the multivariate relationship between an attitudinal outcome and the set of learning environment scales. The standardized regression weight (β) describes the association between a particular learning environment scale and an outcome when all other learning environment scales are mutually controlled.

Table 4.7: Simple Correlation and Multiple Regression Analyses for Associations between Learning Environment Scales and Inquiry and Enjoyment

Scale	Attitude-Environment Associations			
	Inquiry		Enjoyment	
	r	β	*r*	β
Involvement	0.25**	0.00	0.35**	0.07*
Teacher Support	0.23**	-0.04	0.47**	0.20**
Investigation	0.42**	0.31*	0.37**	0.04
Task Orientation	0.33**	0.15*	0.52**	0.29**
Cooperation	0.28**	0.01	0.34**	-0.08**
Personal Relevance	0.29**	0.02	0.49**	0.21**
Understanding	0.23**	0.05	0.31**	0.02
Student Negotiation	0.31**	0.07**	0.33**	0.01
Multiple Correlation *R*		0.47**		0.62**

**p*<0.05, ***p*<0.01
Sample size = 1081 students in 55 classes

The results of the simple correlation analysis in Table 4.7 indicate that all eight learning environment scales were statistically significantly associated with each attitude scale (Attitude to Scientific Inquiry and Enjoyment of Science Lessons). Correlations between Inquiry and the learning environment scales ranged from 0.23 to 0.42 and between Enjoyment and the learning environment scales ranged from 0.31 to 0.52. The results of the simple correlation suggest that more positive student attitudes are associated with more emphasis on the aspects of learning environment assessed in this study.

The multiple correlation (*R*) reported in Table 4.7 for the whole set of eight learning environment scales was 0.47 for Inquiry and 0.62 for Enjoyment and was statistically significant (*p*<0.01) in both cases. This supports the conclusion that the nature of the classroom environment is related to students' attitudes towards science lessons.

To identify which classroom environment scales contributed most to the variance in the two attitude scales, the standardized regression weights (β) were examined. Table 4.7 shows that three learning environment scales were significantly, positively and independently related to Attitude to Scientific Inquiry (namely, Investigation, Task Orientation and Student Negotiation). For the Enjoyment of Science Lessons scale, four learning environment scales were significantly, positively and independently related when all other environment scales were mutually controlled (namely, Involvement, Teacher Support, Task Orientation and Personal Relevance).

All but one of the statistically significant simple correlations and regression coefficients in Table 4.7 were in the positive direction, thus suggesting that a positive classroom environment is linked with better student attitudes towards science. However, for the Cooperation scale, the regression coefficient for Enjoyment was negative, which suggests that more cooperation among the students was associated with less enjoyment. It is interesting to note that, as we move towards a less didactic and more student-centred system in education, we need to be aware of the nature of activities used in the classroom as this result suggests that having activities involving cooperation does not necessarily lead to students enjoying the activity. This is also supported by interview results (reported in Section 4.5) when students said that “they prefer to work on their own” as they do not have to “keep arguing to come to a consensus”. Some students also mentioned that doing group work “is a waste of time” as it takes longer to finish the same task than if it was undertaken individually.

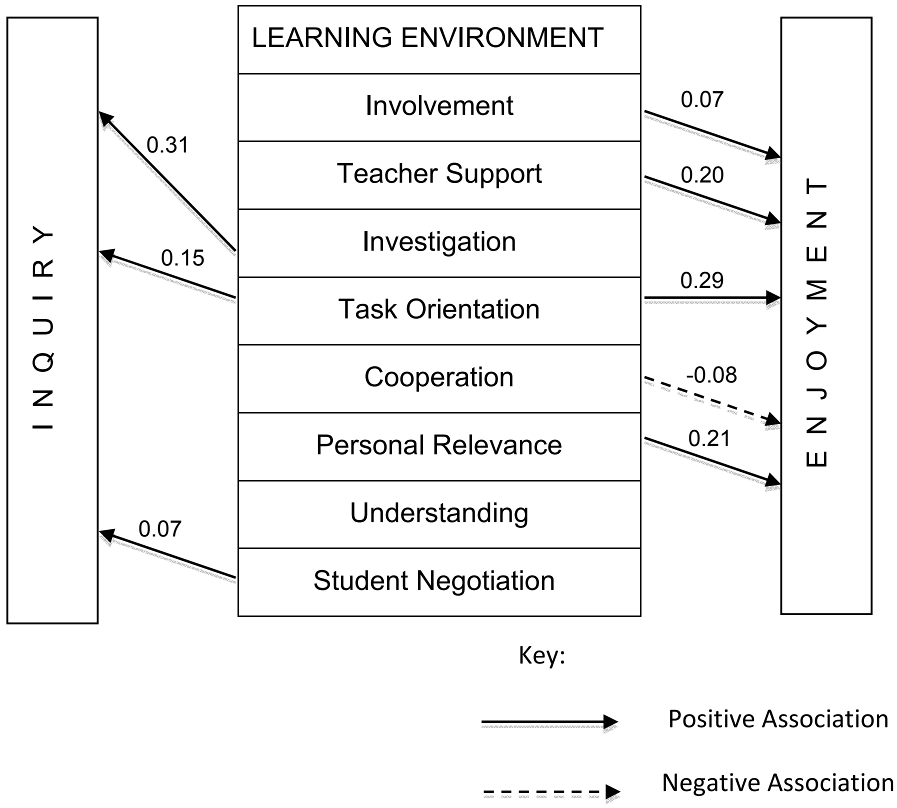

Figure 4.6: Diagrammatic Representation of Statistically Significant Standardised Regression Coefficients for Attitude-Learning Environment Associations

Figure 4.6 diagramatically summarises the statistically significant independent associations between learning environment and attitude scales. Overall, the results reported in this section indicate that statistically significant associations existed between students' attitudes towards science and their perceptions of the classroom learning environment. These findings replicate those in previous learning environment studies, which showed positive and statistically significant relationships between students' perceptions of their classroom learning environment and their attitudes towards science in Singapore (Wong & Fraser, 1996), South Florida (Allen & Fraser, 2007), Korea (Kim, Fisher & Fraser, 1999) and Indonesia and Australia (Fraser, Aldridge & Adolphe, 2010).

4.5 Using Qualitative Interviews to Clarify and Reinforce Survey Findings

Combining quantitative and qualitative methods in one study has many advantages. It allows triangulation of data (Anderson, 1998), an examination of construct validity of learning environmnet/attitude scales, and an in-depth understanding of learning environments from more than one perspective (Fraser, 1999). By including qualitative approaches (interviews) as well in my study, I considered that I could expand the scope, depth and credibility of my study.

One of the various approaches to qualitative research is phenomenological study, which involves various reactions to, or perceptions of, a particular phenomenon. In order to gain insight into the world of the participants and to describe their perceptions, the researcher collects data through in-depth interviewing (Fraenkel & Wallen, 2006). Then, by studying multiple perceptions as experienced by different people, the researcher then tries to determine what is common to the perceptions.

There are some important things to consider when conducting an interview, such as respecting the group being interviewed, being natural, developing appropriate rapport, avoiding leading questions, asking only one question at a time and not interrupting (Fraenkel & Wallen, 2006; Patton, 1990). To ensure that interviewees felt comfortable and at ease, I (the interviewer) listened actively and kept an open and comfortable atmosphere (Anderson & Arsenault, 1998). Also the various interviews took place at different times and on different dates to increase validity (Mathison, 1998). These considerations were taken into account when I conducted my interviews to make sure that the participants shared their perceptions.

To obtain multiple perspectives of science classrooms, I interviewed a group of 24 students from one of the four schools from different streams and grade levels. The interviews was audio-recorded and they were then listened to again and again. Various relevant conversations were transcribed so that they could be used for analysis. The questions asked during the interview were a follow-up to the questionnaire items that students had completed earlier. The interviews were intended to provide insights into what was happening in classrooms during science lessons.

The interview questions were:

1. Do you think that you were involved during your science lessons?
2. Do you get opportunities in class for discussions with your classmates?
3. How often do you work in groups?
4. Is your teacher concerned about you?
5. What is investigation?
6. When are you most/least attentive in your lessons? Explain with examples.
7. Do you prefer to do an experiment or be shown the experiment?
8. Do you work well with your group members?
9. Do you think there is team work in your class?
10. Do you pay attention during science lessons and when?

The type of interview that I conducted in my research was semistructured (Fraenkel & Wallen, 2006). Though I had a set of questions with me which I had planned to ask the students, I allowed students to deviate from the planned set of questions and to talk about their experiences in class, so that I could better understand their learning environment. One question led to other questions depending on what a participant said. This section reports results based on qualitative data collection in an attempt to clarify and reinforce the quantitative findings reported in Section 4.3.1 to 4.3.3.

4.5.1 Using Qualitative Interviews to Clarify and Reinforce Gender Differences

The four scales for which gender differences were statistically significant were Involvement, Teacher Support, Task Orientation and Cooperation (as reported in Section 4.3.1).

Involvement

The scale Involvement measures the extent to which students have attentive interest, participate in discussions, do additional work and enjoy the class. Statistically significant gender differences were found for this scale with females (mean = 3.08) scoring lower than males (mean = 3.31). When interviewed, students (male and female) felt that they were involved in the learning process especially in responding to questions asked by the teacher. The interview responses supported the result that the females scored lower than the males, as reflected in the following comments:

> *Student 1 (female): In my class, there are less females than males. Thus, in a group, usually we have all males and only one female, and they (the boys) talk a lot. So I tend to keep quiet and just get my work done.*
>
> *Student 2 (male): I am frequently able to be involved in my class, as I hear other students' suggestions, think about mine and then share my ideas.*

Student 1's comment reflects the fact that boys tend to be more involved in the classroom because they are boisterous and participate in class activities, and that girls could be less involved because they are quieter when confronted with a greater number of pupils from the other gender. Likewise, the comment from student 2 (comments of a similar nature were obtained from a few other students), shows that the boys tend to be forthcoming in sharing their views and participate in class activities and thus are more involved than the girls, thus supporting the result discussed in Section 4.3.1.

Teacher Support

The scale Teacher Support measures the extent to which the teacher helps, befriends, trusts and shows interest in students. Statistically significant gender differences were found for this scale with males (mean = 3.32) scoring lower than females (mean = 3.44). The students interviewed supported this result. Students of both genders felt that the teacher knew the extent of their learning and assisted when appropriate. They felt that they received adequate support and expressed no concern about approaching their teacher for assistance. They also felt that the teacher was caring and concerned about them. However, only male students provided some comments that support the questionnaire results:

> *Student 3 (male): Mr X is very strict and tends to scold the class frequently.*
>
> *Student 4 (male): My science teacher is always rushing for time to complete the syllabus and not concerned about what we want to say.*

This could have occurred because males were more vocal than females and were ready to mention the problems that they faced. This supported the quantitative results in which males scored lower than the females for Teacher Support.

Task Orientation

The scale Task Orientation measures the extent to which it is important to complete activities planned and to stay on the subject matter. Statistically significant gender differences were found for this scale with males (mean = 3.98) scoring lower than females (mean = 4.14). The students interviewed (both males and females) felt that they were well focused and did not noticeably stray from the material that they were studying. However, there were differences in the responses of the males and the females, and these support the quantitative findings.

Student 5 (female): I will take the textbook and nature study book and have them ready before the teacher enters the class.

Student 6 (male): I will wait for the teacher, to see what she wants, before I take everything out and clutter my table.

Student 7 (male): If I am engrossed in my earlier lessons activity, I will just continue until the teacher comes in and asks us to clear the table.

The above comments illustrate how girls were more focused on the task and how boys tended to be less focused and distracted easily. This supports the quantitative results in which males scored lower than the females for Task Orientation.

Cooperation

Cooperation measures the extent to which students cooperate rather than compete with one another. Statistically significant gender differences were found for this scale with males (mean = 3.75) scoring lower than females (mean = 3.96). In general, the students (both genders) interviewed reported that the class was a coherent unit and that they supported each other in the learning process. However, some comments from the students supported a gender difference for this scale.

Student 8 (female student): We girls don't like to work with boys. As the teacher only lets us work in our class groups, we just focus on the work to be done and get it done.

Student 9 (female student): I cooperate well. We just go by what the majority says and get the task done.

Student 10 (male student): In our groups, when we have different ideas, we tend to argue.

Student 11 (male student): If I get a person I don't like in the group, then the task becomes difficult.

The above quotes suggest that girls, who are task oriented, cooperate on the task at hand to complete the task. However, male students tend to end up arguing and thus cooperate less than the females. This supports the quantitative results that males scored lower than females for Cooperation.

4.5.2 Using Qualitative Interviews to Clarify and Reinforce Grade-level Differences

When comparing different grade levels, the scales that showed a statistically significant difference were Teacher Support, Task Orientation, Cooperation and Enjoyment, as shown earlier in Section 4.3.2. In understanding these grade-level differences, it is important to recall the nature of the primary science curriculum and the way in which the education system is run in Singapore. Science is only taught as a formal subject from Grade 3 and, as it is the first year of studying science, very simple topics such as Materials and Living and Non-living things are introduced. In Grade 4, more interesting topics such as Light and Heat are introduced. Likewise, for GE students, Grade 4 is their first year in the GE programme. This could possibly be the reason for a higher score for Enjoyment for Grade 4 students.

In considering this grade-level difference, it is important to note is that Grade 6 is the final year of primary school education and the teacher is focused on preparing students for the Primary School Leaving Examination (PSLE) at the end of the year. Because the education system in Singapore is examimation-driven, Grade 6 students are very concerned about their results because they determine their entry into a secondary school in the following year. This could possibly be one reason for Grade 6 students scoring a higher mean for Teacher Support and Task Orientation and Cooperation.

Teacher Support

Grade 6 students scored the highest for this scale (mean = 3.54), followed by Grade 4. Grade 5 students scored the lowest for this scale. The students interviewed (from all three grades) felt that the teacher knew the extent of their learning and assisted them when appropriate. They felt that they received adequate support and expressed no concern about approaching their teacher for assistance.

However, from the interview, it was apparent that Grade 6 students approached teachers either during class or after class because they were concerned about the end-of-year examinations. This is reinforced by the responses of Grade 6 students during the interview:

> *Student 9 (Grade 6): My teacher is always willing to answer my questions and will explain to us in detail.*
>
> *Student 10 (Grade 6): I will approach the teacher either during class or after when in doubt about something. My teacher takes time to explain patiently to me, if I am not sure.*

Grade 6 students could possibly interpret the guidance provided by the teacher as greater teacher support. In contrast, some Grade 4 and 5 students mentioned that the teacher is always "rushing for time to complete the syllabus" and this could have been perceived by the students as less Teacher Support, thus supporting the quantitative results.

Task Orientation

In this scale, Grade 6 students scored the highest (mean = 4.12) when compared with Grade 4 and 5. The students (from all three grades) interviewed felt that they were well focused and did not considerably stray from the material that they were studying. One interesting point to note is that it is a common practice in Semester 2 in most schools in Singapore for students in Grade 6 to be 'drilled' with practice papers for the PSLE. As some Grade 6 students mentioned during the interview that they have "less group work" as "we are always doing practice papers", this supports the results that the Grade 6 students are more task oriented as they have to complete their practice papers and also because they are more concerned about their perfomance in the PSLE.

Students in Grade 4 and 5 mentioned that they do "group work for most of the practical sessions" and this creates a chance for some students to be less focused when they have a “dominant person in their team who always is ready to do the work and answer”. This supports the quantitative results.

Cooperation

For this scale, Grade 6 students scored highest (mean = 3.93) when compared with Grade 4 and 5. In general, the students interviewed reported that the class was a coherent unit and that they supported each other in the learning process. However, some comments from the students reinforce why there was a grade-level difference for this scale.

> *Student 9 (Grade 6): I cooperate well. We just go by what the majority says and get the task done. The important thing is to complete the task.*
>
> *Student 10 (Grade 4): In our groups, when we have different ideas, we tend to argue. We are still getting to know our classmates.*
>
> *Student 14 (Grade 6): What is important is that the task must be completed. So, if we have group work, we just make sure it is done.*

Grade 6 students cooperate with their group members as they are task oriented, are more mature and realise that they need to cooperate to complete the task. Their focus is to complete the task so that they can score well in the final examinations. This supports the quantitative findings reported earlier in Section 4.3.2.

Enjoyment

This scale measures the extent to which students enjoy the science lesson. For this scale, Grade 4 students scored the highest (mean = 3.75), followed by Grade 5 (mean = 3.55) and Grade 6 (mean = 3.53). As mentioned earlier, in the Singapore education system, students are exposed to science only in Grade 3 and they start learning more interesting topics where they do hands-on-activities in Grade 4. Thus, it is not surprising to find Grade 4 students scoring more highly. Likewise, Grade 4 is the first year of the GE curriculum, and these students are exposed to various enriching activities in the enriched curriculum. As this is perceived by the students as a novelty, greater enjoyment and a higher mean for the Enjoyment scale could be created.

In an interview, a Grade 6 student said:

> *We are just completing paper after paper, and I just take note of everything that the teacher says (even if I dont understand). Then I go home and learn.*

The extreme focus on the-end-of-the-year examination could be a possible reason why Grade 6 students had the lowest mean for Enjoyment.

4.5.3 Using Qualitative Interviews to Clarify and Reinforce Stream Differences

Stream differences were statistically significant for Involvement, Cooperation and Personal Relevance as reported previously in Section 4.3.3. HA stream students had higher scores on all scales except Involvement and Student Negotiation. Personally, this result is surprising to me (as a teacher teaching both the GE and HA) as I feel that most teachers spend time in preparation for their GE classes as the content is enriched and also there are more hands-on activities. However, the statistically significant difference between the streams could mean that teachers teaching HA students have learnt various strategies for teaching and are making an effort to use them in their lessons and are thus doing more for the HA students. Another interpretation of the result could be that some teachers of GE students use the same strategies for teaching students in both streams. One interpretation could be that GE students are hard to please. This result suggests that the schools that have the GE programme need to look into the curriculum and how the teachers implement it. This needs to be taken into account when redesigning the curriculum and the learning environment of the GE students.

Involvement

GE stream students scored the highest for this scale (mean = 3.28). In general, all students (both streams) felt that they were involved during their lessons. Interview responses support the results, as shown by the following comments:

> *Student 1 (GE student): In a GE class, the boys are always talking a lot.*
>
> *Student 2 (HA student): For almost every topic, we have group work for at least one activity.*
>
> *Student 3 (GE student): For each topic, we have two or three activities that require group work.*

Student 1's comment reflects the fact that boys tend to be more involved than girls (GE classes have less girls) because they are boisterous. Likewise, the comments from students 2 and 3 suggest a greater level of group work in GE relative to HA. Thus GE students have a greater chance of being more involved.

When asked, 'When are you most/least attentive?', most students during the interview said:

> *Student 4: When I am doing activity or experiment, I am most attentive.*
>
> *Student 5: When doing group work, I am most attentive.*
>
> *Student 6: I am least attentive if the teacher talks for very long.*

The above comments suggest that students are involved when doing group work and, as the earlier comment shows, GE classes have more activity for each topic. Thus, this supports that GE students' scores for involvement are higher than for HA students. This sheds light on the extent of involvement of GE and HA student in a primary science classroom.

Cooperation and Personal Relevance

HA students scored higher for Cooperation and Personal Relevance than GE students. As I mentioned earlier, when looking at the curriculum planned for the GE, this result is surprising. According to Silverman (1993), the gifted learn rapidly, have a long attention span only if they are interested, have strong curiosity and are avid readers. Thus it could be that gifted students tend to be more difficult to please.

When asked "if they are ready to start the lesson", the HA students said:

> *Student 1: I will take the textbook and nature study book and keep them ready before the teacher enters the class.*

This was a common reply among the HA students. Likewise, although some of GE students gave the same reply, some students said:

> *Student 2: Because we do not have any specific textbook, I will wait for the teacher to see what she wants before I take everything out and clutter my table.*
>
> *Student 3: I will wait for her to tell us what exactly she wants before I take everything out of my bag.*

Some students even said:

> *Student 4: If I am engrossed in my earlier lessons activity, I will just continue until the teacher comes in and ask us to clear the table.*

This supports the result that HA students scored more highly for Involvement than their GE counterparts. As GE students are engrossed in various activities in all their subjects, they tend to be more distracted if the earlier activity engrosses them more.

Silverman (1993) also states that the GE students tend to question authority. Thus, even within a group for which no authority exists, students try to exert authority and thus find it more difficult to cooperate. Likewise, GE students are concerned with justice and fairness, they reason well and they are perfectionists (Silverman, 1993). Therefore, they tend to find it more difficult to cooperate in a class filled with similar people. This supports the result that HA students scores for Cooperation were higher than scores for GE students.

All inverviewed students mentioned that science is relevant to daily life. Comments from the interviews did not reveal any reason for HA students scoring more highly than GE students for Personal Relevance.

4.6 Summary of Analyses and Results

This chapter reported analyses and results for the three research questions in this study: the validity and reliability of learning environment scales based on the CLES and WIHIC and attitude scales based on the TOSRA; gender, grade-level and stream differences in learning environment and attitudes to science; and relationships between attitudes and the learning environment among primary-school students learning science in Singapore.

Scales chosen from the Contructivist Learning Environment Survey (CLES) and the What Is Happening In this Class? (WIHIC) questionnaires, as well as two scales chosen from the Test Of Science Related Attitudes (TOSRA), were modified and validated. Scores for the refined and validated scales then were used for answering Research Questions 2 and 3. Data from the sample of 1081 students from four primary schools in Singapore were statistically analysed to answer these research questions.

First, to determine the validity and reliability of the learning environment and attitude scales, the data were statistically analysed to determine factor structure, internal consistency reliability, and ability of the learning environment scales to differentiate between classrooms.

To examine the internal structure of the 70 items of the learning environment and attitude scales, the data collected from 1081 students were subjected to principal axis factoring with varimax rotation and Kaiser normalisation. Factor analysis allowed checking of whether removing any items would improve the factorial validity of the instrument. An item was retained if it had a factor loading of 0.40 or above with its a priori scale and below 0.40 with each of the other scales. This led to the removal of 9 items, with 61 items being retained in the same 10-factor structure.

The percentage of variance ranged from 1.95% to 27.92% for the 10 different scales, summing to a total of 58.9% (see Table 4.1). The eigenvalues for the 10 different scales range from 1.36 to 19.54. This strongly supported the factor structure of the refined 61-item questionnaire and attested to the independence of factor scores on the 10 scales consisting of eight learning environment scales based on the WIHIC and CLES and attitude scales based on the TOSRA.

Next, to check whether every item in each scale assesses a similar construct, the internal consistency reliability was estimated using Cronbach's alpha coefficient. When using individual student scores as the unit of analysis, the alpha coefficient for the 10 different scales ranged from 0.77 to 0.94. When using the class mean as the unit of analysis, the alpha coefficient for the 10 different scales were higher and ranged from 0.77 to 0.98. The highest alpha reliability was obtained for the Enjoyment scale and the lowest for the scale Uncertainty. Also results suggested that the learning environment scales based on the CLES and WIHIC were capable of differentiating significantly between different classes in Singapore.

The next step involved investigating gender (male, female), grade-level (Grade 4, 5 and 6) and stream (GE and HA) differences in learning environment and attitude scores, as well as the interactions between gender, grade-level and stream. A three-way multivariate analysis of variance (MANOVA) was conducted with the learning environment and attitude scales as the dependent variables and with gender, grade-level and stream as the independent variables. Because the MANOVA produced satistically significant results using Wilks' lambda criterion, the three-way univariate ANOVA was interpreted seperately for each main effect (gender, grade-level and stream) and each interaction.

The scales for which there were statistically significant gender differences were Teacher Support, Involvement, Task Orientation and Cooperation. The effect sizes for these four scales were modest and ranged from 0.14 to 0.29 standard deviations. When comparing means, male students perceived higher levels of Involvement (mean = 3.31) in their classroom environment than their female counterparts (mean = 3.08). Likewise females perceived higher levels of Teacher Support, Task Orientation and Cooperation than their male counterparts.

The scales for which there were statistically significant grade-level differences were Teacher Support, Task Orientation, Cooperation and Enjoyment. Comparing means showed that Grade 6 students had the highest mean for learning environment scales and Grade 4 students had the highest mean for the attitude scales.

The scales for which there were statistically significant stream differences were Involvement, Cooperation and Personal Relevance. The effect sizes were small, ranging from 0.12 to 0.17 standard deviations, for these scales. When comparing the means, the GE students perceived higher levels of Involvement (mean =3.28) in their classroom environment than their HA counterparts (mean=3.16). However, HA students perceived higher levels of Cooperation and Personal Relevance than their GE counterparts. Figure 4.7 diagrammatically represents the scales for which there were statistically significant differences for gender, grade level and stream.

Next, this chapter reported analyses for various interactions between gender, grade level and stream. In terms of interactions between stream and gender for each learning environment and attitude scale, the results of the three-way ANOVAs showed that the scales for which the stream-by-gender interaction was statistically significant were Task Orientation and Enjoyment. The interpretation of stream-by-gender interaction is that females had higher Task Orientation scores than males only in the GE stream, but that gender differences were negligible in the HA stream. For the Enjoyment scale, although there was a negligible gender difference in Enjoyment in the GE stream, enjoyment in the HA stream was higher for males than females.

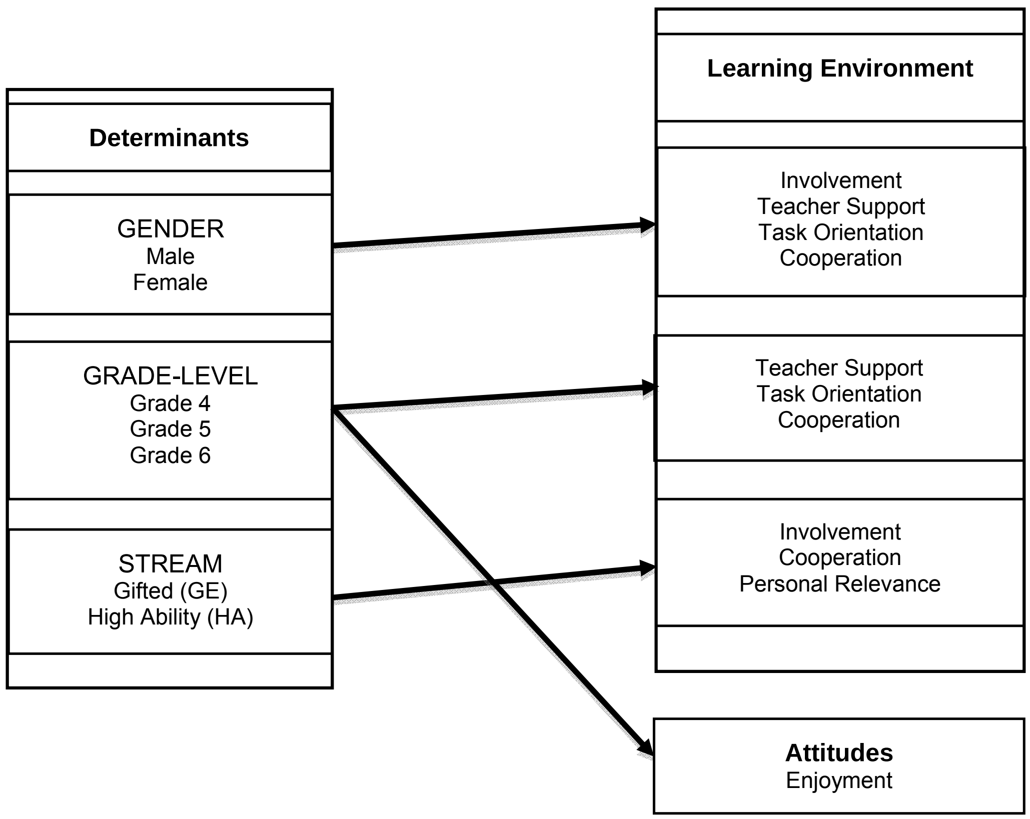

Figure 4.7: Diagrammatic Representation of Scales for which there were Statistically Significant Differences for Gender, Grade-level and Stream Differences

The scales for which the grade-level-by-stream interaction was statistically significant were Investigation, Student Negotiation, Attitude to Scientific Inquiry and Enjoyment. For Grade 4 students, HA scores were lower than GE scores for Investigation, Student Negotiation and Scientific Inquiry. However, for Enjoyment, HA and GE scores were comparable. For Grade 5 students, HA scores were higher than GE scores for all four scales. For Grade 6 students, HA scores were lower than GE scores for the three scales of

Student Negotiation, Scientific Inquiry and Enjoyment. However, HA scores were higher than GE scores for Investigation. The interpretation of this interaction is that Grade 4 students had the highest mean for all three grade levels. However, HA students in Grade 5 had higher scores for Enjoyment than HA students in Grade 6, whereas GE students in Grade 5 had lower scores than HA students in Grade 6.

The MANOVA and ANOVA results for the two-way interaction between grade level and gender and for the three-way interaction between stream, gender and grade-level show that these interactions were statistically nonsignificant for every learning environment and attitude scale.

To answer research question 3, data collected were statistically analysed to determine associations between students' perceptions of their classroom learning environment and their attitudes toward science. Associations between the perceptions of the learning environment scales and each student attitude scales were explored using simple correlation and multiple regression analyses. The results of the simple correlation analysis indicate that all eight learning environmentscales were statistically significantly associated with the attitudes towards science (Scientific Inquiry and Enjoyment). Correlations between Inquiry and learning environment scales ranged from 0.23 to 0.42 and between Enjoyment and the learning environment scales ranged from 0.31 to 0.52. The results of the simple correlation suggested that improved student attitudes are associated with more emphasis on the aspects of learning environment assessed in this study.

The multiple correlation (R) for the whole set of eight learning environment scales was 0.47 for Inquiry and 0.62 for Enjoyment and was statistically significant in both cases, thus supporting the conclusion that the nature of the classroom environment is related to students' attitudes towards science lessons.

Next, to identify which classroom environment scales contributed most to the variance in the two attitude scales, standardised regression weights (β) were examined. Three learning environment scales were significantly, positively and independently related to the Inquiry scale (namely, Investigation, Task Orientation and Student Negotiation). For the Enjoyment scale, four learning environment scales (namely, Involvement, Teacher Support, Task Orientation and Personal Relevance) were significantly, positively and independently related when all other environment scales were mutually controlled. All but one of the statistically significant simple correlations and regression coefficients were in the positive direction, thus suggesting that a positive classroom environment is linked with better student attitudes towards science. However, for the Cooperation scale, the regression coefficient for Enjoyment was negative, which suggests that more cooperation among the students was associated with less enjoyment. It is interesting to note that more cooperation among students was associated with less enjoyment, even though we are moving to a less didactic education system involving more group work and cooperative strategies. Overall, the results reported suggest that statistically significant associations existed between students' attitudes towards science and their perceptions of the classroom learning environment.

Finally, this chapter reported the use of qualitative data from interviews with 24 students to clarify and reinforce gender, grade-level and stream differences. The evidence from the interviews supported the results from the quantitative data as shown in section 4.5. The interviews clarified and reinforced gender differences found for Involvement, Teacher Support, Task Orientation and Cooperation. They also helped to reinforce grade-level differences found for Teacher Support, Task Orientation, Cooperation and Enjoyment. However, for stream differences, the interviews were able to clarify and reinforce differences found for Involvement and Cooperation, but not for Personal Relevance.

Chapter 5
CONCLUSION

5.1 Introduction

In this chapter, I present conclusions and implications from my research. I also discuss the limitations of both the study and the methods used. Finally, I propose future research directions that are suggested by this study and its findings.

The various sections in this chapter are:

- Overview of the study (Section 5.2);
- Research results and discussion (Section 5.3);
- Constraints and limitations of the study (Section 5.4);
- Contributions of the study (Section 5.5);
- Suggestions for future research (Section 5.6); and
- Conclusions (Section 5.7).

5.2 Overview of the Study

The main aims of this research study were to:

- investigate the reliability and validity of a learning environment and attitude questionnaire when used in primary science classrooms in Singapore
- investigate gender, grade-level and stream differences in learning environment and attitudes to science
- investigate relationships between attitudes and the learning environment.

Data were gathered from 1081 students from 55 different classes in four different schools. The sample included Gifted Education (GE) students and High Ability (HA) students from the four schools. The instrument used to assess students' perceptions of their classroom learning environment included scales based on the Constructivist Learning Environment Survey (CLES) and the What Is Happening In this Class? (WIHIC) questionnaires. To assess students' attitudes towards science, two attitude scales were based on the Test Of Science-Related Attitudes (TOSRA).

The instrument was first checked for its validity and reliability using the data gathered from the 1081 primary school students, before data were used to investigate gender, grade-level and stream differences in learning environment and attitudes to science and associations between students' attitudes to science and their perceptions of the classroom learning environment. Gender, grade-level and stream differences in the learning environment and attitudes to science, as well as the interaction effects among gender, grade-level and stream, were also studied. Finally, associations between students' perceptions of classroom learning environment and attitudes to science were investigated.

My study is the first in the Singapore context that focused on GE and HA students in the primary school setting and on investigating gender, grade-level and stream differences in learning environment and attitudes to science within the one study.

This thesis consists of five chapters. Chapter 1 outlined the background and significance of this study, its purposes and its research questions. Chapter 2 comprehensively reviewed literature in areas related to this study. First, the literature review provided insights into the historical background of the field of learning environments. Then it reviewed literature about the development, history and validation of various instruments for measuring learning environments. In particular, it focused on two instruments, the CLES and WIHIC, as scales for my study were chosen from these instruments. Chapter 2 also gave an overview of past learning environment studies in Singapore and studies that focused on gender, grade-level and stream differences. Finally, it gave a comprehensive overview of literature devoted to the assessment of students' attitudes.

Chapter 3 described research methods, techniques and instruments used in this study, as well as its design, samples and methods of data analysis. This chapter gave details of the total sample of 1081 students, in addition to the numbers from each school and subgroup (grade, gender and stream). It also gave details of the scales chosen for my study from the learning environment instruments (CLES and WIHIC) and the scales from TOSRA to measure attitudes to science. This chapter further discussed how the questionnaire was put together and piloted before it was used in the main study. The collection and analysis of quantitative and qualitative data were also described:

- Principal axis factor analysis followed by varimax rotation and Kaiser normalisation was conducted for the 70 items in the learning environment and attitude scales based on the CLES, WIHIC and TOSRA in order to check whether removing any of those items would improve the factorial validity of the scales.
- To check whether every item in each learning environment and attitude scales assesses a similar construct, the internal consistency reliability was calculated. The Cronbach alpha coefficient was calculated at two units of analysis (individual and class mean) as the index of scale of internal consistency.
- One-way ANOVA was used to determine the ability of each learning environment scale to differentiate significantly between the perceptions of the students from the different classrooms.
- To investigate gender, grade-level and stream differences in learning environment and attitudes to science, a three-way multivariate analysis of variance (MANOVA) was conducted. The three-way univariate ANOVA was interpreted seperately for each main effect (gender, grade level and stream) and each interaction.
- To investigate associations between students' perceptions of their classroom learning environment and their attitudes towards science, simple correlation and multiple regression analyses were performed at two units of analysis (individual and class mean).

Chapter 4 presented the results of this study, pertinent to the validation of the instruments that were used to assess students' perceptions of their learning environments and attitudes towards science. It also presented results for gender, grade-level and stream differences, as well as stream-by-gender, grade-by-stream, grade-by-gender and stream-by-gender-by-grade interactions for each learning environment and attitude scale. In Chapter 4, I also reported associations between students' perceptions of their classroom learning environments and their attitudes towards science. Section 5.3 presents a summary and discussion of the research results.

This concluding chapter summarises and discusses this study, proposes further research, and draws conclusions based on the results. It also discusses the limitations and significance of this study.

5.3 Research Results and Discussion

This section presents a summary and discussion of research results. The first research question that this study answered was:

> *Research Question # 1*
> *Are learning environment scales based on the CLES and WIHIC and attitude scales based on TOSRA valid when used with a sample of primary-school science students in Singapore?*

To answer the first research question concerning the reliability and validity of the questionnaire in primary science classrooms in Singapore various analyses were conducted for the sample of 1081 students. Principal axis factor analysis followed by varimax rotation and Kaiser normalization was conducted for the 70 items in the learning environment and attitude scales and the criteria used to retain an item were that it must have a factor loading of 0.40 or above with its a priori scale and below 0.40 with each of the other scales. There were a total of nine items that did not meet the criteria and therefore were removed. From the original 70 items, 61 items were kept in the same 10-factor structure.

As the remaining 61 items each had a factor loading of at least 0.40 on its a priori scale and lower than 0.40 on all of the other scales, the 61-item version of the questionnaire containing learning environment scales based on the WIHIC (5 scales with 4−8 items in each) and the CLES (3 scales with 4−5 items in each) and attitude scales based on the TOSRA (2 scales with 6 items each) was accepted.

The percentage of variance ranged from 1.95% to 27.92% for the 10 different scales, summing to a total of 58.9%. The eigenvalues for the 10 different scales range from 1.36 to 19.54. The factor analysis results supported the factor structure of the 61-item questionnaire and attested to the independence of factor scores on the eight learning environment and two attitude scales.

To check whether every item in each scale assesses a similar construct, the internal consistency reliability was used. When using the individual student scores as the unit of analysis, the alpha coefficient for the 10 different scales ranged from 0.77 to 0.94. When using the class mean as the unit of analysis, the alpha coefficient for the 10 different scales were higher and ranged from 0.77 to 0.98. The highest alpha reliability was obtained for the Enjoyment scale and the lowest for the scale Uncertainty.

Overall, the results reported suggest that the learning environment scales based on the CLES and WIHIC and the attitude scales based on the TOSRA were reliable when used with this sample of elementary school students in Singapore.

Item means and standard deviations were computed to portray the nature of the science learning environment. The very high mean scores for all scales suggest a very positive classroom environment, with the mean scores ranging between 3.05 and 4.05. The standard deviation for all the scales was less than 1.08, suggesting that there was limited diversity in students' perceptions. Generally, students perceived a positive science classroom learning environment.

One-way ANOVA was used to determine the ability of each learning environment scale to differentiate significantly between the perceptions of science students from the different classrooms. The eta^2 statistic, which is a measure of the degree of association between class membership and the dependent variable for each of the learning environment scales, ranged from 0.06 to 0.13 for the sample and was statistically significant ($p<0.05$) for each scale. Overall, the ANOVA results provide further evidence that the learning environment scales based on the WIHIC and CLES were valid when used with my sample in Singapore.

The second research question that this study answered was:

Research Question # 2

For primary school science students in Singapore, do students' scores on learning environment and attitude scales vary with:

- *a) gender*
- *b) grade level*
- *c) stream.*

A three-way multivariate analysis of variance (MANOVA) was conducted with the learning environment and attitude scales as the dependent variables and with gender, grade-level and stream as the three independent variables. Because the MANOVA produced statistically significant results using Wilks' lambda criterion, the three-way univariate ANOVA was interpreted separately for each main effect (gender, grade level and stream) and each interaction. Results indicated whether there were any statistically significant differences between genders, grade levels and stream on each dependent variable. The MANOVA and ANOVAs also identified the presence of any stream-by-gender, grade-by-stream, grade-by-gender and stream-by-gender-by-grade interactions for each scale. The statistically significant findings were:

- significant gender differences for Involvement, Teacher Support, Task Orientation and Cooperation
- significant grade-level differences for Teacher Support, Task Orientation, Cooperation and Enjoyment
- significant stream differences for Involvement, Cooperation and Personal Relevance
- significant stream-by-gender interactions for Task Orientation and Enjoyment
- significant grade-by-stream interactions for Investigation, Student Negotiation, Scientific Inquiry and Enjoyment
- no significant grade-by-gender interaction for any dependent variable
- no significant three-way stream-by-gender-by-grade interaction for any dependent variable.

For the sample of 1081 students in 55 classes, there were 665 (61.5%) male students and 416 (38.5%) female students. The *F* ratio was statistically significant for the four learning environment scales of Involvement, Teacher Support, Task Orientation and Cooperation. The effect sizes were consistent with the ANOVA results in that the magnitudes of the differences between males and females for the four scales for which gender differences were statistically significant were modest (ranging from 0.14 to 0.29 standard deviations) and therefore of modest educational significance.

For the four scales that showed a statistically significant difference, females scored higher than males on three of the scales. Male students perceived higher levels of Involvement than their female counterparts, but females perceived higher levels of Teacher Support, Task Orientation and Cooperation than their male counterparts.

For the sample of 1081 students from 55 classes, there were 394 (36.4%) Grade 4 students, 401 (37.1%) Grade 5 students and 286 (26.5%) Grade 6 students. Grade-level differences were statistically significant for three of the eight learning environment scales (namely, Teacher Support, Task

Orientation and Cooperation) and one attitude scale (Enjoyment). For the scales for which there was a statistically significant difference, Grade 6 students had the highest mean for the three learning environment scales and Grade 4 students had the highest mean for the Enjoyment scale. The eta^2 values for the three scales for which grade-level differences were statistically significant was 0.01, showing that relatively little variance in scores on these scales was attributable to grade level.

Grade 6 students had higher scores for Teacher Support (mean = 3.54) and Cooperation (mean = 3.93). The lowest scores for Teacher Support (mean = 3.26) were for Grade 5 students whereas, for Cooperation, Grade 4 and 5 students had similar scores (mean = 3.80). For Task Orientation, Grade 6 students had the highest scores (mean = 4.12) and Grade 5 students had the lowest scores (mean = 3.93). For Enjoyment, Grade 4 students had the highest scores (mean = 3.75) and Grade 5 and 6 students had lower but similar scores (mean = 3.55 and 3.53).

For the sample of 1081 students in 55 classes, there were 569 (52.6%) students in the GE (Gifted Education) stream and 512 (47.4%) students in the HA (High Ability) stream. *F* ratios from three-way ANOVAs showed that stream differences were statistically significant for three out of the eight learning environment scales (namely, Involvement, Cooperation and Personal Relevance). For the attitude scales, there were no statistically significant differences between streams. The effect sizes for the three environment scales for which differences were statistically significant were small and ranged from 0.15 to 0.17 standard deviations, suggesting a small degree of educational importance for the differences between the GE and HA streams.

GE students perceived higher levels of Involvement (mean = 3.28) in their classroom environments than their HA counterparts (mean = 3.16), but HA students perceived higher levels of Cooperation and Personal Relevance than their GE counterparts. In fact, HA students had higher scores than their GE counterparts for 8 of the 10 scales.

The scales for which the stream-by-gender interaction was statistically significant were Task Orientation and Enjoyment. The interpretation of this interaction is that females had higher Task Orientation scores than males only in the GE stream, but that gender differences were negligible in the HA stream.

The interpretation of the significant gender-by-stream interaction for Enjoyment is that, although there was a negligible gender difference in Enjoyment in the GE stream, enjoyment in the HA stream was higher for males than females.

The scales for which grade-level-by-stream interaction was statistically significant were for Investigation, Student Negotiation, Attitude to Scientific Inquiry and Enjoyment. For Grade 4 students, HA scores were lower than GE scores for Investigation, Student Negotiation and Scientific Inquiry. However, for Enjoyment, HA and GE scores were comparable. For Grade 5 students, HA scores were higher than GE scores for all four scales. For Grade 6 students, HA scores were lower than GE scores for the three scales of Student Negotiation, Scientific Inquiry and Enjoyment. However, HA scores were higher than GE scores for Investigation. The Grade 4 students had the highest mean for all three grade levels. However, HA students in Grade 5 had higher scores for Enjoyment than HA students in Grade 6, whereas GE students in Grade 5 had lower scores than HA students in Grade 6. The eta^2 values was 0.01, showing that relatively little variance in the scores on these scales was attributable to the stream-by-gender interactions.

The MANOVA and ANOVA results showed that both the interaction between grade level and gender and the three-way interaction of stream, gender and grade level were statistically nonsignificant for every learning environment and attitude scale.

The third research question that this study answered was:

> *Research Question # 3*
>
> *Are there associations between students' attitudes to science and their perceptions of classroom learning environment among a sample of primary-school science students in Singapore?*

To answer this question, associations between the learning environment and student attitude scales were explored using simple correlation and multiple regression analyses. The results of the simple correlation analysis indicate that all eight learning environment scales were statistically significantly associated with each attitude scale (Scientific Inquiry and Enjoyment). Correlations between Inquiry and the learning environment scales ranged from 0.23 to 0.42 and between Enjoyment and the learning environment scales ranged from 0.31 to 0.52. The results of the simple correlation analysis suggest that improved student attitudes were associated with more emphasis on the aspects of learning environment assessed in this study.

The multiple correlation for the whole set of eight learning environment scales was 0.47 for Inquiry and 0.62 for Enjoyment and was statistically significant in both cases. This supports the conclusion that the nature of the classroom environment is related to students' attitudes towards science lessons.

To identify which classroom environment scales contributed most to the variance in the two attitude scales, standardised regression weights were examined. Three learning environment scales were significantly, positively and independently related to the Inquiry scale (namely, Investigation, Task Orientation and Student Negotiation). For the Enjoyment scale, four learning environment scales were significantly, positively and independently related when all other environment scales were mutually controlled (namely, Involvement, Teacher Support, Task Orientation and Personal Relevance).

All but one of the statistically significant simple correlations and regression coefficients were in the positive direction, thus suggesting that a positive classroom environment is linked with better student attitudes towards science. However, for the Cooperation scale, the regression coefficient for Enjoyment was negative, which suggests that more cooperation among the students was associated with less enjoyment. This result is interesting as we move towards a less didactic and more student-centred system in education. We need to be aware of the nature of activities used in the classroom as this result suggests that having activities involving cooperation does not necessarily mean the students will enjoy the activity. This is also supported by interview results (reported in Section 4.5) when students said that "they prefer to work on their own" as they do not have to "keep arguing to come to a consensus". Some students also mentioned that doing group work "is a waste of time" as it takes longer to finish the same task than if it was done individually. Clearly, there is a need for futher research to see if this pattern is replicated.

Overall, the results reported indicate that statistically significant associations existed between students' attitudes towards science and their perceptions of the classroom learning environment.

5.4 Constraints and Limitations of the Study

In interpreting the findings from the present study, several factors should be considered:

1. Because the sample came from coeducational schools, we do not know about the responses from single-sex schools. Therefore, it is not clear whether the findings from the present study can be generalised more widely beyond the coeducational schools involved.
2. There are differences between the GE and HA curricula and also between how the curriculum was implemented in the different schools which might have led to HA students scoring more highly for most scales than GE students.

3. The timing of the administration of the questionnaire was potentially a problem. As the questionnaire was administered at the end of the year after the examinations, students might have had a clearer memory of science lessons just before the examinations when the teacher would have been rushing for curriculum time to revise and would have had less hands-on activities. This could have affected the way in which students answered the questionnaire and thus the mean scores obtained for some scales such as cooperation and involvement.
4. Because of logistical and confidentiality issues, I could not collect or obtain information about variables that could influence some of the conclusions. For example, information about school achievement, the school environment, the quality of science laboratories and various teaching methods used was not collected and taken into account in the study.
5. Collection of qualitative data was difficult because the students who were chosen for the focus-group discussion were hesitant to give frank feedback about their science classes, especially concerning what they did not like about the teacher, as students are often more reserved in Asian classrooms.
6. Because the researcher was a full-time GEP science teacher teaching in one of the GEP schools, it was difficult to take time off to collect more qualitative data, such as classroom observations or interviews to provide more comprehensive and richer qualitative data.
7. Because the data were collected at the end of the school year, it was not possible to include some qualitative data-collection methods, such as classroom observations, that could have provided valuable data as in other learning environment studies.

5.5 Contributions of the Study

The present research was distinctive in that it is the first such study that investigated into the classroom learning environments of GE and HA students in primary science classrooms in Singapore. There has been number of previous studies of classroom environment in Singapore (Chionh & Fraser, 2009; Fraser & Teh, 1994; Goh & Fraser 1996; Khoo & Fraser, 2008; Quek, Wong & Fraser, 2005a, 2005b; Wong & Fraser, 1996), but these studies did not involve investigation of GE and HA students in primary science classrooms and none of them compared all three effects (gender, grade-level and stream differences) in one study. Another important contribution of the study was to validate and make available to researchers and teachers a widely-applicable questionnaire for assessing classroom environment and student attitudes to science.

This study has its practical application in that the questionnaire that has been validated is quite versatile and likely to prove useful to researchers and teachers in Singapore for a wide variety of applications in a wide variety of contexts. Secondly, the relatively strong, consistent and positive associations found between science attitudes and classroom environment once again reminds educators of how student attitudes to science can be enhanced by creating positive classroom learning environments. Thirdly, the finding that the regression coefficient for Enjoyment was negative for the Cooperation scale suggests that more cooperation among the students was associated with less enjoyment. Apparently having activities involving cooperation does not necessarily mean the students will enjoy them.

5.6 Suggestions for Future Research

This study suggests avenues for future research studies involving learning environment and attitudes of students. Because the questionnaire that was validated in this study is versatile and economical, it could be used in future research in Singapore to measure the learning environment of other disciplines besides science. Now that the questionnaire can be used with confidence in primary science classrooms in Singapore, the range of its potential future applications includes various academic subjects at different grade levels.

For this study, only students' perceptions of classroom environment were measured. In future research, it might be illuminating to compare actual and ideal perceptions of the classroom learning environment. By comparing the actual and preferred perceptions of students, it might be possible to assess how close actual perceptions are to preferred perceptions for male and female students at different grade level and in different streams. Similar studies have been carried out in other classroom environments. Dorman (2008a) compared the actual and preferred forms of WIHIC for a sample of 978 secondary school students from Australia. Large difference was found between the actual and preferred form for Cooperation scale. Another study conducted by MacLeod and Fraser (2010) involved using the WIHIC with a sample of 763 college students in 82 classes in Dubai.

For this study, only students' perceptions of classroom environment in mixed-gender schools were measured. In future research, it could be illuminating to compare single-sex (either all males or all females) schools with mixed-sex schools in terms of students' perceptions of classroom learning environment. By comparing the two types of schools, it might be possible to identify differences between these schools and also if the curriculum needs to structured differently for the students in these schools. Researchers in other countries have carried out studies comparing other types of schools. Fraser and Lee (2009) investigated the learning environment of senior high-school science laboratory classrooms in Korea for a sample of 439 students (99 science-independent stream students, 195 science-oriented stream students and 145 humanities stream students).

Future studies could also involve assessments of teachers' perceptions of the learning environment, which was not considered in my study. By considering both teachers' and students' perceptions, future research could be able to provide revealing patterns of differences between teachers' and students' perceptions of the learning environments of the same classrooms. For example, a study by Fisher and Fraser (1983a, 1983b) used the ICEQ with a sample of 116 classes for comparing student actual and preferred scores and a subsample of 56 teachers of these classes for contrasting teachers' and students' scores.

Further evaluation studies could be conducted in Singapore to monitor changes in the learning environment when new educational programmes are implemented in classrooms. Use of the questionnaire validated in my study would enable educators and researchers to evaluate these programmes in terms of students' perceptions of the learning environment. Other researchers have carried out similar studies. Fraser and Teh (1994) evaluated a computer-assisted learning program among geography students at the secondary-school level in Singapore. In Florida, Spinner and Fraser (2005) evaluated the effectiveness of the Class Banking System (CBS), an innovative mathematics program, with a sample of Grade 5 students. Mink and Fraser (2005) conducted a one-year study of 120 fifth grade students whose teachers participated in a program entitled Project SMILE (Science and Mathematics Integrated with Literary Experiences).

It would be desirable to conduct a future study with strong administration support, so that it would be easier to obtain data from numerous schools, which would result in a larger sample size. This would decrease the stress and uncertainity that the researcher has to go through in collecting data. This greater sample size would thus make analyses more statistically powerful and the results more representative and dependable.

The learning environment questionnaire validated in my study could be used in teacher action research aimed at improving classroom learning environments. A study was conducted in mathematics classrooms of South African teachers, with the CLES being used to assess learners' perceptions of the emphasis on constructivism in the classroom environment (Aldridge, Fraser & Sebela, 2004) with 1864 mathematics students in 43 grades 4–9 classes. Teachers reflected on feedback from the questionnaire, modified their teaching practices, and maintained daily journals as a way of reflecting on their teaching. Re-administration of the CLES revealed sizeable improvements in teachers' emphasis on all CLES dimensions in their classrooms.

Future research could involve investigating the dimensions associated with group work because, in this study, students clearly indicated a preference for solo study. Such future research could help to furnish possible explanations concerning students' preferred method of group work.

Finally, future research should incorporate qualitative methods that go beyond the interviews used in this study to include techniques such as classroom observations as suggested by Tobin and Fraser (1998). A combination of quantitative and qualitative methods could enable more meaningful conclusions reached as the qualitative methods could be used to reinforce the quantitative questionnaire responses, to explain and elaborate relationships found with the quantitative information, and to furnish possible explanations for gender, grade-level or stream differences and their interactions. Examples of studies that highlight the benefits of combining qualitative and quantitative methods in learning environment research include research on exemplary science teachers (Fraser & Tobin, 1989), a study of higher-level learning (Tobin, Kahle & Fraser, 1990), and an interpretative study of a teacher-researcher teaching science in a challenging school setting (Fraser, 1999).

5.7 Conclusions

It is hoped that the present study will make an important contribution to the flourishing field of learning environment research. The research findings of this study should complement those of some other studies in Singapore (Chionh & Fraser, 2009; Goh, 2005; Goh, Young & Fraser, 1995; Khoo & Fraser, 2008; Teh & Fraser, 1995a, 1995b). By combining the research findings of various studies, hopefully, it will be possible to get a more accurate picture of the state of learning environments in Singapore. This would help to reinforce the educational initiatives that have been established in our educational system.

Our educational system is constantly providing various professional development opportunities and changes within this classroom. However, I feel that no programme is complete without evaluation of its effectiveness. I feel that we should constantly be assessing our learning environment to see if the programmes that we implement have an effect on the students' learning environment.

Last, but not least, I hope that the present study could be used by science teachers in Singapore to guide improvements in their classroom environments in order to enhance their students' attitude to science.

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APPENDICES

Appendix 1

XXXXXXXX 9 September 2009

Principal

YYYYYY Primary School

Singapore

Dear XXXXXXX,

Reg : Permission to conduct survey amongst students of primary 4,5 ad 6 (GE and HA) in your school

I am a Senior Teacher teaching in ___________ School and am currently working on my doctoral dissertation at Curtin University in Australia, in the area of the learning environment and students' attitude towards science. As part of my data collection I will be conducting a survey amongst students of primary 4, 5 and 6 studying in GE and HA (high ability). In this regard I wish to seek your permission to conduct this survey in your school. I have sought and received approval from Ministry of Education, Singapore, to conduct this study.

I have designed a questionnaire to measure students' perceptions towards their learning environment and their attitude. I require the questionnaire to be completed by all your GE and HA classes from primary 4, 5 and 6. I am planning to give out these questionnaires to the pupils after their end-of-year examinations. I can discuss with you/ your staff regarding the exact date that would be suitable for your school. Thank you in advance for your consideration of my project. I would appreciate if you could email your permission to abdul_khader_jarina_begum@moe.edu.sg . If you have further queries, please contact me at 96787042.

Thanking you.

Yours sincerely,

Jarina Peer

Senior Teacher

Appendix 2

Curtin
University of Technology

Curtin University of Technology
Science and Mathematics Education Centre
Information Sheet for Teacher

My name is Mrs Jarina Peer. I am currently completing a piece of research for my Doctor of Philosophy at Curtin University of Technology.

Purpose of Research

I am investigating the classroom learning environment and student attitude towards science in primary science classrooms.

Your Role and Your Pupil's Role

I will ask your pupil to complete a questionnaire. The approximate amount of time that it will take him/her to answer the questionnaire is 35 to 40 minutes and it will be given to them after the end-of-year examinations.

I will need you to give out and collect the Consent Form from student and parent prior to giving out the questionnaire. On the day stipulated by your school, I need you to distribute and collect the questionnaire and also ensure that the student is able to complete the questionnaire uninterruptedly.

Confidentiality

The information collected will be kept separate from your or your pupil's personal details, and only myself and my supervisor will have access to this. The questionnaire will be kept in a locked cabinet for at least five years, before a decision is made as to whether it should be destroyed.

Further Information

This research has been reviewed and given approval by Ministry of Education, Singapore and Curtin University of Technology Human Research Ethics Committee (Approval Number XXXXXX). If you would like further information about the study, please feel free to contact me on 96787042 or by email abdul_khader_jarina_begum@moe.edu.sg.

Thank you very much for your involvement in this research.

Your participation and your pupil's participation is greatly appreciated.

Appendix 3

Curtin University of Technology
Science and Mathematics Education Centre
Information Sheet for Student

My name is Mrs Jarina Peer. I am currently completing a piece of research for my Doctor of Philosophy at Curtin University of Technology.

Purpose of Research

I am investigating the classroom learning environment and student attitude towards science in primary science classrooms.

Your Role

I am interested in finding out students perceptions to their learning environment and their attitudes towards science. I will ask you complete a questionnaire. The approximate amount of time that it will take to answer the questionnaire is 35 to 40 minutes and it will be given to you after your end-of-year examinations.

Consent to Participate

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. When you have signed the consent form, I will assume that you have agreed to participate and allow me to use your data in this research.

Confidentiality

The information you provide will be kept separate from your personal details, and only myself and my supervisor will have access to this. The questionnaire will be kept in a locked cabinet for at least five years, before a decision is made as to whether it should be destroyed.

Further Information

This research has been reviewed and given approval by Ministry of Education, Singapore and Curtin University of Technology Human Research Ethics Committee (Approval Number XXXXXX). If you would like further information about the study, please feel free to contact me on 96787042 or by email abdul_khader_jarina_begum@moe.edu.sg. Alternatively, you can contact my supervisor Prof Barry Fraser by email address b.Fraser@curtin.edu.au .

Thank you very much for your involvement in this research.

Your participation is greatly appreciated.

CONSENT FORM

• I understand the purpose and procedures of the study.

• I have been provided with the information sheet for student.

• 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 in any published materials.

• I understand that all information will be securely stored for at least 5 years before a decision is made as to whether it should be destroyed.

• I have been given the opportunity to ask questions about this research.

• I agree to participate in the study outlined to me.

Name: ____

School : ____

Class: ___________________________

Signature: ____

Date: ______________________

Appendix 4

Curtin University of Technology
Science and Mathematics Education Centre
Information Sheet for Parent

My name is Mrs Jarina Peer. I am currently completing a piece of research for my Doctor of Philosophy at Curtin University of Technology.

Purpose of Research

I am investigating the classroom learning environment and student attitude towards science in primary science classrooms.

Your Child's Role

I will ask your child to complete a questionnaire. The approximate amount of time that it will take for him/her to answer the questionnaire is 35 to 40 minutes and it will be given to them after their end-of-year examinations.

Consent to Your Child's Participation

Your child's involvement in the research is entirely voluntary. Your child has the right to withdraw at any stage without it affecting his/her rights. When you have signed the consent form I will assume that you have agreed to allow your child to participate and allow me to use the data in this research.

Confidentiality

The information your child will provide will be kept separate from his/her personal details, and only myself and my supervisor will have access to this. The questionnaire will be kept in a locked cabinet for at least five years, before a decision is made as to whether it should be destroyed.

Further Information

This research has been reviewed and given approval by Ministry of Education, Singapore and Curtin University of Technology Human Research Ethics Committee (Approval Number XXXXXX). If you would like further information about the study, please feel free to contact me on 96787042 or by email abdul_khader_jarina_begum@moe.edu.sg. Alternatively, you can contact my supervisor Prof Barry Fraser by email address b.Fraser@curtin.edu.au .

Thank you very much for allowing your child to participate in this research.

Curtin
University of Technology

CONSENT FORM

• I understand the purpose and procedures of the study.

• I have been provided with the information sheet for Parent.

• I understand that the procedure itself may not benefit my child.

• I understand that my child's involvement is voluntary and he/she can withdraw at any time without problem.

• I understand that no personal identifying information like my child's name and address will be used in any published materials.

• I understand that all information will be securely stored for at least 5 years before a decision is made as to whether it should be destroyed.

• I have been given the opportunity to ask questions about this research.

• I agree to allow my child to participate in the study outlined to me.

I allow my child to participate in the study.

Student's Name: ____

School : ____

Class: ____________________________

Parent's Signature: ____

Date: _______________________

Appendix 5

Curtin University of Technology
Science and Mathematics Education Centre
Participant Information Sheet

My name is Mrs Jarina Peer. I am currently completing a piece of research for my Doctor of Philosophy at Curtin University of Technology.

Purpose of Research
I am investigating the classroom learning environment and student attitude towards science in primary science classrooms.

Your Role
I am interested in finding out students perceptions to their learning environment and their attitudes towards science.
I will ask you complete a questionnaire.
The interview process will take approximately 20 minutes.

Consent to Participate
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. When you have signed the consent form I will assume that you have agreed to participate and allow me to use your data in this research.

Confidentiality
The information you provide will be kept separate from your personal details, and only myself and my supervisor will have access to this. The interview transcript will not have your name or any other identifying information on it and in adherence to university policy, the interview tapes and transcribed information will be kept in a locked cabinet for at least five years, before a decision is made as to whether it should be destroyed.

Further Information
This research has been reviewed and given approval by Curtin University of Technology Human Research Ethics Committee (Approval Number XXXXXX). If you would like further information about the study, please feel free to contact me on 96787042 or by email abdul_khader_jarina_begum@moe.edu.sg. Alternatively, you can contact my supervisor Prof Barry Fraser by email address b.fraser@curtin.edu.au..

Thank you very much for your involvement in this research.

Your participation is greatly appreciated.

CONSENT FORM

• I understand the purpose and procedures of the study.

• I have been provided with the participation 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 in any published materials.

• I understand that all information will be securely stored for at least 5 years before a decision is made as to whether it should be destroyed.

• I have been given the opportunity to ask questions about this research.

• I agree to participate in the study outlined to me.

Name: ____

School : ____

Class: __________________________

Signature: ____

Date: _____________________

Appendix 6

My Science Class Questionnaire

In this questionnaire, Items 1–40 are based on the What Is Happening In this Class? (WIHIC, Aldridge, Fraser & Huang, 1999), Items 41–58 are based on the Constructivist Learning Environment Survey (CLES, Taylor, Fraser & Fisher, 1997, and Items 59–70 are based on the Test of Science Related Attitudes (TOSRA, Fraser, 1981). These questionnaire items were used in my study and are included in this thesis with the authors' permission.

Directions for Students:

This questionnaire contains statements about your science class. Think about how well each statement describes what this class is like for you and circle either a 1, 2, 3, 4 or 5. Choose 1 for statements that applies almost never to a 5 for statements that applies almost always.

Please answer all questions. If you change your mind about an answer, please cancel and circle the right response.

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:

	In My science Class…	Almost Never	Seldom	Sometimes	Often	Almost Always
Eg:	I choose my partners for group discussion.	1	2	3	4	5

Suppose you were given the statement: "I choose my partners for group discussion."

You would need to decide whether you choose your partners "Almost Never", "Seldom", "Sometimes", "Often", or "Almost Always".

If you selected "Often" then you would circle number 4 on the right hand side.

Eg:	I choose my partners for group discussion.	1	2	3	4	5

Please fill in the particulars below:

Class: ________________________ Register no: _______________

Age: _________________________ Sex: M/F

School: ____

Do you think you want to do a job related to Science when you grow up? Yes/ No

When you grow up what type of job would you like to do when you grow up? ______________________

There are no 'right' or 'wrong' answers. Your opinion is what is wanted. Your response will be confidential. Please answer all questions.

Thank you for your cooperation.

Go to next page …

	In My science Class…	Almost Never	Seldom	Sometimes	Often	Almost Always
1	I discuss ideas in class.	1	2	3	4	5
2	I give my opinions during class discussions.	1	2	3	4	5
3	The teacher asks me questions.	1	2	3	4	5
4	My ideas and suggestions are used during classroom discussions.	1	2	3	4	5
5	I ask the teacher questions.	1	2	3	4	5
6	I explain my ideas to other students.	1	2	3	4	5
7	Students discuss with me how to go about solving problems.	1	2	3	4	5
8	I am asked to explain how I solve problems.	1	2	3	4	5
9	My teacher is interested in my well-being/ welfare.	1	2	3	4	5
10	The teacher makes an extra effort to help me.	1	2	3	4	5
11	The teacher considers my feelings.	1	2	3	4	5
12	The teacher helps me when I have trouble with the work.	1	2	3	4	5
13	The teacher talks with me.	1	2	3	4	5
14	The teacher is interested in my problems.	1	2	3	4	5
15	The teacher moves about the class to talk with me.	1	2	3	4	5
16	The teacher’s questions help me to understand.	1	2	3	4	5
17	I carry out investigations to test my ideas.	1	2	3	4	5
18	I am asked to think about the evidence for statements.	1	2	3	4	5
19	I carry out investigations to answer questions coming from discussions.	1	2	3	4	5
20	I explain the meaning of statements, diagrams and graphs.	1	2	3	4	5
21	I carry out investigations to answer questions that puzzle me.	1	2	3	4	5
22	I carry out investigations to answer the teacher’s questions.	1	2	3	4	5
23	I find out answers to questions by doing investigations.	1	2	3	4	5
24	I solve problems by using information obtained from my own investigations.	1	2	3	4	5
25	Getting a certain amount of work done is important to me.	1	2	3	4	5
26	I do what I plan to do.	1	2	3	4	5

Go to next page …

	In My science Class…	Almost Never	Seldom	Sometimes	Often	Almost Always
27	I know the goals for this class.	1	2	3	4	5
28	I am ready to start this class on time.	1	2	3	4	5
29	I know what I am trying to accomplish in this class.	1	2	3	4	5
30	I pay attention during this class.	1	2	3	4	5
31	I try to understand the work in this class.	1	2	3	4	5
32	I know how much work I have to do.	1	2	3	4	5
33	I cooperate with other students when doing assignment work.	1	2	3	4	5
34	I share my books and resources with other students when doing assignments.	1	2	3	4	5
35	When I work in groups in this class, there is teamwork.	1	2	3	4	5
36	I work with other students on projects in this class.	1	2	3	4	5
37	I learn from other students in this class.	1	2	3	4	5
38	I work with other students in this class.	1	2	3	4	5
39	I cooperate with other students on class activities.	1	2	3	4	5
40	Students work with me to achieve class goals.	1	2	3	4	5
41	I learn about the world outside of school.	1	2	3	4	5
42	My new learning starts with problems about the world outside of school.	1	2	3	4	5
43	I learn how science can be part of my out-of-school life.	1	2	3	4	5
44	I get a better understanding of the world outside of school.	1	2	3	4	5
45	I learn interesting things about the world outside of school.	1	2	3	4	5
46	What I learn in this class has nothing to do with what I do outside school.	1	2	3	4	5
47	I learn that science cannot provide perfect answers to problems.	1	2	3	4	5
48	I learn that science has changed over time.	1	2	3	4	5
49	I learn that science is influenced by people’s values and opinions.	1	2	3	4	5
50	I learn about the different sciences used by people in other cultures.	1	2	3	4	5

Go to next page …

	In My science Class…	Almost Never	Seldom	Sometimes	Often	Almost Always
51	I learn that modern science is different from the science of long ago.	1	2	3	4	5
52	I learn that science is about inventing theories.	1	2	3	4	5
53	I get the chance to talk to other students.	1	2	3	4	5
54	I talk with other students about how to solve problems.	1	2	3	4	5
55	I explain my ideas to other students.	1	2	3	4	5
56	I ask other students to explain their ideas.	1	2	3	4	5
57	Other students ask me to explain my ideas.	1	2	3	4	5
58	Other students explain their ideas to me.	1	2	3	4	5
59	I would prefer to find out why something happens by doing an experiment than be being told.	1	2	3	4	5
60	I would prefer to do experiments rather than to read about them.	1	2	3	4	5
61	I would prefer to do my own experiments than to find out information from a teacher.	1	2	3	4	5
62	I would rather solve a problem by doing an experiment than be told the answer.	1	2	3	4	5
63	I would prefer to do an experiment on a topic than to read about it in science magazines.	1	2	3	4	5
64	I would prefer to learn scientific facts by doing an experiment than to find out from others.	1	2	3	4	5
65	Science lessons are fun.	1	2	3	4	5
66	School should have more science lessons each week.	1	2	3	4	5
67	Science is one of the most interesting school subjects.	1	2	3	4	5
68	I really enjoy science lessons.	1	2	3	4	5
69	I look forward to science lessons.	1	2	3	4	5
70	I would enjoy school more if there were more science lessons	1	2	3	4	5

End of questionnaire