Science and Mathematics Education Centre

Enjoying Science in a Singapore Neighbourhood Secondary School: An Oxymoron?

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DECLARATION

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

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

Human Ethics The research presented and reported in this thesis was conducted in accordance with the National Health and Medical Research Council National Statement on Ethical Conduct in Human Research (2007) – updated March 2014. The proposed research study received human research ethics approval from the Curtin University Human Research Ethics Committee (EC00262), Approval Number #SMEC-11-12.

Signature:

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ABSTRACT

Neighbourhood schools are generally situated in the heartland of Housing Development Board estates. As the majority of dwellers in Singapore live in these estates, unless a child does exceptionally well for the Primary School Leaving Examinations, the majority of Primary school leavers invariably end up in one of these neighbourhood Secondary schools. Even in neighbourhood schools, results are very much emphasized and the level of stress is high.

When I started this study in 2010, I was aghast to see how our drive to excel seemed to be getting out of hand - my students were being pressurised to excel in all aspects; teachers and school leaders were stressed to maintain our high standards of achievements in all areas, while parents were stressed to ensure that their children could get into good schools. It was, and still is, not uncommon for parents to engage tuition for their children to provide extra help and students just seem to be overloaded. Our drive for success seemed to be robbing our children of something just as valuable - their childhood.

Our Singapore education system has been hailed as one of the most successful systems. Many Asian countries visit Singapore to learn how they could set up similar schools in their countries. Our children are a very blessed lot and indeed we have a lot to be thankful for. But are our students enjoying learning? How can we produce truly successful students if students do not enjoy learning?

In an attempt to answer these questions, a study was conducted in a middle-ranked neighbourhood school. 238 Secondary One students at school entry level and 274 Secondary Four and Five graduating students at school leaving level participated in this study. They were asked to complete a *Getting to Know You* (GTKY) questionnaire to find out their attitudes and general views on school and workload, the *What is Happening in this Classroom* (WIHIC), Actual and Preferred versions, to help describe students' perceptions of their Science environment, and the *Questionnaire on Teacher Interaction* (QTI), Student version, to find out about the student - Science teacher relationship. The results for the graduating school leavers were then compared to the Secondary One students at entry level, taking note to see if gender differences played a part in affecting the results.

Using statistical methods, the instruments were checked for internal consistency reliability and discriminant validity. The Attitudes Scales in the GTKY and all scales in the WIHIC and QTI met reliability and validity standards.

Differences between the Secondary One students at entry level and Secondary Four and Five students at graduating level were analysed using ANOVA. Simple correlation and multiple regression analyses were performed to identify possible associations between the learning environment and attitude scales and between attitudes and achievement in Science. As the data collection was conducted in May, the mid-year examinations results were used as achievement scores. Qualitative data were collected from the GTKY questionnaire to corroborate the quantitative findings.

Results of the data analyses showed a significant difference between grade levels for the Attitude to Computers scale for the Attitude instrument in the GTKY and for five scales on the QTI. No significant difference was obtained for both the WIHIC (Actual) and WIHIC (Preferred).

Integrated findings revealed that students are happy in their current Science learning environments, with slightly better results obtained for the graduating students in the Secondary Four/Five level. When students were asked to elaborate why they liked Science, students at both levels wrote that they liked Science because it was fun and interesting, and that they liked learning new and useful knowledge. Students wrote that they liked Science because there were lots of experiments to do. Computer usage for lessons also made it to the list for both levels.

These are positive indications that students are able to enjoy Science in a neighbourhood Secondary school in Singapore despite the results-oriented environment, showing that enjoying Science in a neighbourhood Secondary school in Singapore need not be an oxymoron.

However, upon scrutiny, findings from the qualitative component revealed that only 68.4% of Secondary One students and 68.9% of Secondary Four/Five students enjoyed Science. Although the current Science learning environments are favourable, the students could be happier. The qualitative component also revealed some pertinent areas of concern. Although around 70% of students find their school load manageable, a good 16% of students do not have free time even on weekends and at least 15% of students find their school load heavy.

Moreover, although the vast majority of students indicated that they liked school, we should not forget about the students who have indicated otherwise. Top on the list of reasons why these students disliked school for both levels was stress.

Teachers can build strong teacher-student relationships to help students to cope with the stressful environment. In addition, teachers should refrain from holding any additional remedial lessons for students, especially on weekends. Meanwhile, school management can ensure that schooling hours are capped and kept to a healthy maximum. While there are many good initiatives and programmes that raise achievement scores, there should be a limit to these activities so that intangible costs may be reduced and less tangible benefits may also be reaped.

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CHAPTER 1
INTRODUCTION

It is the quality of life lived out in classrooms
that determines many of the things we hope for
from education. -- Barry Fraser

1.1 INTRODUCTION

Singapore is an island city situated at the southern tip of the Malayan Peninsula. It has a land area of 714.3 km^2 and a population of 5.31 million, of which 74.2 percent are Chinese, 13.3 percent are Malays, 9.2 percent are Indians, and 3.3 percent are of other races (MCI, 2013b). From a little-known dot on the map, Singapore has progressed to be one of the top international cities in the world (CNA, 2014a).

In the area of Education, Singapore's literacy rate in 2013 stood at 96.5 percent (MSF, 2014). Our education system is ranked second in the world in terms of quality, while performances by our students in PISA (2009) and TIMSS (2007) were impressive if not outstanding (MCI, 2013a).

People have asked me how we managed to achieve all these wonderful results in education. My answer to them is always that they were achieved with sweat and tears, literally.

When I started this study in 2010, I was aghast to see how our drive to excel seemed to be getting out of hand - my students were being pressurised to excel in both academic and non-academic areas, teachers and school leaders were stressed trying to maintain our high standards of achievements in all areas, and parents were stressed to ensure that their children could get into the best schools. It was, and still is, not uncommon for parents to engage additional tuition for their children to provide extra help; our students just seem to be overloaded. Our drive for success seemed to be robbing our children of something just as valuable - a carefree and enjoyable childhood.

And I was in the middle of it all, experiencing first-hand the never-ending vicious cycle to maintain standards of excellence. It was then that I decided to do something about this, even in whatever limited way I could. If I embarked on a study that could help to describe objectively what was happening in classrooms that are achievement

-oriented, for the subject of Science because this is what I teach and in a neighbourhood school because this is where the majority of children go, then I would perhaps be able to see if our students were able to enjoy learning under such stressful conditions, at least for the subject of Science.

However, many things have happened and many changes have been introduced over the past five years since I embarked on this study. For instance, over 22,000 educators, students, parents, academics, representatives from community organisations, unions and members of the public took part in Our Singapore Conversation in 2013 to voice and provide feedback about our concerns, one of which was the issue of stress and examinations (MOE, 2013b). Ground-breaking moves to end the practice of naming the top Primary School Leaving Examinations (PSLE) scorer and of including the highest and lowest aggregate scores in results slips were made during the release of the 2013 PSLE results in an attempt to lessen our emphasis on academic results (ST, 2013).

In the Work Plan Seminar held in 2013, our current Minister of Education, Mr Heng Swee Keat, promised to make education in Singapore more student-centric and holistic, and improve the quality of student experience in schools so that, at the end of ten years of basic education, we have citizens with character equipped with a broad and deep foundation for a learning journey long after graduation (MOE, 2013a). Seeing all this happening in Singapore gave me hope. It was like seeing light at the end of a tunnel. I look forward to embrace the changes that promise to make our education system a more exciting and less stressful one.

1.2 BACKGROUND OF THE STUDY

Neighbourhood schools are generally situated in the heartland of Housing Development Board (HDB) estates as the majority of dwellers in Singapore live in HDB flats (also known as public flats). From SG Facts, more than 80 percent of the population live in public flats (MCI, 2013c). Unless a child does exceptionally well for the PSLE, the majority of Primary school leavers invariably end up in one of these neighbourhood Secondary schools. As neighbourhood schools are run by the Singapore government, they are also known as government schools.

The present Singapore educational system consists of at least ten years of basic education, comprising six years of Primary education and four years of Secondary education. Students start school at the age of six years and go through the PSLE at the end of Primary Six. Based on the PSLE results, students are streamed into two main categories in Secondary schools - the Normal Course and the Express Course, with the better-ability students going into the latter. The Normal Course is further divided into the Normal Technical (NT) and Normal Academic (NA) streams, again with the better-ability students going into the latter.

At the end of Secondary Four, students from the Express streams would take the Singapore-Cambridge General Certificate of Education Ordinary Level (GCE 'O' Level) Examination while students from the Normal courses would take the GCE ‘N’ Level Examination. If students in the NA stream do well, they currently can continue their education with one more year in Secondary school and take the GCE ‘O’ Level Examination at the end of Secondary Five, proceed to the Polytechnic Institutes if they do even better, or go on to the Institute of Technical Education to learn a trade before they join the workforce. Secondary Four Express and Five NA students who do well in the GCE ‘O’ Level Examination can proceed to Post-secondary education in Polytechnics or Junior Colleges and then further to Tertiary education.

Besides these three streams, a relatively smaller cohort of high-ability students would be able to enter schools with Integrated Programmes which offer direct routes to Tertiary education without having to go through the usual GCE ‘O’ Level Examinations. These students take the GCE ‘A’ level examinations or the like at the end of Year Six. Figure 1.1 shows an overview of the pathways available in Secondary education.

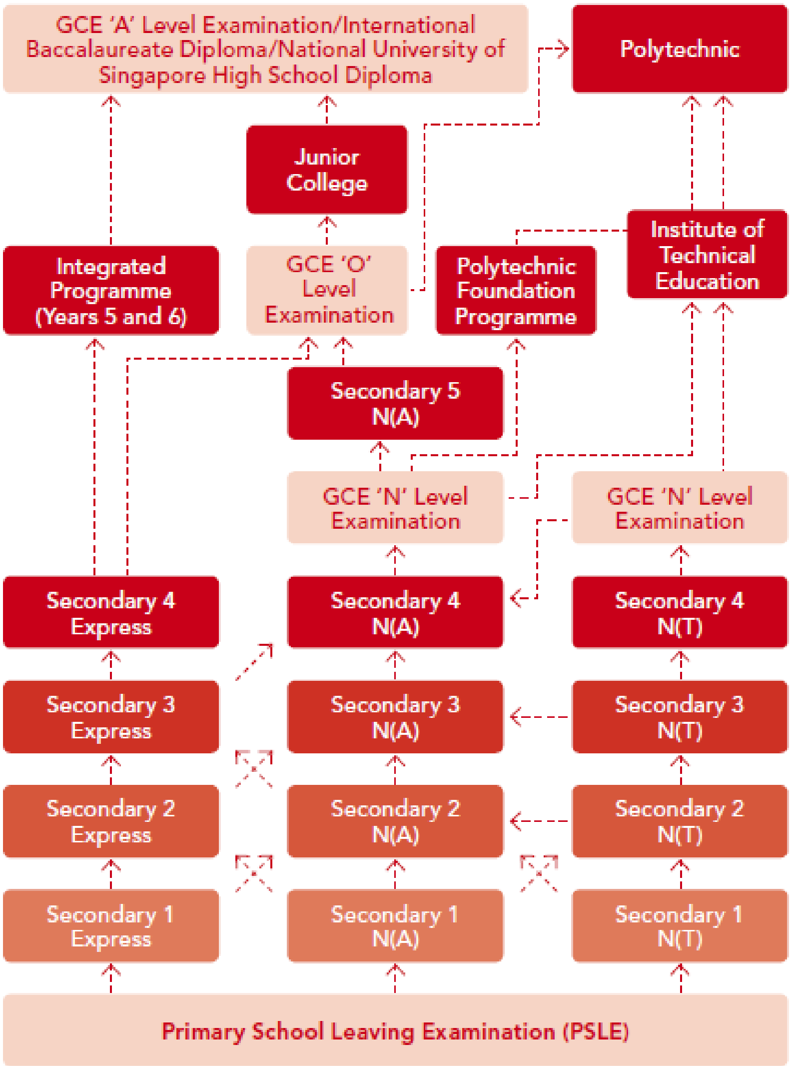

Figure 1.1. Overview of education pathways in Singapore.
(From MOE Corporate Brochure Education in Singapore, 2014, p. 6)

The diagonal and lateral arrows show the flexibility of the system to allow students to switch to a stream that is more suitable for their pace of learning from Secondary One to Secondary Three before taking a major national examination in Secondary Four. For example, late bloomers who do not do well in PSLE and enter a Secondary One NA stream are allowed the flexibility to switch to the Secondary Two Express stream if they do well when they are in Secondary One. On the other hand, students who find the pace of Express classes too fast for them are given the flexibility to switch to NA classes in the NA stream that offer a slower pace of education. For NA to NT, the switch is only available in Secondary One because the pace for NA stream is already slower. Although in theory, the differentiation of the different streams helps students to study at a pace suitable for them, in actual fact, there is a negative impact on the self-esteem of many students who are directed into a NT or NA stream. In addition, separating the better-ability students from the lower-ability students tends to remove the opportunity for the lower-ability students to learn from the higher-ability students.

Although it does not deal with the education of the 'crème de la crème', Secondary education in a neighbourhood school in Singapore is still very much achievement-oriented. We are at the threshold of a new century. Our world is changing rapidly and Singapore is changing rapidly along with the world. Globalization is becoming increasingly prevalent and technology is shrinking our world, resulting in different if not greater demands on our educational system.

To help our youth cope with the pressing demands of the 21st century, the Ministry of Education (MOE) has introduced the 21st Century Competencies initiative, on top of many other programmes, like the Community Involvement Programme (CIP), Co-curricular Activities (CCA), Civics and Moral Education (CME), Pastoral Care and Career Guidance (PCCG), and National Education (NE) for Life Skills and Project Work (PW) for Knowledge Skills to help our young develop holistically. Figure 1.2 shows an overview of the various programmes that are structured into a typical secondary school curriculum.

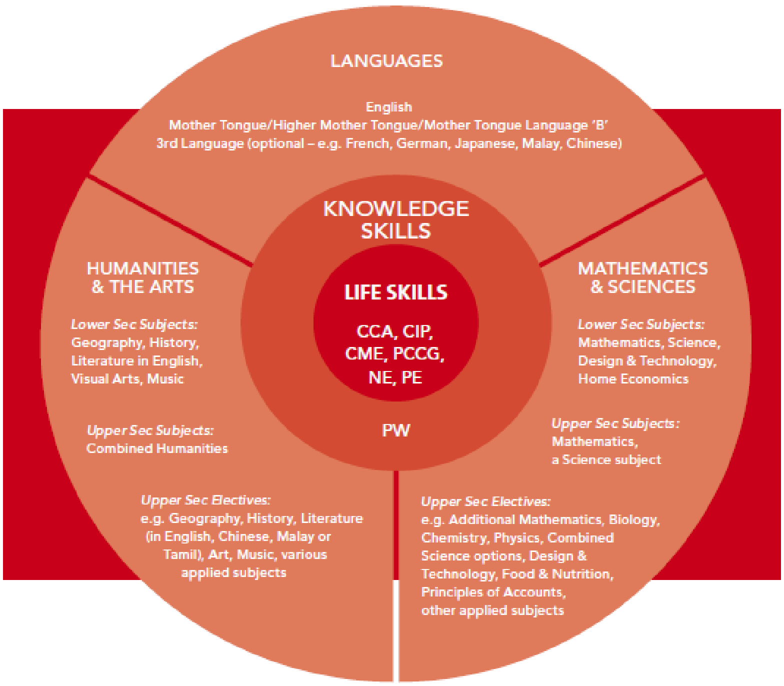

Figure 1.2. School programmes in a typical secondary school.
(Adapted from MOE Corporate Brochure Education in Singapore, 2013, p. 7).

In addition to the myriads of programmes, the Information and Communication Technology (ICT) Masterplans have played a crucial part in the success of our Singapore schools. All the teachers in all schools are equipped with a personal notebook computer and all classrooms are fitted with overhead projectors and other necessary peripherals, so that technology can be easily accessible anytime anywhere. ICT Masterplan Four is currently underway, and future plans are being made so that even more portable devices such as iPads could be used, with Wi-Fi being made available in many schools, making our classrooms truly classrooms without walls in the near future.

The class size in a Singapore Secondary school is still typically large. It is not unusual for the class size in a Secondary school to be around 40 students and even beyond. Secondary Five NA classes can be smaller than the typical class size because of the flexibility of education routes available for the Secondary Five cohorts, allowing many students to leave and progress on these alternative pathways of education. Classes are still predominantly teacher-centred, although there is now more of an inclination to make them student-centric.

Students enter Secondary One at approximately 13 years old. They now take many more subjects compared with when they were in Primary school. Subjects offered in Secondary schools comprise English, Mother Tongue, Mathematics, General Science, Geography, History, Social Studies, Literature, Design and Technology (D&T), Food and Consumer Education (FCE), Physical Education, Computer Applications (CPA) and Art and Music, with the level of difficulty and subjects offered pitched to the various levels of difficulty for the three different streams. For instance, NT students do not take Literature, Geography and History but they take CPA, which is not available to the other streams. In addition, some of the subjects are taken for only one semester. For example, if students take D&T in the first semester, then FCE would be taken in the second semester in place of D&T.

For the teaching and learning of Science, Secondary One and Two students take General Science so that every citizen would have a basic knowledge in all three Sciences (i.e. Biology, Chemistry and Physics). In some Secondary schools, a modular approach is employed from Secondary One in which students learn the three Sciences separately and simultaneously with specialist Science teachers teaching them, like in upper Secondary classes. Lower Secondary levels are comprised of

Secondary One and Two levels while Upper Secondary levels are comprised of Secondary Three to Five levels. To mark this change, boys' uniforms in many schools change from shorts for boys at the Lower Secondary levels to long pants for boys at the Upper Secondary levels.

At the end of Secondary Two, all Secondary Two students are streamed again, but this time according to subject combinations. Secondary Two Express classes are allowed to select pure Science classes which can offer pure Biology, Chemistry and Physics, while other classes can offer Combined Science in its various combinations. For example, Science (Physics/Chemistry) is one of the most popular combinations for Science in the upper Secondary level. The NA classes are offered similar Combined Sciences while NT classes are allowed to choose Science as an elective in some schools (i.e. Science no longer is a compulsory subject). Because Biology as a subject is less popular, many students have Biology knowledge only up to Secondary Two level, unless they read beyond the syllabus of their own accord.

Although practical work is a key component in the learning of Science, laboratory sessions are more frequent in Express classes, with priority given to graduating classes in preparation of the School-Based Science Practical Assessment (SPA) for the pure Science classes and GCE 'O' levels practical examinations for the combined Science classes. There is no equivalent School-Based Science Practical Assessment (SPA) nor GCE 'N' levels practical examinations for NA students. Because of this, some teachers give less emphasis to laboratory sessions in the NA classes until they reach Secondary Five to do their GCE 'O' levels. SPA is a national assessment of practical skills that is conducted over two years from Secondary Three to Four.

Written assessment varies among subjects. In general, class tests and common tests are given in every school term to make up Continual Assessment (CA) 1 marks (for Terms 1 and 2) and CA 2 marks (for Terms 3 and 4) and mid-year and end-of-year examinations given at the end of every semester to make up Semestral Assessment (SA) 1 and SA 2 marks, respectively. The tests are normally used for both formative and summative assessments while the examinations are usually used as summative assessment.

Education in Singapore is based on the foundation of meritocracy and equal opportunity. For the steaming at the end of Secondary Two for subjects-selection, girls and boys have equal opportunities to enter the pure Science classes that offer all the three Sciences, namely, Biology, Physics and Chemistry. For lessons, both genders take D&T classes and FCE classes. And for Co-curricular Activities (CCA), clubs normally for boys are also available for girls. For instance, the National Cadet Corps for boys has an equivalent National Cadet Corps for girls; Scouts for boys has an equivalent Guides for girls. Unless very few students select the CCA, most schools would have equivalents available for both genders. For CCAs that do not have equivalents, many CCAs are co-educational, like Red Cross Youth and St. John Ambulance, and are open to both genders. However, although CCAs are open to both genders, there are CCAs that are still predominantly of one gender. For instance, Chinese Dance and Malay Dance are comprised of predominantly girls.

1.3 PURPOSE AND SIGNIFICANCE OF THE STUDY

In a preface to a book, Fraser (1986) stated that “it is the quality of life lived out in classrooms that determines many of the things we hope for from education”.

As mentioned, a myriad of programmes have been developed for students in order prepare them for the increasing demands of the 21st Century. Theoretically, the many initiatives and programmes developed for students are valuable and logical moves. However, how do all these good intentions translate into reality as they take root in practice?

During the year-end school staff meeting in 2013 and our first staff meeting at the beginning of this year 2014, our Principal announced that achievement would still be given emphasis. We were reminded that, although new initiatives and programmes were being introduced, our core responsibility was still to make sure our students did well in national examinations. So, it seems to be, despite the changes coming our way, bread and butter issues still precede them. It will probably take many more years before we can truly succeed in placing less emphasis on results.

In the meanwhile, to make learning more authentic and less stressful for students, our school was one of the 12 pilot schools to run the ALP programme for Lower Secondary students. So, in a way, students could still enjoy Secondary school life while in the Lower Secondary levels before they prepare for national examinations at the Upper Secondary levels.

Learning environment research has steadily gained importance in education and much interest has been shown to this field of study. However, a search conducted in ERIC and ProQuest Central in May 2014 revealed that, out of 14,837 peer reviewed abstracts of scholarly journals on learning environments in education since 1968, only 16 (0.1%) were related to education in Singapore. So, despite more interest, research in this area is still lacking in Singapore.

Also, because learning environment is an extremely dynamic and fluid field of study, and with new initiatives constantly being introduced by the Ministry of Education, our classroom environments are constantly changing too. Not only would this study add to local learning environment research, it would also provide more recent findings in this area.

In addition, besides giving insight into the learning environments of a typical Singapore neighbourhood school, the findings from the study could give insights into other areas such as if gender differences still exist, what are the associations between attitudes, performance and Science teacher-student interpersonal relationships. Based on these findings, practical measures that teachers can take to improve classroom environments could be put forward.

Although it is anticipated that these findings could then be generalized across subjects, because the school environment is the same regardless of subject, it is hoped that the findings would stimulate further research to encompass a broader range of subjects and more schools, which is important especially now if we aspire to make education more student-centric for our children.

1.4 RATIONALE OF THE STUDY

This study adds to the increasing list of investigations into learning environments in a secondary school setting in Singapore. However, this study is distinctive in that it focused on investigating the conditions within a neighbourhood Secondary school at two levels - the entry and exit levels. The entry level consists of students from Secondary One level entering the school while the exit level consists of Secondary Four and Five students graduating from the school.

The learning environment of the classrooms was assessed using the *What is Happening in this Classroom?* (WIHIC) questionnaire’s Actual and Preferred versions. Differences between the perceptions of actual and preferred environments would provide practical suggestions to improve classroom environments.

Through the *Getting to Know You* (GTKY) questionnaire, both quantitative and qualitative data were collected from students. This questionnaire provides background information and the attitudes of students based on three scales from the *Technology-Rich Outcomes-Focused Learning Environment Inventory* (TROFLEI).

In order to investigate teacher-students interpersonal relationships, the student version of the *Questionnaire on Teacher Interaction* (QTI) was used to obtain students' perceptions of their teachers.

Although the instruments used in this study have proven reliability and validity, the internal consistency reliability and discriminant validity of any instrument should be checked in the setting that it is used before any other results derived from the questionnaires can used with confidence.

After determining that the instruments could be used with confidence, further data analyses were carried out. Results obtained from these instruments could show if there are significant differences between the two levels, if there were any gender differences, and associations of interest in this study.

Quantitative data were used in conjunction with qualitative data derived from this study. This was done in the hope of obtaining a more complete understanding of the learning environments and students' attitudes not just towards Science as a subject, but also towards school in general. Results from the qualitative aspect of the study also helped to confirm and triangulate results obtained from the quantitative aspect of this study.

1.5 DELIMITATIONS OF THE STUDY

Although I had wanted to find out if the learning environment in general in a typical neighbourhood secondary school was stressful to our students and if this had any negative consequences on students' ability to enjoy what they were learning, this aspiration encompassed a spectrum that was too large to be conducted in this study. To help make this thesis feasible, a few delimitations were set.

First, the selection of schools was delimited. Although both the pilot study and the actual data collection were carried out in different secondary schools, both of the schools are neighbourhood schools. The school in which the pilot test was conducted is a better-ranked Secondary school located in a HDB estate in the north east of Singapore, while the school is a middle-ranked school located in a HDB estate in the south of Singapore. Only the middle-ranked Secondary school was involved in the actual data collection.

Secondly, only one subject area, namely Science, was selected for the purpose of this study. However, even by delimitating this study to Science alone, challenges still abound as various fields of Science are offered in the upper Secondary level.

Thirdly, to see if there were any differences by the end of Secondary education, graduating students leaving the school were compared with a different batch of Secondary One students who had just entered the school. A longitudinal study using the same batch of students was not possible because it would necessitate waiting for another three years for the Secondary One students to reach Secondary Four.

Other delimitations of the study included the relatively small sample size that comes with the selection of only one school for the actual data collection. 274 graduating students at the exit level and 238 Secondary One students at the entering level consented to participate in this study. Of these, some participants stopped halfway through the data collection.

Even though every effort was made to take care that background variables did not come into play in the study, nevertheless, some background variables could prevent generalizing some findings to a wider context (e.g. findings might not necessarily be transferable to the learning environments of other subjects).

1.6 RESEARCH QUESTIONS

The aim of this research was to develop an understanding of the learning environments in a neighbourhood secondary school, particularly in Science classrooms, and to see if these environments had any negative impact on students' ability to enjoy the Science that they were learning.

To achieve the aims stated above, six sets of research questions were developed which then became the focus of study. These questions are listed as follows.

Research Question 1:

Are the instruments used, namely, the *What is Happening in this Classroom* (Actual and Preferred), the *Questionnaire on Teacher Interaction* (Student version) and the Attitude Scales in *Getting to Know You*, reliable and valid for studying Science learning environments in a Singapore Secondary school?

The first research question was formed to establish internal consistency and discriminant validity in order to confirm that the questionnaires could be used with confidence in the current setting.

Research Question 2:

a. What are students' perceptions of the actual Science learning environment in a neighbourhood Secondary school?

b. What are students' preferred Science learning environments in a neighbourhood Secondary school?

c. Are there any differences between students' perceptions of the actual learning environment and what they would prefer it to be?

d. What are students' perceptions of their teacher-student interactions?

e. What are students' attitudes towards Science in a neighbourhood Secondary school?

The second research question was formed to describe the learning environments, which included finding out aspects of student attitudes and teacher-student interpersonal relationships in these Science classrooms for a comprehensive understanding of the environment.

Research Question 3:

Are there differences between graduating classes and Secondary One classes in students' perception of the actual Science learning environment, preferred Science learning environment, teacher-student interactions and attitudes towards Science?

Research Question 4:

Are there gender differences in students' perception of the actual Science learning environment, preferred Science learning environment, teacher-student interactions, and attitudes towards Science?

Additionally, investigations were undertaken to ascertain whether the results were related to the level and gender of the students. The third research question involved differences between the entry level for Secondary One classes and the exit level for graduating classes, while the fourth research question gender differences.

Research Question 5:

a. What associations are there between students' perceptions of their Science environment and their attitudes towards Science?

b. What associations are there between students' perceptions of their Science environment and their achievement in Science?

c. What associations are there between teacher-student interactions and their attitudes towards Science?

d. What associations are there between teacher-student interactions and their achievement in Science?

While achieving the aim of this thesis, this research identified associations between classroom environment, attitudes and achievement in Science and between student-teacher interpersonal relationship, attitudes and achievement in Science. These were established through the fifth research question.

Research Question 6:

In a neighbourhood school in Singapore, what are students' opinions about their school, Science and what makes Science lessons enjoyable?

Lastly, the sixth research question provided the qualitative aspect of this study and was included to obtain a more complete understanding of learning environments and students' attitudes not just towards Science as a subject but also towards school in general. Results from this research question also helped to confirm and clarify results obtained for the rest of the research questions that provided the quantitative aspect of this study.

These research questions listed above are also found in Chapter Three where more detailed elaboration of why they were derived is given and again in Chapter Four where the results are given and the research questions answered.

1.7 OVERVIEW OF THE THESIS

This thesis comprises five chapters. In Chapter One, a brief introduction to Singapore and some background information about Singapore's education system are provided to set the context of the study. The purpose and significance of the study, together with its rationale, delimitations, aims and research questions are also highlighted in this chapter.

Chapter Two is the literature review, which first involves studies on learning environments and how they can be studied and assessed. The literature review on learning environments includes studies carried out locally as well as detailed descriptions of related instruments that could be used in this study. Next, this was followed by a literature review on Science curricula. A more detailed description of assessment in Singapore is also included. Next, having understood how science is taught and assessed in Singapore, a literature review on the learning and teaching of science was carried out. Sections on how ICT can be harnessed to make the learning of science more enjoyable and how independent learning can be fostered are included in this section. Literature reviewing on assessment was also carried out, particularly to see if there are viable alternative forms of assessments that could help to make learning more enjoyable and assessment less stressful. The last section comprises a literature review on school climate and culture, and their important role in enhancing the learning environment, particularly the motivation of both students and staff.

Chapter Three presents the methodology used in this study. The types of research methods are introduced and an appropriate research method for the study was derived after exploring the theoretical framework from Chapter Two. It includes a description of the sample used in this study, an elaboration of how the research questions listed in Chapter One were derived, and why the instruments that were used in this study were selected and modified to include qualitative research. The process of pilot testing, data gathering using technology, data analyses and other considerations like ethical considerations are also included in this chapter.

Chapter Four reports the findings from the study. The results of the quantitative and qualitative analyses are presented in this chapter, followed by interpretations of the results. The answers to the research questions are also presented in this chapter.

In Chapter Five, the findings from Chapter Four are then related to literature and the answers to the research questions obtained are discussed. The findings of this study are next summarized in the conclusion. This is followed by the limitations of the study and recommendations for future research. Finally, the thesis concludes with a final word.

CHAPTER 2
REVIEW OF LITERATURE

2.1 INTRODUCTION

Fraser noted that students spend as long as 15,000 hours in school by the time they completed Secondary education and 20,000 hours by the time they graduate from university (Fraser, 2001). A conservative figure for ten years' of basic education in Singapore, at seven hours a day for five days a week for nine months a year would yield a figure of 12,600 hours, which is still a considerable amount of time. With so many hours of our students' life spent in school, it is no wonder that students' perceptions of school experiences and improvement of the quality of life in these classrooms have become important.

As the emphasis of this study is to find out if students are enjoying Science in a neighbourhood Singapore school despite the high-achievement environment, a literature review was carried out in five main areas relevant to this thesis, starting with learning environments in Section 2.2. Next in Section 2.3, the Science curriculum and assessment in Singapore is presented in greater detail. This is followed by Section 2.4, which covers a literature review on teaching and learning and why it is important to make learning enjoyable. This is written with emphasis to the teaching and learning of Science and practical ways that could help make the learning Science enjoyable and meaningful in the 21st century are provided here. The use of ICT is naturally included in this section. In addition, fostering independent learning which is so crucial for promoting lifelong learning is also included in this section. Next, Section 2.5 consists of a literature review on assessment, with emphasis on alternative assessment methods that can help to make assessment less stressful, without the loss in rigour. Lastly, Section 2.6 investigates the effect of school culture and school climate and suggests how it may be improved. This chapter ends with Section 2.7, which summarizes Chapter Two.

2.2 RESEARCH ON CLASSROOM ENVIRONMENTS

Section 2.2 on learning environment research includes five sub-sections. In Section 2.2.1, a historical background of environment research is given, followed by Section

2.2.2 which consists of the development of some of the key instruments used to rigorously measure and describe learning environments. Next, in Section 2.2.3, to help the selection of instruments for use in this study, detailed descriptions of instruments that would be of particular interest in this study are highlighted. In Section 2.2.4, past studies carried out in Singapore are investigated to see if these key instruments have been used in the Singapore context, and if so, to see how they were used in Singapore. Finally, Section 2.2.5 concludes with the selection of the instruments for this study and how they may be used in conjunction with one another.

2.2.1 Instruments Measuring Learning Environments

In the field of education, a lot of emphasis has been given to the psychosocial characteristic approach. An important way to assess the psychosocial characteristic of a classroom includes the design and development of instruments. One of the first instruments developed was the *Learning Environment Inventory* (LEI), designed by Walberg in the 1960s in the USA in the Harvard Project Physics research (Fraser, 1998).

However, as the LEI was long and had too many scales, other instruments were developed, such as the *My Class Inventory* (MCI). The MCI is a simplified LEI designed for younger children in Primary schools by Anderson and Walberg in 1976. The MCI was validated by Fisher and Fraser in 1981 (Fisher & Fraser, 1981).

Another historically important instrument developed independently from and slightly after the LEI is the *Classroom Environment Scale* (CES) designed by Rudolf Moos (Fraser, 1998). Moos believed that an environment can only be described appropriately by considering three dimensions – the personal development, the relationship dimension and the systems change and systems maintenance dimension (Fraser, 1998). Personal development, as the term implies, describes the development of the individual; relationship dimension seeks to describe the way people relate to one another; systems change and systems maintenance dimension seeks to describe how the physical environment is organized and how innovative it is.

Three scales in the CES measured the relationship dimension - involvement of students in the class, affiliation of students with each other and teacher support; another four scales measured the systems change dimension - teacher control, rule clarity, order and organization and innovation; and two scales measured the personal development dimension - task orientation and competition (see Table 2.1).

For the LEI, cohesiveness, friction, favouritism, cliqueness, satisfaction, apathy measured the relationship dimension. Speed, difficulty and competitiveness measured the personal development dimension while the remaining scales measured the systems change dimension.

Table 2.1

Summary of Scales of the LEI, CES and MCI

Instrument	**Year developed & Author(s)**	**Items**	**Total items in the instrument**	**Scales**
CES	1974, Moos	10 items in 9 scales	90	Involvement Affiliation Teacher Support Teacher control Rule clarity Order and Organization Innovation Task Orientation Competition
LEI	1968, Walberg	7 items in 15 scales	105	Cohesiveness Friction Favouritism Cliqueness Satisfaction Apathy Speed Difficulty Competitiveness Diversity Formality Material Environment Goal Direction Disorganization Democracy
MCI	1976, Anderson and Walberg	9 items in 5 scales	45	Difficulty Competitiveness Cohesiveness Friction Satisfaction

The MCI only measured the learning environment on two dimensions, as it was designed for younger children in mind. It measured the learning environment on the personal and relationship dimensions. Two scales in the MCI measured the personal dimension (difficulty and competitiveness) while the remaining scales measured the relationship dimension (cohesiveness, friction and satisfaction).

These three instruments mentioned above were designed for use in teacher-centred classroom environments. As many schools in Asia are teacher-centred, the use of these instruments should still be appropriate in Asia. The *Individualised Classroom Environment Questionnaire* (ICEQ) was the first learning environment instrument to focus on dimensions which distinguished student-centred classrooms from conventional teacher-centred classrooms.

Over the course of time, other modifications included those made to suit specific needs. For example, the *Science Laboratory Environment Inventory* (SLEI) was designed to suit the needs of laboratory settings in the teaching of science, the *Technology-Rich Outcomes-Focused Learning Environment Inventory* (TROFLEI) was designed for use in a technologically-rich setting. See Table 2.2 for the summary of scales for these instruments.

Besides those listed, there are numerous more, such as the *Computer Learning Environment Inventory* (CLEI), designed for use in a computer laboratory setting, the *Web-Based Learning Environment Instrument* (WBLEI), designed for use in an internet-rich setting.

Table 2.2

Summary of Scales of the ICEQ, SLEI and TROFLEI

Instrument	Year developed & Author(s)	Items	Total items in the instrument	Scales
ICEQ	1979, Fraser & Rentoul	10 items in 5 scales	50	Personalization Participation Independence Investigation Differentiation
SLEI	1995, Fraser, Giddings & McRobbie	7 items in 5 scales	35	Student Cohesiveness Open-Endedness Integration Rule Clarity Material Environment
TROFLEI	1996, Fisher, Fraser & McRobbie	7 items in 10 scales and 18 items in 3 attitude scales	131	Student Cohesiveness Teacher Support Involvement Investigation Task Orientation Cooperation Equity Differentiation Young Adult Ethos Computer Usage Attitude to Subject Attitude to computer use Academic Efficacy

Some of the popular instruments used to assess the classroom environment in Asia are the *What is Happening in this Class?* (WIHIC) questionnaire, the *Questionnaire on Teacher Interaction* (QTI), the *Constructivist Learning Environment Survey* (CLES), and the SLEI and TROFLEI mentioned above (Fraser, 2002). See Table 2.3 for the summary of scales for these instruments.

Table 2.3

Summary of Scales of the WIHIC, QTI and CLES

Instrument	Year developed & Author(s)	Items	Total items in the instrument	Scales
WIHIC	1996, Fisher, Fraser & McRobbie	8 items in 7 scales	56	Student Cohesiveness Teacher Support Involvement Investigation Task Orientation Cooperation Equity
QTI	1990, Creton, Hermans & Wubbels	6 items in 8 scales	48	Leadership/Authoritative Friendly/Helpful Understanding Student Responsibility Uncertain Dissatisfied Admonishing Strict
CLES	1995, Dawson, Fraser & Taylor	7 items in 5 scales	35	Personal Relevance Uncertainty Critical voice Shared Control Student Negotiation

Developments in instrument-design also included dividing the instruments into Actual and Preferred versions, with students being happiest when the actual and preferred environments coincided. If the versions do not coincide, the differences identified by the instruments could then be used to design strategies aimed at reducing these differences in the hope of improving these classroom environments (Fraser, 1989). They described how the WIHIC Actual and Preferred versions were used to improve a Secondary Science classroom environment.

Fraser (2012) gave a summary of past researches in which associations between the WIHIC scales and enjoyment and attitudes were studied. For example, Aldridge and Fraser related the WIHIC to enjoyment in 2000 and Chionh and Fraser related the WIHIC to achievement, attitude and self-esteem in 2009.

Other developments in the area of instrument-design are the availability of ‘Short’ forms (i.e. shorter versions of the instruments), the availability of Personal and Class versions as well as instruments to describe the school environment as opposed to just the classroom environment. Mixed-research involving qualitative analysis showed that students would normally be able to answer Personal forms better over the Class forms. Class forms have since then become obsolete (Fraser, Fisher, & McRobbie, 1996).

The Short version of the WIHIC for both the Actual and Preferred versions have 25 questions each. However, it is generally recognised that the more items there are in the instrument, the higher the reliability (McMillan & Schumacher, 1993).

2.2.2 Historical Background of Environment Research

Back in 1936, Curt Lewin first described human behaviour as a function of our personality and our environment, B = f (P,E) (Fraser, 1998). Before him, it was thought that different people behaved differently in accordance with their personality. For example, a reticent individual (personality) would tend to keep to himself/herself (behaviour). Lewin’s theory helps to give a broader perspective. For example, a talkative student (personality) might be reticent (behaviour) when he/she is surrounded by strangers (environment).

Based on Lewin’s proposal, Murray came up with a Needs-Press model in 1938 (Fraser, 1998). The personal needs described the personality aspect while the press described the environment where the needs were expressed or suppressed. He proposed an ‘alpha press’ where the environment was assessed by a detached observer and a ‘beta press’ where the environment was assessed by those within the environment. The alpha press would include observations of the classroom by an external observer while the beta press would include observations of the students in the classroom. This gave rise to instruments in which the information gathered was obtained from the students in the classroom.

In 1956, Stern, Stein, and Bloom extended the idea of a beta press further into 'private beta press' where individual perceptions of the environment are obtained and 'consensual beta press' where group perceptions of the environment are obtained, giving rise to instruments which obtained responses from groups rather than individuals (Fraser, 1998).

In order to study human environments, several approaches were developed, namely, ecological dimensions, organizational structure, personal characteristic and psychosocial characteristic. Ecological dimensions tries to explain human behaviour using ecological factors, such as weather, for example, the tendency for students to be less attentive on a hot and humid afternoon. Organizational structure tries to explain behaviour using the structure of the environment, for example, the layout of the classroom, the facilities available in the classroom, the teacher to student ratio in the class. Personal characteristic tries to explain behaviour through the characteristics of the environment, for example, intellectual versus artistic. Psychosocial characteristic tries to explain how individuals develop psychologically, for example, how students interact amongst themselves (peer influence) and with teachers (teacher-student interaction) and how these interactions affect the way they behave and ultimately learn.

2.2.3 Descriptions of Some Learning Environment Questionnaires

There are numerous good instruments that have been used to study learning environments. Of interest in this study are instruments that are popularly used to assess the classroom environment in Asia, namely, the WIHIC, the QTI, the SLEI, the TROFLEI, and the CLES. A detailed description of each of these instruments is included in this section.

The WIHIC:

The WIHIC questionnaire is one of the most, if not the most, popular instruments used in Asia. It has been translated and cross-validated in Brunei, Taiwan, Korea, Indonesia and in Singapore (Aldridge & Fraser, 2000). In Singapore, the WIHIC has been used successfully both in its original or modified form. The original WIHIC questionnaire had 90 items over nine scales and was developed in Australia by Fisher, Fraser, and McRobbie in 1996 to provide an understanding as to what was happening in a classroom. In 2000, through the use of both qualitative and quantitative methods, Aldridge and Fraser reduced the original version of WIHIC into its present final form with seven eight-item scales, measuring Student Cohesiveness, Teacher Support, Involvement, Investigation, Task Orientation, Cooperation, and Equity (see Table 2.3).

As mentioned, the instruments come in at least two versions - the Actual and the Preferred. In the Actual version, the student participants answer the questionnaire according to their perceptions of the actual environment. In the Preferred version, the students answer based on their preference of an ideal environment. See Table 2.4 for the description and example of items for each of the scale in the WIHIC (Actual and Preferred).

Table 2.4

Description and Example of Items for Each Scale in the WIHIC Actual and Preferred Instruments

Scale	**Description**	**Item example for the Actual version**	**Item example for the Preferred version**
Student Cohesiveness	The extent to which students know, help and are supportive of one another.	I work well with other class members.	I would work well with other class members.
Teacher Support	The extent to which teacher helps, befriends, trusts, and shows interest in students.	The teacher helps me when I have trouble with my work.	The teacher would help me when I had trouble with my work.
Involvement	The extent to which students have attentive interest, participate in discussions, perform additional work and enjoy the class.	The teacher asks me questions.	The teacher would ask me questions.
Investigation	The extent to which there is emphasis on the skills and their use in problem solving investigation.	I carry out investigations to test my ideas.	I would carry out investigations to test my ideas.
Task Orientation	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.	I would know what I was trying to accomplish in this class.
Cooperation	The extent to which students cooperate rather than compete with one another on learning tasks.	When I work in groups in this class there is teamwork.	When I work in groups in this class there would be teamwork.
Equity	The extent to which the teacher treats students equally.	I get the same amount of help from the teacher as do other students.	I would get the same amount of help from the teacher as do other students.

The WIHIC (Actual) and WIHIC (Preferred) with the complete set of items can be found in Appendices 7 and 8 respectively. The validity, reliability and usefulness of the WIHIC have been established internationally using confirmatory factor analysis. Confirmatory factor analysis supported the international validity of the WIHIC and showed that this factor structure was similar across countries, grade levels and student genders (Chionh & Fraser, 2009; Fraser, 1998).

The QTI:

Another popular instrument used in Asia is the QTI. However, unlike the other instruments which measure all or at least two of the three dimensions in Moos' scheme, the QTI only measures the environment on one dimension, namely, the relationship dimensions. To make up for the lack of measurement in other dimensions, the QTI has been used in conjunction with other instruments to give a more holistic picture of the learning environment. The current version of the QTI has 48 questions consisting of eight six-item scales. See Table 2.5 for the description of the scales and item examples in each scale of the QTI. The full version of the QTI with the complete set of items can be found in Appendix 9.

Adapted from the Leary model which maps interpersonal relationships onto the Dominance-Submission and Hostility-Affection axes in clinical psychology, teacher behaviour is mapped on a Proximity dimension (Cooperation-Opposition axis) and Influence dimension (Dominance-Submission axis) to form four quadrants. The greater the influence and proximity, the higher the affective student outcomes. However, for cognitive student outcomes, associations were not as straightforward, appearing to be curvilinear (Brekelmans, Wubbels, & den Brok, 2002).

The four quadrants are divided into eight sectors forming an octagon, with each sector describing a behaviour characteristic a teacher may exhibit: DC for Leadership and SO for Uncertain, CD for Friendly and OS for Dissatisfied, CS for Understanding and OD for Admonishing, and SC for Student Responsibility and DO for Strict.

Table 2.5

Description and Example of Items for Each Scale in the QTI

Scale	Description	Item example
Leadership [DC]	Extent to which teacher provides leadership to class and holds student attention	This teacher explains things clearly.
Helpful/Friendly [CD]	Extent to which the teacher is friendly and helpful towards students.	This teacher is friendly.
Understanding [CS]	Extent to which the teacher shows understanding and care to students.	If we don't agree with this teacher, we can talk about it.
Student Responsibility / Freedom [SC]	Extent to which the students are given opportunities to assume responsibilities for their own activities.	We can influence this teacher.
Uncertain [SO]	Extent to which teacher exhibits his/her uncertainty.	This teacher seems uncertain.
Dissatisfied [OS]	Extent to which teacher shows unhappiness/dissatisfaction with the students.	This teacher thinks that we don't know anything.
Admonishing [OD]	Extent to which the teacher shows anger/temper and is impatient in class.	This teacher gets angry.
Strict [DO]	Extent to which the teacher is strict with the demands of the students.	We are afraid of this teacher.

Teachers with high scores for the DC Leadership sector tend to be directive. They lead, give directions, organises, set tasks, determine procedures, explain and hold attention. Teachers with high scores for the CD Helpful/Friendly sector tend to be supportive. They assist, show interest, behave in a friendly or considerate manner, is able to joke, and inspire confidence and trust. Teachers with high scores for the CS Understanding sector tend to be tolerant. They empathize, listen, show confidence and understanding, accept apologies, are patient and open to students. Teachers with high scores for the SC Student Responsibility/Freedom sector tend to be flexible. They give students opportunity for independent work, and give freedom and responsibility to students.

Teachers with high scores for the SO Uncertain sector tend to be repressive. They are usually timid, hesitant, uncertain and they keep a low profile. Teachers with high scores for the OS Dissatisfied sector tend to be drudging. They show dissatisfaction, look glum and are unhappy. Teachers with high scores for the OD Admonishing sector tend to be aggressive. They get angry easily, express irritation, are sarcastic, forbidding, admonishes and punishes. Teachers with high scores for the DO Strict sector tend to be authoritative. They keep a tight rein of the class, expect and maintain silence, set rules and are strict.

The boundaries between the sectors are not strict and overlapping between neighbouring sectors is possible. For example, teachers who have high scores for the CD Helpful/Friendly sector would also tend to exhibit CS Understanding sector behaviours. On the other hand, sectors on the opposite sides of each other describe opposite behaviours. As the scales of the QTI are arranged to form a circumplex model, it predicts that correlations between two adjacent scales are expected to be highest, then gradually decrease until opposite scales are negatively correlated. Figure 2.1 shows the circumplex model of teacher behaviours.

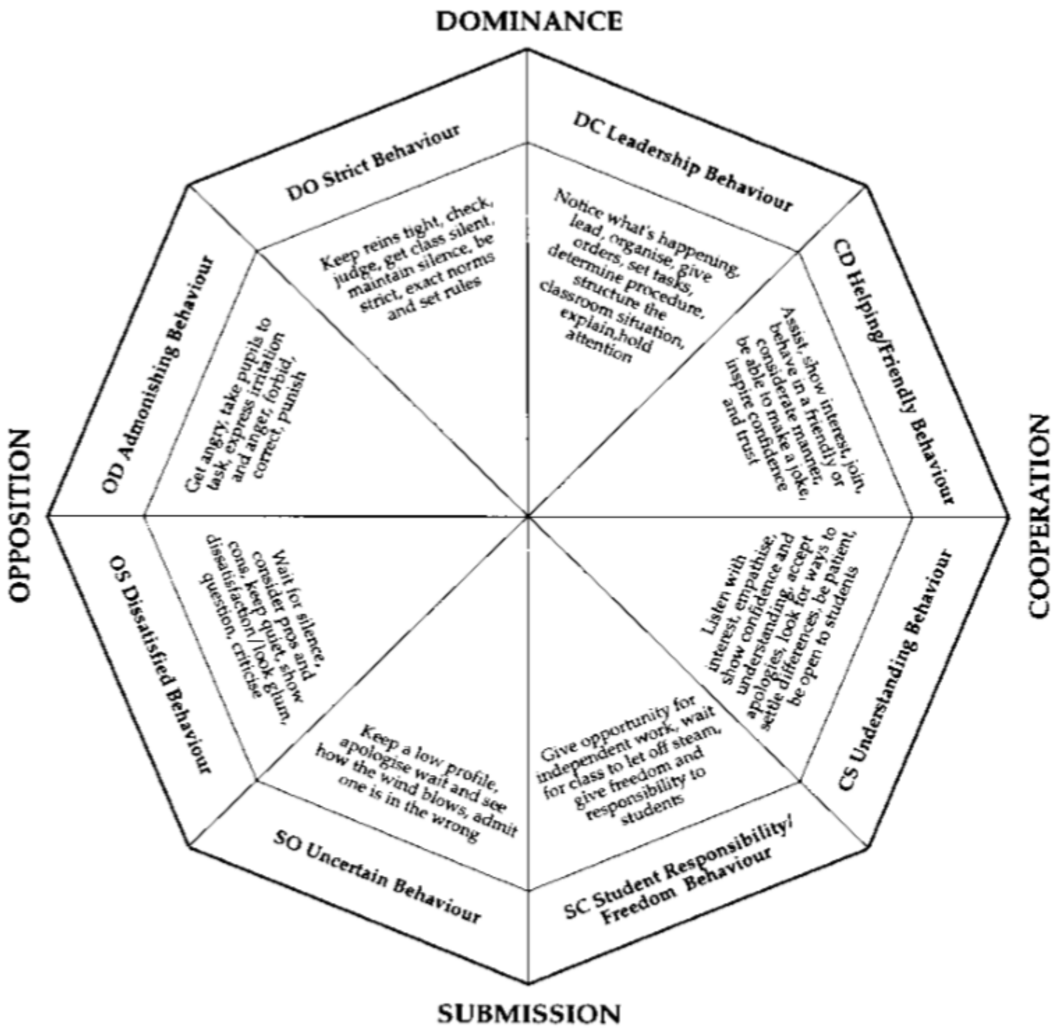

Figure 2.1. The circumplex model (Goh & Fraser, 1998; Wubbels & Levy, 1993).

Unlike other instruments where all the items measuring the same scale are together, the 48 items of the QTI are arranged in a cyclic order, in blocks of eight, with one item in each block measuring a different scale in the sequence, starting with the Leadership scale and ending with the Strict scale. The process is repeated again in the next block so that a circumplex model is obtained. See Table 2.6 to see the allocation of the items into the eight scales. So for the DC Leadership scale, the mean score is obtained from item numbers 1, 9, 17, 25, 33 and 41. Likewise for the other scales.

Table 2.6

Allocation of the Items in Each Scale of the QTI

Scale	No. of Items	Item number in the Scale
DC Leadership	6	1, 9, 17, 25, 33, and 41
CD Helpful/Friendly	6	2, 10, 18, 26, 34, and 42
CS Understanding	6	3, 11, 19, 27, 35, and 43
SC Student Responsibility / Freedom	6	4, 12, 20, 28, 36, and 44
SO Uncertain	6	5, 13, 21, 29, 37, and 45
OS Dissatisfied	6	6, 14, 22, 30, 38, and 46
OD Admonishing	6	7, 15, 23, 31, 39, and 47
DO Strict	6	8, 16, 24, 32, 40, and 48

From the mean scores obtained in all the scales, charts of various teacher behaviours could be plotted. See Figure 2.2 of general plots of the some teacher behaviours.

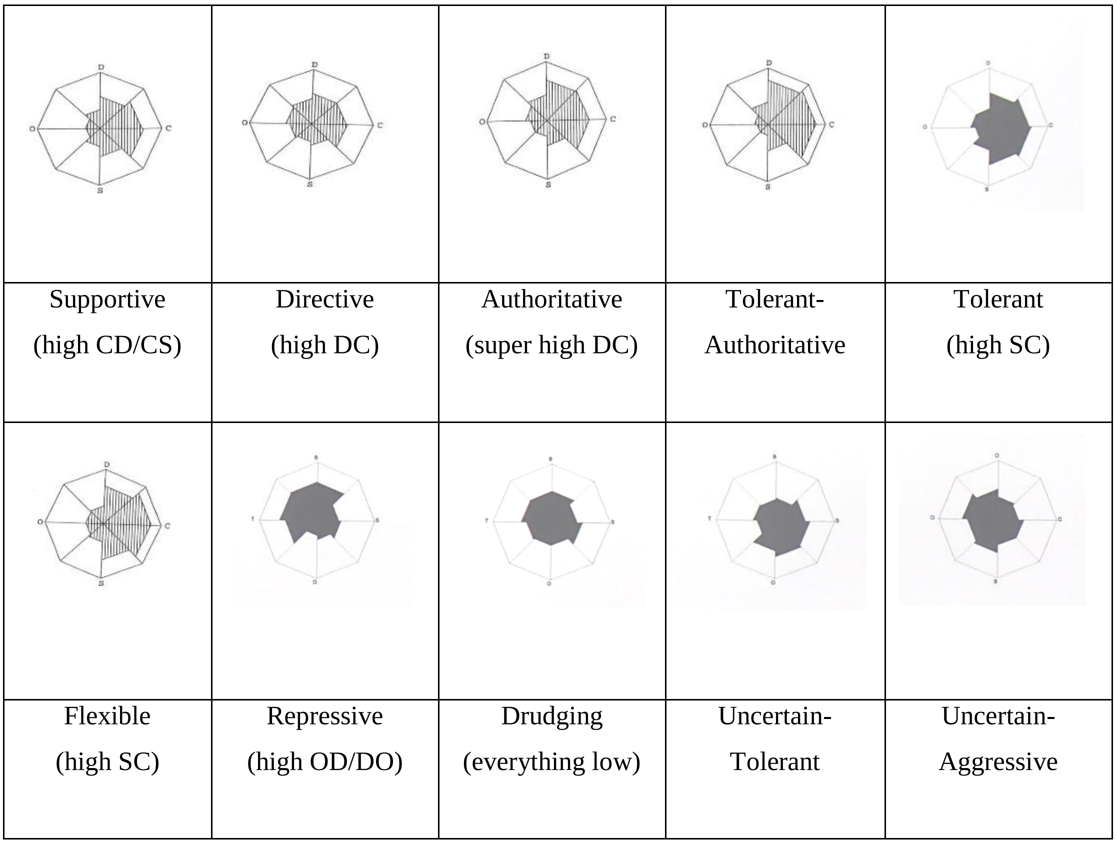

Figure 2.2. General plots of some teacher behaviours.

(Adapted from Brekelmans et al., 2002, p. 78)

Each of the shaded area represents a measure of a particular behaviour. In each sector, the further the shading is from the centre, the more significantly or frequently the behaviour is perceived to be exhibited. It was found that classes with Uncertain-aggressive teacher behaviours generally had low cognitive student outcomes, low affective outcomes and medium participation rate while classes with authoritative teacher behaviours generally had high cognitive and affective outcomes and high participation rate (Brekelmans, Wubbels, & den Brok, 2002).

The QTI comes in three versions - the Students' Actual version, Students' Ideal version and the Teacher's Self version. The Students' Actual version measures students' actual perception of their teachers while the Students' Ideal version captures students' perception of their ideal teacher. Moreover, the QTI may not only be used to provide an understanding of student-teacher relationship in the classroom from the perspective of students, the QTI Teacher Self version provides an understanding of the interaction from the teacher's perspective as well. It has been used to provide understanding of teacher profile with learning outcomes in Asia. The QTI has been used in Singapore, Brunei, Korea and Indonesia. The QTI has been cross-validated internationally. It showed good reliability and validity across different countries and quickly became another popular instrument used to help assess and improve classroom environments (Fraser, 1998; Goh, 2002).

In addition, for the QTI to be reliable, it should be administered to at least 10 students in a class for at least two classes. As teacher behaviour is relatively stable, it does not need to be administered more than once a year (Brekelmans, Wubbels, & den Brok, 2002).

<u>The SLEI:</u>

The SLEI was developed for use in the laboratory settings for senior high school or higher education levels (Fraser, Giddings, & McRobbie, 1992). It was developed because of the importance of laboratory settings in science education. It has five seven-item scales and assesses Open-Endedness, Student Cohesiveness, Integration, Rules Clarity, and Material Environment. Of special mention is the Open-Endedness, which according to literature, is important in science practical sessions. See Table 2.7 for the description of the scales, item examples in each scale, and scoring of the SLEI.

Table 2.7

Description and Example of Items for Each Scale in the SLEI Actual Instrument

Scale	Description	Item example for the Actual version	Scoring
Student Cohesiveness	The extent to which students know, help and are supportive of one another.	I get along well with students in this laboratory class.	Items are scored 1, 2. 3, 4, 5
Open-Endedness	The extent to which the laboratory activities emphasize an open-ended divergent approach to experimentation.	In my laboratory sessions, the teacher decides the best way for me to carry out the experiments.	Items are scored 5, 4, 3, 2, 1
Integration	The extent to which the laboratory activities are integrated with non-laboratory and theory classes.	I use the theory from my regular Science class sessions during laboratory activities.	Items are scored 1, 2. 3, 4, 5
Rule Clarity	The extent to which behaviour in the laboratory is guided by formal rules.	There is a recognized way for me to do things safely in this laboratory.	Items are scored 1, 2. 3, 4, 5
Material Environment	The extent to which the laboratory equipment and materials are adequate.	I find that the laboratory is crowded when I am doing experiments.	Items are scored 5, 4, 3, 2, 1

The SLEI has been used in the USA, Canada, England, Israel, Australia and Nigeria, and in Singapore (Fraser, 2002). The validity of the SLEI has been established in Singapore by Wong and Fraser (Wong & Fraser, 1996, 1997). The SLEI is intended for use in situations in which a separate laboratory class exists.

<u>The TROFLEI:</u>

The TROFLEI was developed by Fisher, Fraser, and McRobbie in 1996 to assess classroom environments where technology is used so that the impact of Information and Communications Technology (ICT) on the learning environment could be monitored. It drew upon the robust nature of the WIHIC questionnaire such that with it as the basis, other scales were added to it to form the TROFLEI instrument. Thus, the first seven scales of the TROFLEI are in fact scales from the WIHIC, assessing Teacher Support, Equity, Student Cohesiveness, Involvement, Investigation, Task

Orientation, and Cooperation. Three scales were added to these which were considered especially relevant to ICT and outcomes-focused learning environments, assessing Differentiation, Young Adult Ethos, and Computer Usage. The original scales had eight items each which were later reduced to seven items each.

Table 2.8
Description and Example of Items for Each Scale in the TROFLEI

Scale	Description	Item example
Student Cohesiveness	The extent to which students know, help and are supportive of one another.	I work well with other class members.
Teacher Support	The extent to which teacher helps, befriends, trusts, and shows interest in students.	The teacher helps me when I have trouble with my work.
Involvement	The extent to which students have attentive interest, participate in discussions, perform additional work and enjoy the class.	The teacher asks me questions.
Investigation	The extent to which there is emphasis on the skills and their use in problem solving investigation.	I carry out investigations to test my ideas.
Task Orientation	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.
Cooperation	The extent to which students cooperate rather than compete with one another on learning tasks.	When I work in groups in this class there is teamwork.
Equity	The extent to which the teacher treats students equally.	I get the same amount of help from the teacher as do other students.
Differentiation	The extent to which teachers cater for students differently on the basis of ability, rates of learning and interests.	I do work that is different from other students' work.
Young Adult Ethos	The extent to which teachers give students responsibility and treat them as young adults.	I am encouraged to take control of my own learning.
Computer Usage	The extent to which students use their computers as a tool to communicate with others and to access information.	I use the computer to take part in on-line discussions with other students.
Attitude to Subject	The attitude of the student towards Science.	I look forward to Science lessons.
Attitude to Computer Use	The attitude of the student towards the use of computers.	I like working with computers.
Academic Efficacy	The extent to which students are confident in their ability to do well in the subject.	I find it easy to get good grades in Science.

The TROFLEI was further modified to include three affective outcome scales - Attitude to Subject (from the Test of Science Related Attitude instrument developed by Fraser in 1981), Attitude to Computer Use (from the Computer Attitude Scale developed by Newhouse in 2001) and Academic Efficacy (from scale developed by Jinks and Morgan in 1999) to investigate students' attitudes (Aldridge & Fraser, 2003). See Table 2.8 for the description of the scales and item examples in each scale of the TROFLEI. Results from attitude scales would give a good indication of whether students are enjoying the subject as students who enjoy the subject would tend to have better attitudes towards the subject.

The CLES:

The CLES was developed by Fraser and Taylor in 1991 to assess the degree to which a particular classroom's environment is consistent with a constructivist epistemology to enable teacher-researchers to monitor their development of constructivist approaches to teaching.

It was based on a theory of constructivism underpinning recent research in the teaching and learning of Science and Mathematics at that time. According to the constructivist view, meaningful learning is a cognitive process in which individuals make sense of the world in relation to the knowledge which they already have constructed.

The original version of CLES had 36 items which assessed the environment on five scales - Personal Relevance, Uncertainty, Critical Voice, Shared Control, and Student Negotiation. The CLES has been revised to include 42 items. See Table 2.9 for the description of the scales and item examples in each scale of the CLES.

The goal of this instrument was to provide teachers with an efficient means of learning about their students' perceptions of the extent to which their classrooms enabled them to reflect on their prior knowledge, develop as autonomous learners, and negotiate their understandings with other students. The CLES has been used in Singapore, Korea and Taiwan (Fraser, 2002).

Table 2.9

Description and Example of Items for Each Scale of the CLES

Scale	Description	Item example
Personal Relevance	The extent to which school Science is relevant to students' everyday out-of-school experiences.	What I learn has nothing to do with my out-of-school life.
Uncertainty of Science	The extent to which opportunities are provided for students to experience that scientific knowledge is evolving and culturally and socially determined.	I learn about the different knowledge used by people in other countries.
Critical Voice	The extent to which students feel that it is legitimate and beneficial to question the teachers' pedagogical plans and methods.	It's okay to ask the teacher 'why do we have to learn this?'
Shared Control	The extent to which students share with the teacher control for the design and management of learning activities, assessment criteria, and social norms of the class.	I have a say in deciding how my learning is assessed.
Student Negotiation	The extent to which students have opportunities to explain and justify their ideas, and to test the viability of their own and other students' ideas.	Other students ask me to explain my ideas.

2.2.4 Previous Learning Environment Studies in Singapore

Research studies on learning environments began to emerge in Singapore in the early 1990s (Goh, 2002). According to Goh, studies in learning environment have been carried out at all levels ranging from Primary to Adult education, in different streams spanning Normal to Gifted streams, and across various disciplines as diverse as Science and General Paper.

According to Goh, the first learning environment study in Singapore could be said to have taken place in 1993, when Lim conducted research on Secondary Four students to see what perceptions they had of their classroom environment using the ICEQ. It was an extensive study involving different types of schools (below average to elite), different streams (Gifted, Special, Express and Normal), different subjects specializations (Art, Science, Technical and Commerce), and varied socio-economic backgrounds (high, middle and low). Both the Actual and Preferred versions of the ICEQ were used. The findings revealed that the school, stream, subject specialization and socio-economic backgrounds had an impact on students' perceptions on all the scales of the Preferred classroom environment, while they had impact only on some of the scales of the Actual environment. The differences between the two perceptions were also used to improve classroom environments to help the students learn better in their classes.

Studies that involved Secondary schools include one carried out by Wong and Fraser in 1994 on Science laboratory classroom environments using the CLEI, which is a modified SLEI and the QOCRA, which is a modified TOSRA, to find out students' attitudes in Chemistry laboratory classes (Wong & Fraser, 1996). A sample of 1,592 students in 56 classes from 28 schools were involved in this research. Findings revealed gender differences in favour of girls who had more positive perceptions of their Science laboratory environment. Significant associations were also found between the Chemistry laboratory environment and students' attitudes.

Goh and Fraser conducted a study in 1998 to establish associations between the classroom environment and achievement and attitudes towards Mathematics (Goh & Fraser, 1998). The study involved 1,512 Primary students in 13 Primary schools and the MCI and simplified QTI were used in conjunction. Findings revealed that student-teacher relationships and classroom environment were significantly related to students' achievement and attitude towards learning. The study also cross-validated the QTI for use in Singapore.

In 2001, Quek, Wong, and Fraser combined the use of the CLEI, QTI and QOCRA to study the Chemistry laboratory environment and teacher interpersonal behaviour in Secondary Four Gifted and Express streams (Quek, Wong, & Fraser, 2005). This time, a sample of 497 students were involved in this study. The researchers found strong associations between students' enjoyment of their Chemistry laboratory classes and perceptions of teacher interpersonal behaviour, especially on the helpful/friendly scale. Gender differences were found in the Actual and Preferred Chemistry laboratory classroom environments and teacher-student interactions. In the Gifted stream, girls had better perceptions of their teachers while girls had less favourable perceptions of their teachers in the Express stream. The results were also used for improving the Chemistry laboratory classroom environments.

The CLES was used in Singapore in an expanded and modified way to study the classroom environment of 1,046 Junior College students in 48 classes for General Paper (Fraser, 2002). Data supported strong support for the validity and reliability of the modified CLES. There was no apparent overall pattern of differences between genders and educational and socio-cultural factors responsible for obstacles to constructivist changes were specified. The research was the first of its kind conducted in Singapore and provided a rich source of data for study related to constructivism in the Singapore context.

Another popular instrument that has been used in Singapore is the WIHIC. The WIHIC was used by Chionh & Fraser in 2000 to study relationships between classroom environments in Mathematics and Geography classes and three student outcomes, namely achievement, attitude and self-esteem (Chionh & Fraser, 2009). The study involved 2310 students in 75 classes from 38 randomly selected schools in Singapore. Higher examination scores were found in classrooms with stronger student cohesiveness, while higher self-esteem and better attitudes were found in classes with more teacher support, task orientation and equity. Students also perceived their Geography and Mathematics classrooms in relatively similar manners.

A customized WIHIC was used by Chua, Wong, and Chen in 2000 to study the validity of the instrument for use in Chines Language classrooms in Singapore (Chua, Wong, & Chen, 2006). A sample of 1460 students from 25 government schools were involved in this study. The scales exhibited high internal consistency reliability and satisfactory discriminant and factorial validity.

The WIHIC was also used to establish links between student satisfaction and the classroom environment in adult Computer classes (Khoo & Fraser, 2008). A sample of 250 adults were involved in this study. Findings showed that there was more student satisfaction when there was more teacher support, involvement and task orientation. The study also revealed gender differences in student satisfaction, with men perceiving more Teacher Support and Involvement and women perceiving less Equity.

2.2.5 Summary

With so many instruments that could be used for my study, a careful literature review on learning environment and how it may be measured was carried out. The review on learning environment began with a historical study of environment research. This was followed by a description of the development of some of the key instruments used to rigorously measure and describe learning environments. Next, past studies carried out in Singapore was investigated to see if these key instruments have been used locally, and if so, to see how they were used in conjunction with one another.

As the literature review progressed, an idea of how they could be used in this study was obtained. To help the selection of instruments for use in this study, a detailed description of five instruments that have been used in Singapore were then highlighted.

The WIHIC, one of the most robust instruments for measuring learning environments, was selected for this study as the literature review showed that it not only has strong standing in countries out of Singapore, but in Singapore as well.

On this foundation, the QTI and the attitude scales from the TROFLEI were next selected for use in conjunction with the WIHIC in order to capture a more holistic picture of the environment. The QTI was selected as it would give insights into student-teacher interpersonal relationships in the classroom environment. The TROFLEI was selected as it comprised a comprehensive set of affective outcomes scales. These attitude scales would enable the attitudes component to be captured comprehensibly. Moreover, the QTI and TROFLEI also have strong validity and reliability for use in the Singapore context.

According to Fraser (1998), the learners are in the best position to assess the environment. The average student would not only be aware of the tremendous variation that exists in learning environments as they move from primary to secondary school or teacher to teacher, but also a clear understanding of what he or she prefers. For this reason, only the student version of QTI was used in my study. Data collection using the teacher self-version was not included. For practical reasons, only the actual version of the student version was used in this study.

To measure attitude, instead of using the TROFLEI in its entirety, only the three affective outcome scales of the TROFLEI, namely the Attitude to Subject, Attitude to Computer Use and Academic Efficacy scales, were selected in conjunction for use with the WIHIC and the QTI in an attempt to reduce survey fatigue. The complete set of items for the three affective outcome scales can be found in Appendix 10.

Lastly, as the focus of the study was not to obtain information about students' perceptions of the extent to which their classrooms enabled them to reflect on their prior knowledge, develop as autonomous learners, and negotiate their understandings with other students, the CLES was not selected. As the Science classrooms rather than the Science laboratory environments were the focus of the study, the SLEI was not selected as well.

2.3 THE SCIENCE CURRICULA AND ASSESSMENT IN SINGAPORE NEIGHBOURHOOD SCHOOLS

This section presents the Science curriculum and assessment in a typical Singapore neighbourhood Secondary school in greater detail in three sub-sections. Section 2.3.1 introduces the Singapore 21st century competencies framework that encapsulates the thrust of education in Singapore for the future. This is followed by Section 2.3.2 which introduces the Singapore science curricula. The syllabi for some sciences are included to show how the curricula are covered in actual teaching. Section 2.3.3 covers assessment in Singapore in greater depth. Lastly, Section 2.3.4 concludes the section with a summary.

2.3.1 The 21st Century Competencies Framework

Like in many countries around the world, Singapore has come up with a vision to prepare our students to thrive in the 21st Century. The 21st Century competencies framework (see Figure 2.3) encapsulates the thrust of education in Singapore in the future. It aspires to develop future citizens who are confident, self-directed life-long learners, concerned, and active contributors of society.

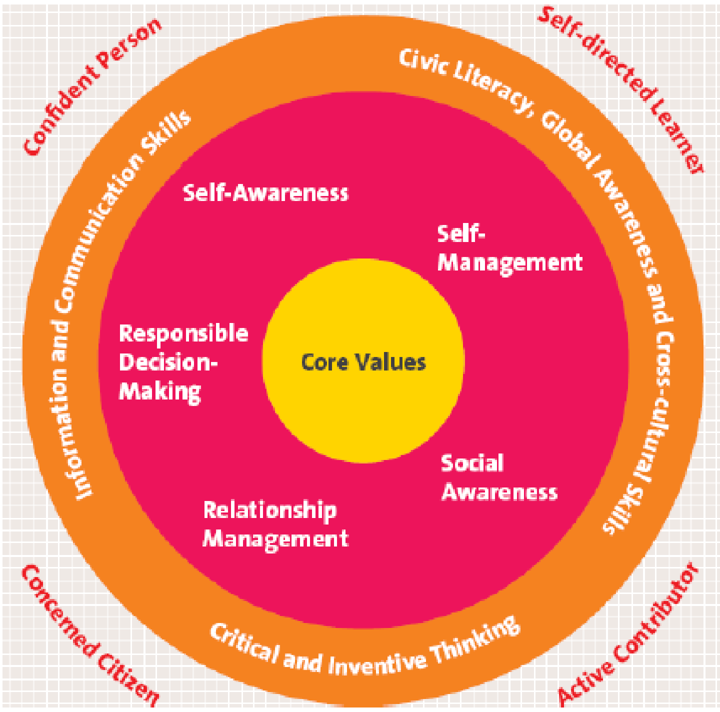

Figure 2.3. The Singapore 21st century competencies framework.

Competencies in three domains which are of paramount importance in the 21st Century are built into the framework around the core values. These domains include Civic literacy, global awareness and cross-cultural skills, Critical and inventive thinking skills, and Information and communications skills. These competencies encompassed in the three domains have been termed as the 21st Century Competencies in Singapore and are integrated into the Singapore Science curricula described in the next section.

2.3.2 The Singapore Science Curricula

The Singapore Science curriculum seeks to nurture the student as an inquirer. This is based on the belief that children are curious by nature and have the inherent desire to explore and learn about the things surrounding them. The Singapore Science curriculum leverages on this point and seeks to develop this spirit of curiosity. The teacher is the leader of inquiry in the science classroom. Teaching and learning approaches centre around the student as an inquirer.

The Science Curriculum Framework (see Figure 2.4) is derived from the policy framework for the teaching and learning of Science.

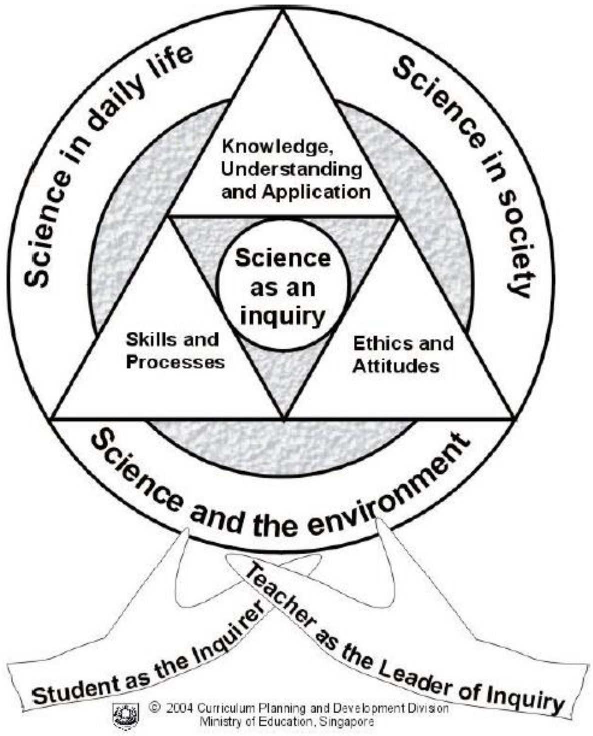

Figure 2.4. The Singapore science curriculum framework.

At the centre of the framework is the inculcation of the spirit of scientific inquiry. Represented by the three triangles, the conduct of inquiry is founded on three domains (a) Knowledge, understanding and application, (b) Skills and processes, and (c) Ethics and Attitudes. Table 2.10 provides the description of each domain that frames the practice of science in Singapore. Students and teachers need to work hand-in-hand to make the learning of Science a success. Whilst teachers have to be hardworking and responsible, students also need to play a part and learn how to be responsible for their own learning.

Table 2.10

Description of Each of the Three Domains

Knowledge, Understanding and Application	**Skills and Processes**	**Ethics and Attitudes**
Scientific phenomena, facts concepts and principles Scientific vocabulary, terminology and conventions Scientific instruments and apparatus including techniques and aspects of safety Scientific and technological applications	Skills: Posing questions Formulating hypothesis Defining the problem Generating possibilities Predicting Observing Using apparatus and equipment Comparing Classifying Inferring Analysing Evaluating Verifying Communicating Processes: Creative problem-solving Planning investigation Decision-making	Curiosity Creativity Objectivity Integrity Open-mindedness Perseverance Responsibility

As the curriculum design seeks to make the study of science meaningful and authentic to students, inquiry is thus grounded in issues and questions that relate to the roles played by science in daily life, in society, and in the environment.

Science in daily life caters to the personal perspective that focuses on the individual. This component comprise of using scientific skills in everyday life e.g. observing trends and analysing data from media reports; being adaptable to new scientific and technological advances e.g. the use of IT tools; and making informed choices that are related to science and technology e.g. consumption of genetically modified food. To help to nurture confident citizens in a technological world in the 21st Century, domains that are integral to the conduct of Science inquiry are developed. The acquisition of Science knowledge and understanding, skills and abilities, and other attributes relevant to the study of science to make further studies possible are developed. Integrating 21st Century competencies also involves promoting awareness that the study and practice of Science are cooperative and cumulative activities, subject to social, economic, technological ethical and cultural influences and limitations.

Science in society provides the social perspective that focuses on human interactions. This component comprise of engaging in meaningful scientific discourse with others, understanding the impact of science and technology in society, and contributing to the progress of science. Science in the environment provides the naturalistic perspective that focuses on man-nature relationship. This component comprise of understanding the place of humanity in the natural world, showing awareness of safety and biological issues (e.g. SARS), and demonstrating care and concern for the environment (e.g. global warming). To nurture 21st century competencies to develop concern citizens and active contributors, students are engaged in Science-related issues to stimulate their curiosity, interest and enjoyment in Science promoting their interest and care for the environment.

The Lower Secondary Science Syllabus is based on the Science Curriculum Framework and emphasizes on the need for a balance between the three domains, namely, acquisition of science knowledge, skills and attitudes. 85% of curriculum time is set aside for the acquisition of the three domains. 15% of the curriculum time known as ‘white space’ is set aside for teachers to use more engaging teaching and learning approaches or to implement customized school-based programs to make learning more meaningful and enjoyable.

As students are streamed according to their abilities at the end of Primary school, there are two different syllabi available at the Lower Secondary level - one for the Normal Technical (NT) stream and one for the Normal Academic (NA) and Express streams. Although the NA and Express streams share the same syllabus, there are optional topics for the NA stream. However, whatever the stream, both syllabi are based on the Science Curriculum Framework which emphasizes the balance between the acquisition of science knowledge, skills and attitudes. See Appendices 11 and 12 for sample pages of the Singapore NT and NA/Express Science syllabi respectively. Streaming allows differentiated learning, which allows students to learn at their own pace. At present, the Subject-based Banding (SBB) program is being piloted in 12 schools, which allows students in NT and NA streams to take a the subject at a higher stream, for example, NT student may take NA science and NA student may take Express Science. In the pilot stage, only three subjects are involved - English, Maths, and Science.

The Knowledge component is structured in a similar way to the Primary Science Syllabus so that transition into Secondary school may be smoother. It is based on themes that the students can relate to in their everyday experiences and to commonly observed phenomena in nature, namely, Diversity, Models, Systems and Interactions with the purpose of providing a broad-based understanding of the environment. In addition to these four themes, knowledge about Science is highlighted in an introduction. Although the syllabus is organized around these four themes and the introduction, there are no clear cut boundaries between these themes in the hope to minimize compartmentalization of content.

Teachers are encouraged to provide opportunities for students to use concepts and integrate skills and processes to inquire about phenomena around them. In all scientific inquiry, the adoption of good attitudes is encouraged and the teaching of ethics in Science incorporated (e.g. use of virtual reality to introduce the anatomy of a frog instead of live dissection to teach animal testing). The broad-based understanding would help to build a foundation for students to rely on as they continue with further studies.

At the end of Secondary Two, students are streamed into classes based on their subject combinations. The Lower Secondary syllabi prepare students for Upper Secondary levels, where they spend two to three years in preparation of the Singapore-Cambridge General Certificate of Education (GCE) ‘N’ level or ‘O’ level examinations. The Science syllabi at the Upper Secondary level are dependent on the various different types of Sciences chosen by the students. See Appendices 13 to 16 for sample pages of the syllabus content for Science at the ‘N’ level and Chemistry at the ‘O’ level, Combined Chemistry at the ‘O’ and ‘N’ levels for the various streams.

In the next section, Section 2.3.3, assessment in Singapore neighbourhood schools is covered in greater details.

2.3.3 Assessment in Singapore Neighbourhood Schools

Assessment is an integral part of the teaching and learning process in Singapore, often providing formative and summative feedback to teachers, students, schools and parents.

The aims of the Lower Secondary Science are the acquisition of knowledge, understanding and application of science concepts, the ability to use process skills and the development of attitudes that are important to the development of science. The assessment objective of the syllabi are aligned to the three domains in the Science Curriculum Framework, namely, assessment of knowledge, assessment of skills and processes, and assessment of attitudes.

Written assessment varies among subjects. In general, class tests and common tests are given in every term to make up Continual Assessment (CA) 1 marks (for Terms 1 and 2) and CA 2 marks (for Terms 3 and 4) and mid-year and end-of-year examinations given at the end of every semester to make up Semestral Assessment (SA) 1 and SA 2 marks respectively. The tests are normally used for both formative and summative assessments while the examinations are usually used as summative assessment.

The large class size in a typical neighbourhood school does not make it easy for assessment in the other domains to be carried out. It also makes regular formative assessment more difficult to carry out in practice.

After the Primary School Leaving Examinations, the students are streamed into Normal Technical (NT), Normal Academic (NA) and Express streams according to their abilities. The mid-year and end-of year examinations format differ accordingly to these streams. See Tables 2.11 to 2.13 for samples of the NT, NA and Express examination formats.

Table 2.11

Scheme of Assessment Lower Secondary NT Science

Sections	Type of Question	Duration	Marks	Weighting
A	Multiple Choice Questions		40	40%
B	Structured Questions	1 h 15 min	30	30%
C	Essay Questions		30	30%

Table 2.12

Scheme of Assessment Lower Secondary NA Science

Sections	Type of Question	Duration	Marks	Weighting
A	Multiple Choice Questions		40	40%
B	Structured Questions	1 h 45 min	30	30%
C	Essay Questions		30	30%

Table 2.13

Scheme of Assessment Lower Secondary Express Science

Sections	Type of Question	Duration	Marks	Weighting
A	Multiple Choice Questions		30	30%
B	Structured Questions	1 h 45 min	40	40%
C	Essay Questions		30	30%

As the syllabus for the NA Science is similar to the Express Science, its level of difficulty is closer to that of the Express paper than to the NT paper. The allocated time for the NA examination is thus the same as that allocated for the Express examination.

In a typical neighbourhood school, at the end of Secondary Four, NT and NA students sit for the national examinations, namely, the GCE 'N' level examinations. If the NA students do well and choose to continue their education in their Secondary school, they will sit for the GCE 'O' level examinations together with the Secondary Four Express students in the following year when they are in Secondary Five. Tables 2.14 and 2.15 show a sample scheme of assessment for Science (Phy/Chem) for NA students and Science for NT students. Note that there is no practical examination for Normal students.

Table 2.14

Scheme of Assessment for GCE 'N' level Science (Phy/Chem)

Paper	Type of Paper	Duration	Marks	Weighting
1	Multiple Choice (Physics)	1 h 15 min	20	20%
2	Structured (Physics)		30	30%
3	Multiple Choice (Chemistry)	1 h 15 min	20	20%
5	Structured (Chemistry)		30	30%

Table 2.15

Scheme of Assessment for GCE 'N' level Science Syllabus T

Paper	Type of Paper	Duration	Marks	Weighting
1	Multiple Choice	1 h	40	40%
5	Short-answer or structured	1 h 15 min	60	60%

Secondary Express students are given the option to do pure Sciences and combined Sciences. For students taking Pure Sciences, besides the theory examinations, the School-Based Science Practical Assessment (SPA) is conducted to assess practical skills.

SPA is a national assessment on practical skills that is conducted over two years from Secondary Three to Four. Assessment comprises Skill Set 1 on performing and observation, Skill Set 2 on data analysis and Skill Set 3 on planning. Students take two tests on Skill Set 1 and 2 and take one test on Skill Set 3. For Skill Set 1, students are assessed individually on practical skills using rubrics. See Table 2.16 for more information on SPA.

Table 2.16

Marks Allocation for the School-Based Science Practical Assessment

Skill Set	No. of Assessments (a)	Max Marks per Assessment (b)	Weight (c)	Sub-total (a x b x c)	Weighting
1	2	6	4	2 x 6 x 4 = 48	50%
2	2	4	3	2 x 4 x 3 = 24	25%
3	1	4	6	1 x 4 x 6 = 24	25%
Total Marks for SPA				96	

The total 96 marks for SPA will make up 20 percent of the total assessment for the pure Science subject, as shown in Table 2.17.

Table 2.17

Weighting of Each Paper for a Pure Science GCE 'O' Level Examination

Paper	Type of Paper	Duration	Marks	Weighting
1	Multiple Choice	1 h	40	30%
2	Structured and Free Response	1 h 45 min	80	50%
3	School-based Science Practical Assessment (SPA)	-	96	20%

For the combined Sciences, the GCE 'O' level practical examinations are conducted. Table 2.18 shows a sample scheme of assessment for combined Biology.

Table 2.18

Scheme of Assessment for GCE 'O' level Science (Biology)

Paper	Type of Paper	Duration	Marks	Weighting
1	Multiple Choice	1 h	40	20%
2	Structured and Free Response (Physics)	1 h 15 min	80	32.5%
3	Structured and Free Response (Chemistry)	1 h 15 min	80	32.5%
4	Structured and Free Response (Biology)	1 h 15 min	80	32.5%
5	Practical Examination	1 h 30 min	30	15%

For example, if a student chooses Science (Biology/Chemistry), the student would take Papers 1, 3, 4 (which are the theory papers) and 5 (which is the practical paper).

2.3.4 Summary

Like many countries around the world, Singapore is preparing its future generation not only for survival in the 21st Century, but to thrive in the 21st Century. The 21st Century competencies framework encapsulates the thrust of education in Singapore in the future. It aspires to develop future citizens who are confident, self-directed life-long learners, concerned, and active contributors of the global society.

The Singapore Science curriculum nurtures the Science student as an inquirer. Although lessons in classrooms are meant to be inquiry-based, more often than not, Science lessons are often conducted in a traditional manner. Textbooks and workbooks are still heavily relied on and teachers tend to disseminate information to students. However, it is more common to see students working in groups, there is more emphasis on understanding key concepts, and more teachers are willing to spend ‘wait time’ for students to ask and answer questions.

The Lower Secondary Science syllabus is based on the Science Curriculum Framework and emphasizes balance between the three domains. The aims are the acquisition of knowledge, understanding and application of Science concepts, the ability to use process skills, and the development of attitudes that are important to the development of Science. The assessment objective of the syllabi are thus aligned to the three domains in the Science Curriculum Framework, namely, assessment of knowledge, assessment of skills and processes, and assessment of attitudes.

In a typical neighbourhood school, the Lower Secondary syllabi prepare students for Upper Secondary levels, where they spend two to three years in preparation of the Singapore-Cambridge General Certificate of Education (GCE) ‘N’ level or ‘O’ level examinations. The curriculum for Upper Secondary students depends on the subject and streams of the students.

At the end of Secondary Four, NT and NA students sit for the national examinations, namely, the GCE ‘N’ level examinations. If the NA students do well and choose do continue their education in their Secondary school, they will sit for the GCE ‘O’ level examinations together with the Secondary Four Express students in the following year when they are in Secondary Five. NT students progress to further education in Institute of Technical Education (ITEs) where they will learn skills of trade. There are no practical examinations for GCE ‘N’ level.

Secondary Express students are given the option to do pure Sciences and combined Sciences. For students taking Pure Sciences, besides the theory examinations, the School-Based Science Practical Assessment (SPA) are conducted to assess practical skills. For Express students taking combined Sciences, the GCE ‘O’ level practical examinations are conducted. Students who do well progress to further education in institutions like the Junior Colleges for their GCE ‘A’ levels or Polytechnics for their diplomas.

Once the student leaves school after taking the GCE ‘N’ level or ‘O’ level examinations, Secondary School education in Singapore is competed.

2.4 TEACHING AND LEARNING

The literature review in Section 2.4 consists of a literature review on teaching and learning broken down into five sub-sections. It begins with Section 2.4.1, with an introduction on learning theories in general followed by Section 2.4.2, a section devoted to the teaching and learning of Science.

From the learning theories introduced in the Section 2.4.1, not only can teaching be made more effective, the learning of Science can be made both meaningful and enjoyable, such as through the use of Information and Communications Technology (ICT). As we make our progress into the 21st century, the use of ICT in schools is given great emphasis in Singapore schools, as witnessed by the introduction of the many ICT MasterPlans in Singapore. Section 2.4.3 is devoted to the use of ICT in the teaching of Science. Suggestions on how to capitalize and harness this powerful tool are included in this section to make lessons effective and lessons more enjoyable. In particular, literature review is conducted to investigate how ICT has been used to foster self-regulated and independent learners. Section 2.4.4 describes the role of self-regulation in independent learning and suggests some ways to develop self-regulation in students.

In Section 2.4.5, a literature review on the role of attitudes in science and self-efficacy is studied. Common associations of learning environments and student-teacher interactions with attitude and performance in the subject are included in this section. In Section 2.4.6, suggestions on how to improve student-teacher interpersonal relationships are included. The role of attitude, including academic efficacy, and the role of student-teacher interactions in learning is described in the last section. Other associations in particular with students' cognitive outcomes are also included in this section.

Section 2.4.7 ends the section with a summary.

2.4.1 Learning Theories

Learning theories have developed in the past century from behaviourism, to cognitivism, to constructivism (Duit & Treagust, 1998). Constructivism, later expanded to include social constructivism as learning often takes place in a social context. The influence of these different learning theories could be seen in the changes of focus in research in science education.

The influence of behaviourist learning theories led to a focus on discovering whether or not changes in a teaching procedure or curriculum led to changes in students' academic performance. Less or little attention was given to why or how these changes occurred.

As our thoughts also have an important control over our behaviours, Piaget's cognitive theory which was developed in the 1920s replaced behavourism as the dominant school of thought in the late 1960s. Cognitive theories focused on the human mind for understanding how people learn. Mental processes like thinking, memory, problem solving gained importance and learning was defined as a change in a learner's schemata. In the cognitive theories of learning, the learner is a computer who actively processes the information from the environment, before outcomes are produced.

Piaget's cognitive theory emphasized the need for manipulative materials to strengthen connections (Novak, 1978). The application of this can be observed when teachers help students build schemata and make connections by providing opportunities for discussions, role playing, incorporating visual aids and other techniques to strengthen connections.

The cognitive theories developed into constructivist theories of learning, which dominated science education in the 1980s and early 1990s. In cognitive theories of learning, the learner is a computer that processes information. In constructivism, the learner is the constructor of information or knowledge, with new knowledge constructed on the basis of prior knowledge. The teacher provides scaffolds for learning so that the students can make sense and construct new knowledge. Battista (1990) even went as far as to say that no one could teach - effective teachers merely stimulate students to learn and that students learn well only when they construct their own understanding.

In constructivism, as the learner actively constructs knowledge, past experience and cultural factors are also brought into the learning process. A constructivist model of learning encourages students to develop deeper understandings, challenge what they learn and how they learn, negotiate their learning, see relevance in what they learn and reflect on what and how they learn.

Although the learner has to construct individual meaning of the new idea, the process is always embedded in a social setting in which the learner is a part, namely, the classroom. For example, one of the key aspects of mainstream constructivist approaches in the 1980s and early 1990s consisted of conceptual change approaches which include providing learning experience that develop conceptual understanding.

Conceptual change are embedded in conceptual change supporting conditions, which includes motivation, interests, beliefs of learners and teachers, classroom climate and school climate.

In my study, more emphasis was given to the 'classroom climate', 'learners' and 'teachers' components. The 'classroom climate' component is investigated mainly through the use of robust learning environment instruments like the WIHIC earlier discussed in Section 2.2. Attributes pertaining to 'learners' was investigated through the GTKY questionnaire which consists of a comprehensive set of attitude scales. The 'teachers' aspect is investigated through instruments like the QTI to obtain not just information on 'teachers' but also on the student-teacher interactions, which is covered in Section 2.4.6. Moreover, although the focus of the study did not include 'school climate', the GTKY questionnaire comprised of some self-designed questions which helped to describe this important component. Literature review on school climate is covered briefly in Section 2.6.

From a social constructivist view, teachers are facilitators of students' learning with 'a key role to assist students to problematize and reconstruct their existing conceptions and to determine the viability of their new ideas in the social forums of the classroom and the broader community'. As facilitators of students' learning, the responsibility of the learning becomes shared.

To develop student understanding of concepts, teachers can check for prior knowledge and misconceptions. To make learning more meaningful and to reduce the chance of misconceptions, analogies can be used in teaching (Harrison, 2004) and introducing opportunities for authentic problem-solving can be employed to stretch thinking. Students who are challenged to do the discovery and reasoning themselves enhance personal construction and so reduce the occurrences of misconceptions (Gunstone, 1995). As facilitators of students' learning, opportunities must be given to students to be challenged and time must be planned into lessons for students to discover and problem solve.

In social constructivism, students are provided with the opportunity to learn through social interactions (von Glasersfeld, 1995). With time for discussions and for social interactions planned into lessons, there would be more two-directional flow of information (Bodner, 1986), if not between the teacher and the student, then among students. In such lessons, students would certainly have more opportunities to have their ideas listened to (Driver et al., 1994). For example, instead of merely submitting their answers in the forms of worksheets, students would get more opportunity to listen to their peers' answers and clarify any differences. Thus, opportunities for discussions and student sense-making must be incorporated into instruction.

Having seen how learning theories address how people learn, and as teaching and learning are two sides of the same coin, a good foundation in learning theories would help to improve how we teach, including how we teach Science as a subject.

2.4.2 Teaching and Learning of Science

As we progress into the 21st century, rapid change has become an accepted part of our society and people are required to adapt as ideas become quickly obsolete (Venville, Adey, Larkin, & Robertson, 2003). The ability to think is a valuable skill in such an environment. And a good way to foster thinking is through the learning of science.

The Singapore 21st Century Competencies include, Critical and inventive thinking skills, and information and communications skills. The learning of science also gave students opportunities to identify and formulate problems (Washton, 1967). Washton wrote about the importance of science discussions and practical lessons as these also encouraged intuitive thinking. Many proven hypotheses in science were a result of intelligent guessing. So allowing students to test their hypotheses and evaluate their findings in the laboratory provided a way for them to develop such intuitive but intelligent guessing.

Testing hypotheses allowed students to learn first-hand that rejecting hypotheses was as important as proving that a hypothesis is correct. Washton wrote that through the process of hypotheses testing and evaluation, students would also learn other traits like perseverance and risk-taking. The ability to overthrow a preconceived idea on the basis of new evidence is developed through science activities and investigations.

An approach that is often used for the teaching of Science is as a form of inquiry. Using this approach satisfies our inborn curiosity and desire for explanations (Hassard, 2013). Scientific inquiry may be defined as the activities and processes which scientists and science students engage in to study the natural and physical world around us.

Teaching science as an inquiry goes beyond merely presenting the facts and outcomes of scientific investigations. In Science as an inquiry, students learn how the products of scientific investigations were derived. They learn how to ask questions, are actively engaged in the collection of evidence, learn how to formulate, and communicate explanations based on scientific knowledge. Students must be given opportunities to learn how to gather information, classify, and organize it to increase their understanding so that they can apply it in solving problems and generating new ideas.

The problem-solving activities, open-ended investigative experiments, projects, and discussions carried out in science lessons are avenues through which higher-order thinking skills are promoted. Problem solving activities offer opportunities for students to find new ways of solving problems. Open-ended investigations and projects allow opportunities for children freedom to design, carry out hands-on activities, and present their findings, while discussions allow opportunities for the students to share ideas. Not only are thinking skills fostered in the learning of science, students are provided with the opportunity to develop other positive attributes, such as good attitudes and values like curiosity, healthy skepticism, open-mindedness, and concern for living things as they carry out scientific inquiries. See Table 2.19 for a comparison between a typical traditional classroom with an inquiry-based classroom.

Table 2.19

Comparison Between Inquiry-based and Traditional Classroom (Adapted from Science Syllabus Lower Secondary Express/NA 2013, p.16)

Inquiry-based Classroom	**Traditional Classroom**
Students often work in groups	Students often work alone
Emphasis is on understanding the key concepts	Emphasis is on mastery of facts
Allows for pursuit of student questions	Follows a fixed curriculum closely
Activities rely mainly on primary sources	Activities rely mainly on textbooks and workbook materials
Students are viewed as thinkers with their own ideas about the world	Students are viewed as 'blank slates'
Teachers as facilitators in an interactive learning environment	Teachers tend to disseminate information to students
Teachers tend to seek to understand students' learning	Teachers tend to seek correct answers
Assessment is interwoven with teaching	Assessment tends to be separate from teaching

In Singapore, other popular strategies to promote inquiry-based learning and teaching have included cooperative learning, field trip, model building, Strategies for Active and Independent Learning (SAIL), and the use of Information and Communication Technology (ICT). In cooperative learning, students are divided into groups so that each student assumes certain responsibilities towards the completion of a task, learning cooperative skills along the way. Field trips provide opportunities for students to explore, discover and experience Science in real-life, making the learning of Science both authentic and exciting. Model-making provides students with the opportunity to design and be creative and gives them opportunity to construct a representation of a concept or object. Of interest is the SAIL approach, which emphasizes learning as a formative and development process through the use of clear learning expectations and rubrics. Instruction and assessment point the way for students to learn and improve continuously and teaches them how to be independent learners. ICT supports the inquiry process by facilitating collaboration, data collection, and self-directed learning etcetera. These strategies not only make the learning of Science meaningful, they help make lessons enjoyable.

Bruner focused on learning and the learner in the education of science in 1960 and came up with four themes: subject matter, readiness for learning (which led to new ideas revisited in curriculum planning), intuition and analytical thinking (this led to inquiry and discovery approaches) and motivation for learning. A matrix can be used to show the positions of some typical learning activities on a continuum of rote and meaningful learning (on the y-axis) and reception and discovery learning (on the x-axis), as shown in Figure 2.3 below.

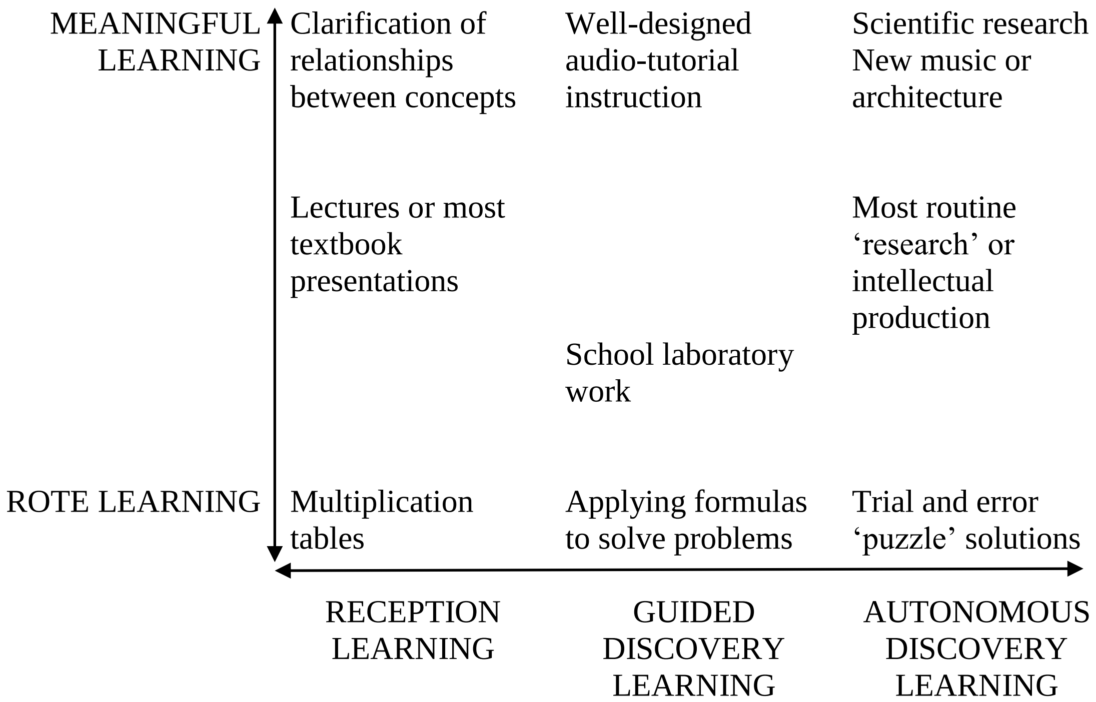

Figure 2.5. Typical forms of learning to illustrate representative different positions on a rote learning and meaningful learning matrix.

Activities like clarification in discussion sessions are high up in the matrix on the meaningful learning continuum while lectures or daily teaching with powerpoint slides and science practicals are in the middle of the matrix. Of interest is that it does not favour discovery learning over reception learning. Expository or receptive teaching can still lead to meaningful learning, depending on activities used.

From the previous section, in constructivism, the learner is the constructor of information or knowledge, with new knowledge constructed on the basis of prior knowledge. The goal of all instruction is to develop students' conceptual understanding. The application of this is observed in programs which incorporate field trips for experiential learning, problem-solving lessons for learning, inquiry and discovery learning into the teaching of science.

Also from the previous section, we saw how Piaget's cognitive theory emphasized the need for manipulative materials to strengthen connections. In the teaching of science, teachers can help students build schemata and make connections by providing opportunities for discussions, role playing and incorporating visual aids. Incorporating practical lessons into the teaching of science also gives opportunity for hands-on experience to students as they do experiments in these lessons, thereby strengthening connections.

Joyce and Calhoun (2012) wrote that successful student learning depends on the rapid and improved literacy curriculum as students with limited language skills and ICT skills will struggle with ICT applications in the content areas. It would also depend on mastery of cooperative, inductive and inquiry-based ways of learning. ICT can lead to information overload without increasing understanding of the concepts that form the domain of study. Teaching students how to learn ameliorated low socioeconomic status related problem seriously.

2.4.3 The Use of Information and Communications Technology (ICT)

Schools should capitalize on the remarkable development of ICT and its massive influence in modern life across the world (Joyce & Calhoun, 2012). ICT defines the 21st century through its pervasive influence on social relations and on how our youths use their time. ICT has resulted in positive changes in many areas, including in education. How we incorporate ICT optimally in curriculum areas is of critical importance at this time.

Apart from the reason that computers are fast becoming an integral part of everyday life in Singapore and that it is one of our government's objectives for education to go high-tech, computers are indeed useful in education as they can be extremely powerful educational tools if appropriately used. This section covers key capabilities of the computer, with particular interest to the way its use as a learning tool affects students' attitudes and academic achievement. A few practical suggestions as to how computers can be incorporated are also included.

Successive ICT Masterplans for Education supported initiatives by the Ministry of Education (MOE) of Singapore to enhance teaching and learning in schools in order to prepare our students for the future, a future that is intensely competitive, where technologies are replaced at increasing pace and where values are changing (Goh, 1997). In the fast changing global landscape, not only do future citizens have to be life-long learners, the potential of ICT as a key enabler in accelerating economic development of the country was also recognized.

The use of ICT for activities that support the development of 21st century skills, such as communicating effectively, collaborate with one another, search for information, analyse and use information from multiple sources can be incorporated into subjects taught in schools. Not only may learning be anytime, anywhere, but through any device (Foo, 2008). Learning can become ongoing and more personalised at one's own pace and at own interest. Students have access to scholars and professionals from all over the world at the click of a mouse or button. Collaborations with people in other countries around the world is available, making it possible for learning to go beyond not only the boundaries of the class but beyond that of the country. ICT enriches students' learning beyond the classroom.

Classroom activities becomes more learner-centered and interactive, teacher becomes the facilitator or collaborator of learning, instructional emphasis is shifted to finding relationships, inquiry and invention rather than sole memorization of facts, concept of knowledge is shifted from accumulation of facts to transformation of facts.

Over the last 50 years, computers have been used in the classrooms in a number of ways. Atkinson broadly categorized these ways into two basic categories - as supplementary material to the regular classroom, and as a substitute for other modes of instruction (Atkinson, 1984). In Singapore, it is mainly used as a supplementary material in classroom teaching.

Dwyer (1994) summarized some advantages of using the computer in teaching into five main reasons. The first advantage is that students are able to learn how to explore and represent information dynamically and in many different forms. Next, students learn how to communicate effectively about complex processes, become independent learners and self-starters, and learn how to work well collaboratively. Thirdly, ICT can also support assessment for and of learning through the use of simulation software to assess students' ability to formulate and test hypotheses and self-assessment software for students to monitor their own learning. The fourth advantage was that the use of e-portfolios or technobiographies by students can help them to reflect on their learning progression. The fifth and final advantage is that ICT tools can be embedded into assessments.

On top of these, Berger (1998) wrote that the wider variety of instructional environments offered through computers provide more chances for students to discover domains that match their interests, skills and learning styles. The computers also allow children to learn at their own pace. This is useful towards curriculum differentiation which is important in teaching and learning (Berger, 1998; Teo et al., 1998). It allowed more active engagement of learners, a greater degree of independent learning enabling more competent students to expand their learning beyond the curriculum.

The Internet, being rich in quality educational resources, provides students with an interconnected world of knowledge for exploration. The large amount, variety and complexity of information allows the learner to be an active processor who explores, discovers, reflects and constructs his own knowledge, which is in line with the constructivist approach towards learning (Mann, 1994).

The computer is also an excellent tool for developing social skills (Dwyer, 1994). When linked to other schools, institutions or organizations, the Internet has the added benefit of enabling students to collaborate on worldwide projects, share discoveries, and develop strategies for acquiring knowledge in a social context.

Another powerful resource available on the Internet are the numerous virtual field trips available. Virtual field trips are the new interactive learning experiences in schools today made possible by extensive online and technological resources. Like many other resources available in the computer, virtual field trips highly motivate students about their subjects and infuse in them an eagerness to explore and discover. When students are motivated intrinsically to learn, that is half the battle won by educators.

The benefits of computer-based learning have been well documented by Kulik through the process of meta-analysis (cited in Hofstetter, 1998) who showed that learning time was reduced sometimes as much as 80% and achievement levels were higher when computers were used. Kosakowski reported that Kulik not only showed that students usually learned more rapidly, they also learned more (Kosakowski, 1998). This was true across all subject areas, from preschool to higher education, and in both regular and special education classes. According to Roblyer, one of the highest effects observed was that for the subject Science. In the review, it was also found that there was no statistical significance between student ability level and the effectiveness of computer-based applications, which means educators can use it for all streams (Roblyer, 1990).

In Singapore, Chen et al. (2001) conducted a research to look for ways to incorporate IT so that it may result in effective learning. Chen's team found that the learning environment should have proper provisions for both intellectual and social interactions. They thought cooperative learning was an essential feature for quality IT integrated learning and that giving problem-based projects was one of the best means by which students could focus on learning. In short, the learning principles of using IT could be summarized as the 5 I's: interactivity, increased accessibility, increased connectivity, immediacy, and integration while the learning process of using IT may be summarized as 4 stages: beginning with negotiation for entry, planning and preparation; knowledge sharing and building; inter-group communication, IT project design and creation; and finally, allowing students to report and present their projects.

More practical suggestions on how computers may be used in the classroom were found in Copernicus Education Gateway (CEG). The link has since then been removed but the suggestions are still practical (CEG, 2000). First, from the site, it was suggested that teachers should familiarize themselves with the technology and take time to understand how it works well ahead of the session. Next, care must be given in selecting appropriate resources. Teachers should always try to look for resources which motivate students whenever possible, such as puzzles, quizzes, interactive lessons, virtual field trips and collaborative experiments. Online materials should be printed so that students can relive the computer experiences at a later time. Opportunities to teach new skills should be made. For example, virtual field trips can enhance students' judgmental and observational skills and Internet search techniques can also be trained.

Lastly, teachers should engage students in as much hands-on activities as possible so that students can enjoy the process of discovery and experience the full potential of learning through interactive experiences.

With unparalleled opportunities to harness the emerging learning spaces of the future, schools must guide students in making the right economic, creative and ethical choices in their exploration of these spaces. Students must be made to understand the far-reaching consequences of irresponsible use of new media. The opportunity to use ICT in learning can instil responsibility in students. Rather than stifle their creative participation, we as educators should embrace ICT and teach our students to be responsible users of technology.

2.4.4 Fostering Independent Learning

> A nation's wealth in the 21st Century will depend on the capacity of its people to learn. (Goh, 1997)

One of the aspirations of the Singapore Education System is to develop future citizens who are confident, self-directed life-long learners. If we are serious about achieving this, adults must give opportunities to children to learn how to be independent and self-regulated learners. At home, parents should give their children opportunities to manage their homework, revisions for tests and examinations, and hobbies while at school, teachers should give students more opportunities for independent study and self-assessment or peer assessment for learning.

Harvey and Chickie-Wolfe (2007) wrote that children can learn without being taught by an adult anything that interests them out of school. For example, they can easily learn how to play the guitar, speak and write a foreign language like Korean, learn a new computer game, and even intricate dance techniques. Not only can they self-learn, they can even go near or beyond expert stage. Is there a way to foster independent learning? If so, how can it be fostered?

Independent learning involves being able to self-regulate. It involves self-regulating motivation, emotions, behaviour, time-management, cognitive and metacognitve strategies, physical functioning, academic skills, and context management.

Self-regulating motivation can be enhanced by fostering better parent-child relationships. Emotions refer to the positive emotions about studying and learning that can be developed. Behaviour refers to setting routines for homework. Time-management refers to the making of schedules and breaking up of larger assignments into manageable components. Cognitive and metacognitve strategies include setting goals, selecting appropriate strategies to code and store information, assessing learning tasks. Physical functioning refers to planning regular exercise to build physical health, taking breaks, or making sure there is ample sleep and well-balanced diets. Academic skills include developing good study habits like note-taking, highlighting, and reading. Finally, context management refers to seeking help with homework when help is needed.

When students self-regulate, they compare their current performance with an ideal and adjust future behaviour to better approximate that ideal. Such ideals are culturally embedded and are developed in a network of socially mediated factors, namely, the family. Involvement of parents and parent figures in students' education is closely tied to school attendance, higher achievement scores, increased homework completion, and appropriate behaviour in school.

As students move into secondary school, students increasingly turn to peers for information, support and coping strategies. Positive peer relationships increase motivation and positively affect academic success.

The attitudes and beliefs regarding learning and academic achievement held by people whom the student is emotionally attached (family members and friends) profoundly influence academic effort and student's own beliefs.

2.4.5 The Role of Attitude and Self-Efficacy in Learning

The role of attitude in the educational process is assuming increased importance in our schools today (Johnstone, 2014). Not only is the acquisition of knowledge important now, the appreciation and application of that knowledge is an important part of education.

Many definitions of attitudes could be obtained. One of the earliest definitions of attitude is provided by Thurstone (1929) who described an attitude as the 'affect for or against a psychological object' (cited in Johnstone, 2014). Krech took a new approach in 1946 by suggesting that attitudes were aspects of learning, referring to those involved in attempting problem-solving questions. Later, the affective nature of attitudes was stressed by various researchers, like Katz and Sarnoff in 1954 and

Rhine in 1958. But it was in 1963, that Defleur and Westie first argued for 'precise attitudes to specific social objects in specific situations which could be measured.

According to Johnstone, the various definitions reflect the psychological backgrounds of the researchers. However, despite the differences in backgrounds, researchers have divided attitude into three components - the cognitive (knowledge), affective (feeling) and conative (tendency-towards-action) components. Resources in schools have been devoted to cognitive growth and measurement in the past, and less emphasis was placed on affective outcomes. According to Hoch (cited in Johnstone, 2014), the three components are strongly interconnected. The cognitive component affects the affective component and vice versa.

In 1973, Khan and Weiss criticised the neglect of attitudinal outcomes, suggesting that they were too important to be neglected (cited in Johnstone, 2014). Whether or not they are emphasized by schools, students will still develop attitudes towards the subject, teachers and school. By enhancing the attitude component, the cognitive and conative components would also be enhanced. Naturally, one easy way to enhance attitudes towards the subject is to make the learning enjoyable (Jonas, 2010).

Another important component of learning is self-efficacy, defined as a sense of confidence regarding the performance of specific tasks (Jinks, 1999). This is often measured when measuring attitudes towards a subject. According to Jinks, performance self-efficacy influences several aspects of behaviour that are important of learning, among which are 'choice of activities', 'effort', and 'persistence'.

Students with higher self-efficacy make things happen and thus have a higher tendency-towards-action. A higher sense of efficacy results in sustained task involvement, which results in higher achievement. Such students will also try different strategies and persevere when they encounter difficult questions.

On the other hand, low self-efficacy usually means less effort, which usually leads to less success, resulting in even lower efficacy. Students with lower self-efficacy also have lower outcome expectations. Outcome expectation refers to the belief of the student regarding the result regardless of the personal efficacy to perform the action. For example, a student with high self-efficacy might have low outcome expectation if the student feels that the teacher does not like him or her. Both self-efficacy and outcome expectations are important to student motivation.

Students who were taught coping strategies to enhance their self-efficacy were more likely to put in more effort in their studies, which contributed to academic success (Bandura, Adams, & Beyer, 1977).

It is apparent that besides making lessons enjoyable, teacher-student interpersonal relations in a class affect students' attitudes towards a subject.

2.4.6 Enhancing Teacher-Student Relationships

An environment is conducive to learning when the students are not only happy, but the teacher enjoys facilitating and motivating students to learn. Other than students' attitude, a good teacher-student relationship is paramount to the creation and maintenance of a positive classroom learning environment (Goh, 2002).

There are many benefits of a classroom with strong student-teacher rapport (Moore, 2009). First, positive peer pressure is created in the classroom. Secondly, there is increased attendance - students enjoy and want to be in the school. Thirdly, there are less disciplinary issues as intrinsically motivated students are less likely to make poor choices like disrupting lessons. As a consequence, there is greater academic achievement as teachers would be able to spend more time facilitating the learning process. Another related benefit of better discipline is that learning that lasts become possible. This is because experiments and field trips would be easier to administer, resulting in more meaningful and authentic learning. Finally, yet another benefit of strong teacher-student relationships include teachers being able to enjoy their career experiences. On the other hand, without good teacher-student relationship, measures like instilling fear are often used to control the class and maintain classroom discipline.

Practical ways in which strong teacher-student relationships may be built in five stages or levels (Moore, 2009). Level 1 involves Personal Alignment, where steps to strengthen six qualities to manage our personal life are suggested. These include developing emotional intelligence so the teacher can be more empathetic and better listeners. Other examples consist of being mission-driven, having integrity, being able to see own future, living a disciplined life, being able to master habits, and maintaining personal good health.

In Level 2, steps to carry out professional alignment were suggested by building up eight qualities that contribute to teacher competency. These included content mastery, being prepared, having positive expectations, being life-long learners ourselves, being a better team-player, developing the ability to stay calm in a crisis, being appropriately attired, and again, being a great listener.

In Level 3, steps to build up teacher qualities that contribute to the smooth daily operation of the classroom are suggested. The first step is to learn the business of teaching, i.e. knowing how attendances are taken, how to decorate the class, how to manage finance, how to maintain a grade book, how to hold parent-teacher meetings and the like. The second step is to learn how to set classroom routines, such as homework collection, how to trace missed homework, grading of daily work, and issuing of toilet passes and the like. Other steps include developing clear communication skills by learning how to keep language concise, measuring students' progress through the use of clear objectives, sharing high quality work, use of rubrics, portfolios, and learning how to teach with a variety of tools (e.g., using smart phones, computers, mock conversations, videos, experiments, role plays).

Level 4 suggests ways of creating an inviting classroom culture, which include teaching students how to set goals, reconnecting with our own passion and professional purpose, embracing teachable moments, showing students the relevance of what they are learning, using humour, and using theatrics. Theatrics include anything that helps to make learning fun. For example, reading poetry, inserting field trips and other experiential learning, role-playing, using manipulatives, playing games, doing demonstrations, doing experiments, carrying out group work, carrying out project work, using student teaching, and using computers for learning.

Going on to Level 5, a further four more steps are suggested to build qualities that can help teachers win the trust of our students. In this stage, teachers can be inspirational by finding out what motivates the class. This can be independence, curiosity, acceptance, order, social contact, or family. Again, further developing on emotional quotient, a teacher's ability to express empathy and meet unexpressed needs play an important role in winning students' trust. Teachers should have good observation skills, listening skills as well as intuition skills. Lastly, teachers can also unleash students' potential by pushing students beyond their comfort zone.

Further to these practical ways to improve teacher-student relationships, Moore also suggested four keys to building a strong teacher-student relationship.

The first key is that enduringly happy teachers yield enduringly happy students. These teachers draw on their central core of strength when working with students. Teachers' enduring happiness and principle-centred core is what allows them to weather the storms of education.

The second key includes closing the teacher-student gap, somewhat like closing the generation gap. Doing so makes it easier for the teacher to win the trust of their students as knowing that the teacher is even remotely in touch with their world makes it more likely for students to be open to their teacher's teaching.

The third key is to motivate the student. Great teachers inspire their students, often revealing talents that are unknown even to the students themselves. Students' motivation lies in two areas - the first motivator is the human need to feel important and the second is pleasure-seeking or pain-avoidance. For example, students who watch too much TV or play too much computer games have desires for instant gratification greater than their vision of their future.

The last key involves motivating students with an action plan, so there is motivation with a goal. To accomplish this, the teachers must meet the students' needs to feel safe, cared for and important. The greater the clarity the student has of their future, the more motivated they will be in the present.

2.4.7 Summary

As we begin the 21st century, rapid change has become an accepted part of our society and people are required to adapt as ideas become quickly obsolete. The ability to think is a valuable skill in such an environment so thinking programs must be implemented in schools. A good way to foster thinking is through the learning of science.

Learning theories address how people learn. As teaching and learning are two sides of the same coin, a good foundation in learning theories would help to improve how we teach, including how we teach science as a subject. In particular, through sociocultural learning theories, we learn how learning can be made meaningful and authentic through discussions and how by making time for discussions, misconceptions in science may be reduced.

It has been shown how computers have become an integral part of everyday life in Singapore in this 21st century. Computers and other forms of technology are useful in education as they are extremely powerful educational tools, if appropriately used.

By giving opportunities for our students to use technology as a tool for learning, many vital computer skills are acquired naturally, preparing them for life in this modern world. ICT is also an important platform to foster independent learning in students. If we are serious about developing future citizens who are confident, self-directed life-long learners, it is crucial that we, as adults, give opportunities to our children, who are our future, to learn how to be independent and self-regulated learners.

Linking to the sociocultural learning theories, it has been demonstrated that there are other factors that can influence students' learning. The important roles of attitude and student-teacher interpersonal relationships in learning were described in the last section which reiterated their important place in learning. By attitude, we saw that it encompasses self-efficacy of a student.

What are recognized as good teaching and learning pedagogies were introduced and put forward in Section 2.4. Assessment approaches that encourage the sets of skills and values in our students in the teaching and learning of science should thus be encouraged and emphasized. In the next section, Section 2.5, I hope to introduce these approaches.

2.5 ASSESSMENT

Section 2.5 includes four sub-sections. Section 2.5.1 gives an introduction into the roles of assessment in education and some of its negative effects. This is followed by Section 2.5.2 which discusses the various types of assessment, with particular interest on assessment for learning. In this section, reasons on why more emphasis on this form of assessment are offered. Next, Section 2.5.3 focuses on alternative assessments methods that make assessment less stressful without loss of rigor. From these, alternative assessments that are feasible and sustainable for use in the large class size of a typical neighbourhood Singapore Secondary classroom are recommended. Section 2.5.4 ends this section with a summary.

2.5.1 Introduction

Assessment has its place in education. Although it is one of the least preferred activity in schools, some of its important roles include providing feedback to the learners, determining stated objectives have been achieved, providing information to improve curricula, helping students in personal decision-making (which subject or course to select, career to choose), and showing how well students perform in school (to parents, employers, government planners). Standardized tests, be it school-based, national or international are objective ways of meeting demands for greater accountability in schools.

However, despite its necessity, it is important to make assessment less stressful for our students. Sutton wrote about the negative effects of assessment, which includes performance anxiety, fear of failure, increased effort and increased severity of students' psychological problems (Sutton, 2004).

According to the Straits Times (Wee, 2012a), in Singapore, depression in our young is already significant enough to warrant a separate mention in the guidelines on depression by the Ministry of Health. Wee (2012b) wrote that the earlier onset of depression and anxiety in our young was because our society places strong emphasis on excellence and meritocracy and that youths become anxious and stressed when they do not measure up to the high demands.

Manning and Bucher also wrote about other negative effects of assessment, stating that too much emphasis on assessment could take a toll on our students' self-esteem (Manning & Bucher, 2005). Nicol and MacFarlane-Dick remind us of the importance of motivation and self-esteem in learning. They wrote that frequent high-stakes assessment had a negative impact on motivation for learning and that it militates against preparation for lifelong learning, the very value which we hope to see in our future citizens (Nicol & MacFarlane-Dick, 2006).

Is it possible to carry out assessment without imposing too much stress on our students? Can we do this without sacrificing the rigour of the assessment? A section on a literature review on assessment for learning and a section on alternative assessments are introduced in the next two sections in the hope of looking for ways to carry out the important task of assessment in a less stressful manner.

At the same time, these suggested alternative assessment methods would help to promote some of the other values in our students, in particular, being independent self-regulated learners. The use of self-assessment and peer-assessment methods and the use of rubrics and study logs and how they might be carried out in the Singapore context are thus included in this section.

2.5.2 Assessment for Understanding

Evaluation is the judgment of a measurement (normally the data collection obtained from tests and examinations) while assessment is the interpretation of the data collected. Although there is a distinction between evaluation and assessment, the two terms have been used interchangeably.

Assessment may be divided into three main categories - formative assessment (which helps us to track students' progress during learning), summative assessment (evaluation at the end of learning experience) and diagnostic assessment (which helps us to determine the causes of deficiencies). Formative assessment is also known as 'assessment for learning' while summative assessment is also known as 'assessment of learning'. When assessment is used as a platform for learning it is 'assessment as learning' (Leong, 2014).

All three types of assessments are carried out in schools to varying degrees and often in conjunction. However, summative assessment outweighs the other two types of assessment as it has direct bearing over a student's progression within the school or to an institution of higher learning upon leaving the school. As they are usually standardized to ensure a high degree of validity and reliability, they are also known as standardized tests. In addition, as high-stakes are usually involved, such summative assessment is also known as high-stakes assessment and is usually associated with a corresponding high degree of stress.

Gagné wrote about some of the positive effects of formative assessment, which include encouraging active learning, guiding choice of further instructional activities, and helping students feel a sense of accomplishment.

Gibbs reminds us that assessment is not about measurement, but about learning. According to him, the most rigourous and reliable assessment systems are often accompanied by dull and lifeless learning with short-lasting outcomes, that some assessments generate unhelpful learning activity even if they produced reliable marks, and that we might be encouraging students to obtain marks at the expense of their learning (Gibbs, 2004). The Singapore education system consists of one of the most rigourous and reliable assessment systems. Thus far, it does not seem to be accompanied by dull and lifeless learning. However, it does seem to have generated unhelpful learning activities like perhaps answering questions by rote.

Darling-Hammond (1995) asks if students answer questions by rote. If we provide assessments that have a real-world orientation and are indicative of authentic learning, it would be more meaningful than the regurgitation of facts and rote memorization. Indeed, quite a fair number of my students have become examinations-smart, at least, for those who do well. Students who do well might seem to merely concentrate on passing examinations rather than on understanding the subject. If we do not want students to be merely examinations-smart, then we must help our students to prepare for the standardized tests without compromising our beliefs about the importance of constructivist ideas in teaching.

Meaningful assessment practices are supposed to promote learning. A constructivist model can be used to show how teaching, learning and assessment are interactively related and that assessment is both for learning and of learning (Hackling, 2004). Hackling wrote that we could go about collecting the evidence of students' learning through observation and conferencing, asking closed and open questions, giving students opportunities to do project work and carry out investigations, keeping portfolios, and by using rubrics. Hackling also suggested that quality assessment should be authentic, fair, comparable and educative besides being valid and reliable.

In the next section, these alternative forms of assessment for learning are introduced and elaborated in greater details.

2.5.3 Alternative Assessment

Tan (2011) lamented the lack of a clear-cut definition of what alternative assessment is. According to Tan, literature abounds with descriptions of what it is not but not what it is, often describing it as an assessment that is not reduced to a paper and pen test or examination. Tan defined alternative assessment as ‘assessment practices characterized as an alternative to standardized tests in controlled environments’ (Tan, 2011, p. 9). According to Tan, alternative assessment is viewed as having primarily formative function. This being true, alternative assessment would help teachers assess students for their learning and understanding.

Therefore according to Tan, alternative assessment in Singapore has three characteristics - it has the capacity to be contextualized for recognizing different learning outcomes in diverse authentic contexts, it has the capacity for students to be involved in the assessment process, and it is applied in real-world contexts that expand the potential for greater student involvement and scope of assessment. As alternative assessment emphasizes assessment and learning in a more holistic way, it leads to meaningful student involvement that enhances holistic understanding. This is understanding which includes knowing how well different knowledges are connected with each other, rather than on simply on how much a single knowledge is understood.

Print stated that besides standardized tests and teacher-made tests, other measurement instruments for alternative assessment may include oral tests, systematic observation, interviews, questionnaires, checklists and rating scales, self-reports, sociograms, and anecdotal records (Print, 1993).

When we look at this list, we realize that alternative assessment instruments can be more subjective, and less rigourous when compared to paper and pencil tests with set marking schemes. Secondly, the use of conferencing, interviews, and observations would be difficult to sustain in practice, especially in the current Singapore context, where the teacher to student ratio is still large, given the existing stressful results orientated environment.

One way to overcome the problem in rigour is to make any alternative grading methods more effective by making it explicit, quantifiable, and precise. For example, in the use of rubrics which is increasing used in recent years, the most effective rubrics are developed when collaboratively developed together with students.

We certainly use a lot of standardized and teacher-made tests in our Singapore schools. We have also been using a fair share of alternative assessments. Traditionally, oral tests for subjects like English and Mother Tongue and we carry out systematic observation for Science Practical Examinations. More teachers use rubrics to assess project work in an increasing number of subjects, ranging from Science to Geography. Such alternative assessment instruments are more tedious to conduct in practice. Is there an alternative that would be more sustainable in the Singapore context?

Nicol and MacFarlane-Dick (2006) also wrote that if students are to be prepared for learning throughout their lives, they must be given the opportunities to develop the capacity to regulate their own learning. According to him, learners who are more self-regulated are more effective learners. When we do everything for our students, we are denying students the opportunities to learn how to be self-regulated and independent learners. Instead, we, as teachers, need to create opportunities for students to self-monitor and to evaluate and feedback on each other's work. Such formative assessment and feedback can help students take control of their own learning. This would be a good example of 'assessment as learning'.

Whether it is for 'assessment as learning' or 'assessment for learning', one of the simplest ways we can encourage students to be self-regulated learners is by encouraging them to keep a study log. Leong suggested that self-reflection questions may include 'What did you like about your work?', 'What was difficult about this piece of work?', 'What would have made the work better?', 'What do you think you still need to work on?', and 'What do you now know that you did not know before?'

Furthermore, students' reflections could also include the type of feedback they want from the teacher, the good questions/comments during group work and what they would like to learn in the subsequent lesson (Nicol & MacFarlane-Dick, 2006).

Self-regulation is developed in the active monitoring and regulation of learning processes such as setting of goals and strategies to achieve these goals. In this log book, students could write not just the goals but the strategies to meet the goals, the number of hours they spent on the topic and their reactions to their marks or comments given by teachers in their daily work. This log could help students think about their work and be more reflective.

There are other things a teacher should do too, besides providing opportunities for students to be self-regulated learners. For instance, teachers could clarify what good performance is and facilitate in self-assessment. Teachers could give high-quality feedback and encourage teacher and peer dialogues. Teachers could encourage positive motivation and self-esteem, and provide students with opportunities to close the gap. And teachers could also make use of online tests that are designed to give feedback any time, any place and with unlimited times.

Students could also be involved in peer-assessment. To ensure that peer-assessment is reliable, this can be used in conjunction with teacher-feedback, with the grade provided only after self-assessment, peer-assessment or teacher feedback has been completed.

In a typical large classroom setting, if teacher-feedback is not a viable method, simply encouraging self-assessment in conjunction with peer assessment helps to promote ‘assessment for learning’ and ‘assessment as learning’. Best of all, carrying out these alternative forms of assessment makes assessment less stressful if not more enjoyable.

2.5.4 Summary

In the literature review above, I have shared how high-stakes standardized testing may have negative impact on our students. To counter these negative effects, some alternative forms of assessment methods that could be used in our Singapore classes were introduced in the hope that they can help to reduce examinations stress without sacrificing too much on rigour. For example, the use of effective rubrics that are developed collaboratively by teachers together with students, the use of study logs that not only promote reflective thinking but also self-regulated learning. Self-assessment used in conjunction with teacher-assessment or in cases where this is not feasible, in conjunction with peer-assessment were suggested as ways to promote meaningful learning.

To many teachers, some products are less important than the process. For example, project work carried out in groups can engage students in much discussion so the report that is marked may be less important than the learning process that created it.

Lastly, the move by our new minister of education to emphasize character building should come in conjunction with changes in assessment. As early as 1993, Print stated that standardized tests have a high degree of validity and reliability but can be inappropriate if they are exclusive measures of performance. Unless the less stressful alternative forms of assessment can be given more weighting, high-stakes assessment will always be given great emphasis in Singapore schools.

2.6 SCHOOL CLIMATE AND CULTURE

In the last part of my literature review, I would like to include a short section on school climate and culture. Ramsey (2008) wrote that a school culture 'determines how honest people are, how happy they are, how hard they will work, how loyal they will be, and how much they are willing to put up with. It is the culture that attracts people to the organization or drives them away. A school can only be as good as its culture allows it to be. In a school where there is good school culture, the school climate would be positive for learning and growing.

Why is a good school culture with good school climate important? Ramsey used the metaphor of a frail and fragile canary to represent the student. He wrote that just as canaries are easily affected by poor air quality, our students cannot thrive in a school with a culture that is toxic.

So how can we recognize when the culture in a school becomes toxic? School climate can be gauged informally by asking ourselves the following questions: Are teachers burnout or counting days to retirement? Are there high turn-over rates? Are teachers, middle management and school leaders too consumed with testing? Is decision making top-down? Is there an undercurrent of complaints?

In addition, what is missing in an organization is also a good indicator of the school culture. In a culture that is positive, passion, laughter, frivolity, wonder, and fun cannot be missing from the organization.

2.6.1 What School Leaders Can Do

If the signs indicate that there is something amiss with the school culture, can anything be done? A school culture is organic and can be changed (Ramsey, 2008). Everyone has a part to play to improve school culture. However, building a good school culture begins with servant leadership.

A good school culture cannot be built by leaders with a drive for status and power whose only concern is to advance their own career. In servant leadership, the leader serves the organisation, instead of controlling it. Leadership exists for the benefit of the followers, and humility is the core. The traits of a servant-leader include a whole list of attributes, ranging from having passion, strong moral compass, trustworthiness and credibility, non-judgemental attitude, to having a beginner's eye, boldness, is quick thinking, having humour, and patience. Good leaders also need to know when to push and when to wait. They go slow and start small.

Next, school leaders can create a culture that benefits everyone and prompts peak performance by following these steps like declaring war on rudeness, walking the talk, making it okay for people to make mistakes, celebrating together often, surprising people; and simplifying the organization.

Other culture building steps include:

1. Appreciative inquiry: build on existing strengths;
2. Create and expand connections (i.e. relationships): connections are the core of the culture and relationships are the way leaders get things done. David Gergen (2001) wrote that ‘at the heart of learning is the leader’s relationships with followers’;
3. Dare to discuss core values: inspire your staff;
4. Use language to shape the culture: words are powerful. Be generous with authentic praise;
5. Spend 50 percent of your time with the middle 70 percent of your staff;
6. Use the power of good news;
7. Make some physical changes in the environment (e.g. round table for meetings);
8. Walk around to see where help is needed;
9. Dare to be silly;
10. Be prepared: to hold conferences, give pep talks, handle confrontations, explain and sell ideas, deal with crises, and ask ‘what if’ questions;
11. Hire culture builders: hire people who are better than yourself; and lastly
12. Get out often: attend conferences and seminars to get new ideas.

School leaders can provide staff with freedom, especially the freedom to fail, because freedom uncorks the bottle on creativity (Ramsey, 2008). According to him, school leaders should simply point people in the right direction and then get out of the way.

Next, for empower staff, that is, to give staff the power to make choices, Ramsey goes as far as saying giving staff the choice on how to use funds, to make public statements without approval, and to set seemingly frivolous goals. Trust is important in building strong school culture.

Other steps school leaders can take to improve school culture include hiring the right people, in particular, teachers who are genuinely passionate about children. They should recruit tomorrow's culture builder. Once this is achieved, the next step would be to promote loyalty of these staff to the school. School leaders should strengthen these connections within the culture, and be intentional about staff morale. Schools should provide staff development opportunities and develop mentorship programmes. There are many things school leaders can do! Leaders may also build up the culture of innovation, recognize outstanding performance and invest in culture building.

2.6.2 What Teachers Can Do

On the other hand, what can teachers also do in class to help improve school culture? We all know that ultimately, it is the student who chooses to think and learn, or not. School is a partnership with students. When learning becomes engaging and meaningful to students, discipline issues decrease while academic interest increases.

Emerging research on the brain and learning confirms that the brain 'lights up' for complex, challenging social and contextualized experiences. The brain is wired to make connections, construct meaning and solve problems. We need to interact in a social manner to develop understandings. This means that the model of education where students sit silently and motionless in rows goes contrary to what brain research indicate. Such educational practices interfere with these processes natural to the brain and fights against the way our brain really works best.

Thus, teachers can first of all try to make learning engaging and meaningful for students in classes. There are many things teachers can do to achieve this. One thing teachers can do is to provide students with choices of learning in order to make learning more dynamic. The process or product is the most basic and common method of personalizing learning. For example, students may also be provided with what is known as 'Assignment choices'. This has commonly be used in differentiated learning, for example, Science students may choose to present their understanding via Powerpoint slides, a laboratory report, a narrated video, an essay or a cartoon. Students must show that they understand the key science concepts and be able to communicate their understanding clearly, regardless of the format.

Students may also be offered the choice of a differentiated learning process. Here, students are allowed to choose to work alone, work in groups, to follow the teacher or even create their own lessons of learning. Students are given a few assignments concurrently with a due date for all the assignments. Teachers can also offer students opportunity to modify assignments. This invites students to take responsibility for their learning needs.

Lastly, instead of covering the curriculum, students can be led to uncover and discover. More routes to learning would vary more as more choices are given. Giving students choices does not mean giving up control; the teacher retains ultimate decision-making authority in the classrooms and creates the parameters within which the students can exercise their independence.

Another way teachers may engage students is by using Problem-based Learning (PBL). Students are challenged with problems to solve rather than being given textbook exercises to complete. The most powerful learning experiences often involve students working on authentic, real-world problems which make learning alive and meaningful.

Yet another way teachers can help to build school culture is by providing students with learning opportunities beyond the school through service learning in the community. Not every learning experience needs to occur in the classroom within the 35 minute or so class period. Curriculum can be broadened to include fundamental assets of service, teamwork, compassion, persistence, making good choices and the like.

Teachers may also employ the use of assessment for learning for continuous improvements. This also provide students with opportunities to be reflective: What is working well? What needs to be modified? What are the logical next steps?

Finally, discipline in classrooms would be less about punishment but more about restorative justice and rectifying the situation.

2.6.3 Summary

A school can only be as good as its culture allows it to be.' In a school where there is good school culture, the school climate would be positive for learning and growing.

Everyone has a part to play to improve school culture. Building a good school culture begins with servant leadership. A leader leads by example and is often not only passionate in endeavour but also patient with his/her staff. In a nutshell, school leaders can build a strong school culture by making staff feel valued.

Likewise, teachers may do their part to improve school culture. Teachers may build stronger relationships in classrooms through shared work, when individual students are empowered and valued. Students are encouraged and empowered to take responsibility for their learning needs.

As results ultimately counts, teachers should always clearly connect the means with the ends. The ‘means’ includes steps like improving teacher-student relationships, improving student engagement, and improving teacher effectiveness while the ‘end’ refers to decreased discipline problems and improved student learning.

2.7 SUMMARY

In the first section of this chapter, literature review on learning environment and how it may be studied was described. Some established instruments that were more extensively used in Asia were next highlighted and studied in more detail. A literature review on how some of these instruments had been used in Singapore was next carried out. From here, instruments that would be appropriate for use in this study were selected.

The WIHIC (with both its Actual and Preferred versions) was selected to assess the learning environment on seven different scales in this study. Next, a literature review on attitude towards science was conducted, resulting in the selection of the three outcomes scales on attitudes in the TROFLEI and the QTI (Student version) to complement the use of the WIHIC. As literature review supported the use of the instruments in conjunction, the TROFLEI scales would help to determine the attitudes towards the subjects while the QTI would help to determine the attitudes of the students towards the teacher-student relationships, giving a more comprehensive view of the classroom environment.

The literature review on learning environments showed some gaps in past research that could be addressed in this study. Past research in Singapore have been few and were mainly conducted in Chemistry, Mathematics, Geography and Chinese Language classrooms and in Science Laboratory settings. This study not only adds on to the lack of research in learning environments in Singapore, it also helps to shed more information on how the WIHIC and QTI are used particularly in the area of Science classroom environments.

The literature review on the assessment of science showed how attitudes and the learning environment impact achievement. However, although achievement outcomes are important, other outcomes are also important. Our people need to become independent lifelong learners with a passion to learn new skills and knowledge in order to succeed and adapt to a fast changing global future. If our students are to be future life-long learners, they must first learn to be independent self-regulated learners now. Searching for alternative ways of assessment may not only make schooling less stressful, it would also help us take the first step to developing independence in our students, killing two birds with one stone.

Alternative forms of assessments also tend to make assessment more authentic, thereby helping to make learning more meaningful to our students. Self-assessment and keeping study logs give opportunities for students to develop the capacity to be self-reflective and critical, yet another attribute that is important for work in the 21^{st} century. Promoting alternative forms of assessment ‘for learning’ and ‘as learning’ would be an important step towards preparing our students for learning throughout their lives long after graduation.

Finally, we saw in this chapter that a school can only be as good as its culture allows it to be. In a school where there is good school culture, the school climate would be positive for learning and growing. We also say that everyone has a part to play to improve school culture. Beginning with school leaders who lead the school by example, school leaders can build a strong school culture by making staff feel valued.

Likewise, teachers need to do their part to improve school culture. One way is to make students feel valued too. More opportunities may be given to students to make their own choices. Students thus empowered take more responsibility of their own learning needs.

As results ultimately counts, teachers should always clearly connect the means with the ends. The ‘means’ includes steps like improving teacher-student relationships, improving student engagement, and improving teacher effectiveness while the ‘end’ refers to decreased discipline problems and improved student learning.

In our quest for excellence, it is easy for schools to lose sight of what is truly important. In a results-driven education system, it is often difficult to say ‘yes’ to intangible benefits which are equally if not more important. Focusing our attention on the individual experiences and perspectives of students is the key to transform schools into engaging learning communities with strong school culture - a place where every child finds success and a place where learning can be enjoyable. If learning is made more enjoyable, our students would naturally grow into adults who want to learn throughout their lives.

Learning can indeed be fun if you let it. Let it.

CHAPTER 3
METHODOLOGY

Methodologists, get to work!

-- C. Wright Mills

3.1 INTRODUCTION

According to Gerring, there is a distinction between 'methods' and 'methodology'. The first refers to "a specific procedure for gathering and/or analysing data" while the latter refers to "the tasks, strategies, and criteria governing scientific inquiry, including all facets of the research enterprise" (Gerring, 2012, p. 6). Although methodology is important, there should be a good balance between 'discussion about how to get there' and actually doing something 'about what's there'. In this chapter, the methodology of the study is described and presented.

In Section 3.2, types of research methods are introduced. This is followed by a description of the research design employed in this study in Section 3.3. Next, in Section 3.4, the research sample is described. In Section 3.5, the research questions are presented again, this time with elaboration on how they were formed and addressed based on theory derived from the literature review in the previous chapter. In Section 3.6, a description of how the instruments were derived is included, with explanations of how the qualitative aspect was combined with the quantitative component of the study. In Section 3.7, the pilot test why two tests were used are described. This is followed by a description of the actual data collection in Section 3.8. Details of the process for data collection are described, such as when the data collection took place and how the computer laboratories were assigned. Data collection also involved achievement scores in Science for the mid-year examinations which took place in the same month. Details of the process of data analysis are also described in this section. In addition, the ethical considerations for the study are outlined in Section 3.9. Finally, the chapter is summarized in Section 3.10.

3.2 TYPES OF RESEARCH

Research can be grouped into two different types - quantitative and qualitative. Bryman stated that both quantitative and qualitative research can be viewed as a means of exhibiting a set of distinctive but contrasting pre-occupations (Bryman, 2012).

> Quantitative research is a means for testing objective theories by examining the relationship among variables. These variables can be measured, typically using instruments, so that numbered data can be analysed using statistical procedures. (Creswell, 2009, p. 233)

The reporting structure for such research studies usually consists of an introduction, literature, methods, results and discussion.

In the field of education, quantitative research methods that make use of statistical information obtained from instruments have provided information on students' perceptions of the classroom psychosocial environment. For example, the What Is Happening In this Class? (WIHIC) for both Actual and Preferred versions were administered to 2,310 students in 75 Junior College classes for Geography and Mathematics in Singapore by Chionh and Fraser (2000). Statistical analysis of the responses provided objective understanding of what was happening in the Geography and Mathematics classrooms from the perspectives of the students. It also provided objective understanding of what the students preferred in their classrooms.

> Qualitative research is a means for exploring and understanding the meaning individuals or groups ascribe to a social or human problem. (Creswell, 2009, p. 232)

Mason enlarged the definition of qualitative research as "an umbrella term for an array of attitudes and strategies for conducting inquiry aimed at discerning how human beings understand, experience, interpret and produce the social world" (Mason, 1996).

In the field of education, qualitative methods include conducting classroom observations, the use of journals and other written work of the students, interviewing students and teachers and use of open-ended questions. For example, face-to-face and email interviews with students and teachers and photographs were taken and classroom observations were conducted in a study conducted in Korea involving 439 students in 13 classes. The information obtained from interviews with teachers helped to give background information on the practical situation in the class and school and helped to give a more in-depth and complete understanding of the environment.

Instead of choosing one research method over the other, both methods are now commonly used in conjunction with each other in many educational research studies in what is known as mixed-method research so that the best of both worlds is obtained. Furthermore, either one of the methods can complement the other, for example, in research studies where data collection was carried out using observations and interview sessions, surveys can be conducted to give an added perspective of students' and teachers' views of the environment.

In cases where instruments were used to describe the classroom environment, observations and interviews can be conducted to give an added perspective that explains some of the responses obtained from the instruments. For example, in the Korean study mentioned above, the qualitative method was used in conjunction with the use of learning environment surveys like the Science Laboratory Environment Inventory (SLEI), Constructivist Learning Environment Survey (CLES) and Questionnaire on Teacher Interaction (QTI). The findings from qualitative analyses replicated the findings from the quantitative analyses.

3.3 THE RESEARCH DESIGN

According to Creswell (2009), there are four aspects to consider when planning a mixed-method design for research - timing, weighting, mixing and theorizing. Timing of data collection refers to whether data would be collected in one phase concurrently or in phases sequentially. Weighting refers to the priority given to the two research methods, for example, would it be equal or would more weighting be given to one of the methods. Mixing refers to the mixing of the data, for example, embedding the qualitative component into the quantitative component. Theorizing refers to the consideration from a larger theoretical perspective. Table 3.1 shows a summary of the four aspects of consideration.

Table 3.1

Aspects to Consider in Planning a Mixed-Methods Design (Adapted from Creswell, 2009)

Timing	Weighting	Mixing	Theorizing
Concurrent	Equal	Integrating	Explicit
Sequential with qualitative first	More qualitative	Connecting	
Sequential with quantitative first	More quantitative	Embedding	Implicit

As the qualitative and the quantitative data are collected concurrently, the concurrent design is employed in this study. There would be only one data collection phase so that collection of both qualitative and quantitative data would be carried out simultaneously. According to Lewis-Beck et al. (2004), qualitative data can be embedded in the questionnaires employed. In this study, the use of open-ended questions in the Getting to Know You (GTKY) questionnaire would provide the qualitative aspect of the study. As the qualitative component would be embedded in the GTKY instrument, the concurrent embedded strategy was employed, with more quantitative weighting.

The mixed-method approach was used to gain a more complete picture of the Science classroom learning environment using both quantitative and qualitative methods. The quantitative component was achieved through the use of four instruments and the examinations results while the qualitative component played a supportive role through the use of open-ended questions in the self-designed GTKY instrument. The qualitative component embedded in the quantitative component would be used to provide in-depth results presented in the next chapter. Figure 3.1 shows diagrammatically the theoretical framework of this study.

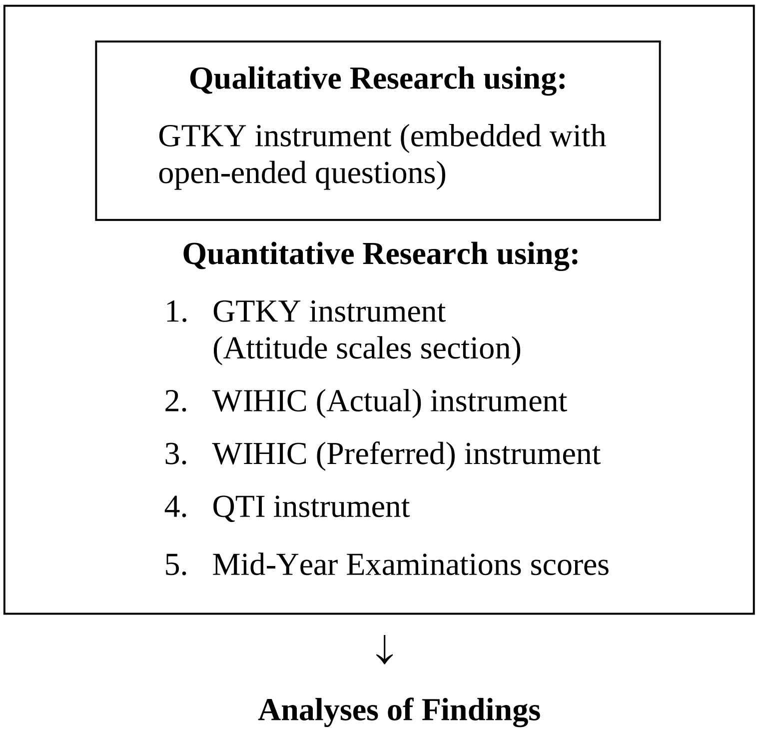

Figure 3.1. The concurrent embedded mixed-method research theoretical framework of this study.

Based on the research design, a conceptual framework was developed for the purpose of this study, as shown in Figure 3.2.

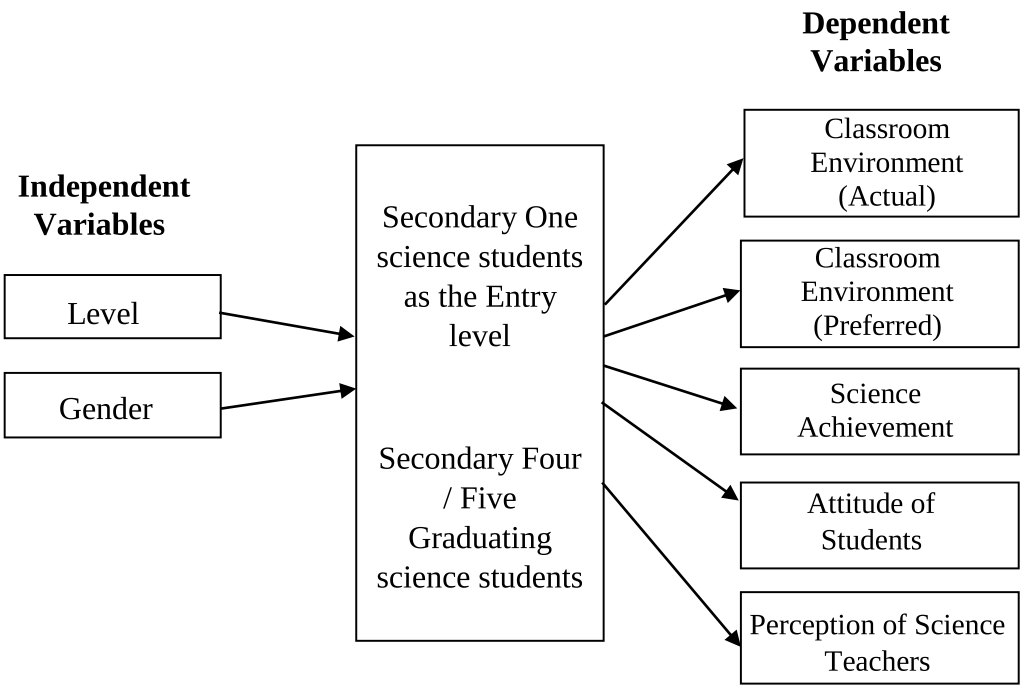

Figure 3.2. The conceptual framework of this study.

To determine if students were able to enjoy Science in a neighbourhood Secondary school, two levels of students were selected - the entry level which consists of students from Secondary One level entering the school while the exit level consists of Secondary Four and Five students graduating from the school. If students were still enjoying Science by the time they left school, it would mean that enjoying Science in a Singapore school is not an oxymoron. The level and gender of these students make up the independent variables in this study.

The dependent variables would consist of the actual and preferred Science classroom learning environments as measured by the WIHIC (Actual and Preferred) instruments, the teacher-student interactions as measured by the QTI (Student) instrument, the attitude to Science of students as measured by the Attitude scales in the GTKY questionnaire, and Science achievement as measured by the Mid-year examination scores.

3.4 THE SAMPLE

This study was conducted in a middle-ranked neighbourhood school (See Appendix 2). Singapore schools are ranked according to the results achieved by the school in national examinations. A miiddle-ranked school refers to a school ranked in the middle. The school is situated in an older HDB estate and has a student population of 1120. The Secondary One Science students entering the school were taken to be the Entry level while the Secondary Four and Five graduating Science students were taken to be the Exit level.

In total, 238 Secondary One students (86.9% of the cohort) and 274 Secondary Four/Five students (82.5% of the cohort) agreed to participate in this study. Altogether, 512 students in 16 classes participated in this study. See Table 3.2 for a description of the sample.

Table 3.2

Description of the Sample

Level	Stream	No. of Classes	Gender		Race			
			Male	Female	Chinese	Malay	Indian	Others
Secondary One (Entry level)	NT	1	142	96	175	29	16	18
	NA	2						
	Exp	4						
Secondary Four/Five (Exit level)	NT	1	150	124	198	23	22	31
	NA	4						
	Exp	4						
Total		16	292	220	373	52	38	49
Percentage			43%	57%	73%	10%	7%	10%

3.5 THE RESEARCH QUESTIONS

To achieve the aim of the study, that is, to find out if students are enjoying learning Science in a typical neighbourhood Secondary school in Singapore, six sets of research questions were developed which then became the focus of study.

Research Question 1

Are the instruments used, namely, the What Is Happening In this Class? (Actual and Preferred), the Questionnaire on Teacher Interaction (Student version), and the attitude scales in Getting to Know You, reliable and valid instruments for studying Science learning environments in a Singapore Secondary school?

To begin, I needed to develop an understanding of the learning environments of the Science classrooms in the Singapore Secondary school. Based on the literature review on learning environments in the previous chapter, the WIHIC, one of the most robust instruments for measuring learning environments, was selected for capturing information on the Science learning environments. Both Actual and Preferred versions were administered to measure this.

Next, the QTI and the attitude scales from the TROFLEI were selected for use in conjunction with the WIHIC in order to capture a more holistic picture of the environment. The second questionnaire, the QTI (Student version), was selected as it would give insights into student-teacher interpersonal relationships in the classroom environment, thereby providing more insights into classroom dynamics. The TROFLEI was incorporated into the third questionnaire, the GTKY as it comprised a comprehensive set of affective outcomes scales which helped to capture students' attitude towards Science in these classrooms. Moreover, based on the literature review, the QTI and TROFLEI also have strong validity and reliability for use in the Singapore context.

Although the WIHIC scales, the QTI scales and the Attitude scales used in GTKY have proven reliability and validity, the internal consistency and discriminant validity of any psychosocial measurement instrument should be checked in the setting that it is used before any other results derived from the questionnaires can be used with confidence. This gave rise to my first research question.

Research Question 2

a. What are students' perceptions of the actual Science learning environment in a neighbourhood Secondary school?

b. What are students' preferred Science learning environments in a neighbourhood Secondary school?

c. Are there any differences between students' perceptions of the actual learning environment and what they would prefer it to be?

d. What are students' perceptions of their teacher-student interactions?

e. What are students' attitudes towards Science in a neighbourhood Secondary school?

Once reliability and validity were established, the second research question was formed to provide information in three main areas for a comprehensive picture of the Science classroom environment - the classroom environment itself using the WIHIC, the teacher-student interactions using the QTI, and attitudes of the students involved in the study using the Attitude scales in the GTKY.

To investigate classroom environment, the actual and preferred Science classroom environments were measured using the WIHIC (Actual) to the WIHIC (Preferred) respectively. Statistical tests conducted to compare the WIHIC (Actual) to the WIHIC (Preferred) would be able to reveal if the students were happy in the classroom environments as the closer the actual and preferred environments are to each other, the happier the students are in the Science classrooms.

The QTI was used to give added insights into teacher-student interpersonal relationships. Better relationships would mean happier students in the Science classrooms.

In addition, the Attitude scales in the GTKY, measuring attitude towards the subject, towards computer usage and academic efficacy, gave a comprehensive picture of students' attitude towards Science and helped to indicate if the students were enjoying Science as students who enjoy a subject would tend to have better attitudes towards the subject.

Research Question 3

Are there differences in students' perception of the actual Science learning environment, preferred Science learning environment, teacher-student interactions, and students' attitudes towards Science between the graduating classes and Secondary One classes?

Once a comprehensive picture of the Science environments was obtained, to determine if students were still enjoying Science by the time they left Secondary school, I needed to compare Secondary Four and Five graduating students exiting the school with Secondary One students entering the school. This gave rise to the third research question.

Research Question 4

Are there gender differences in students' perception of the actual Science learning environment, preferred Science learning environment, teacher-student interactions, and students' attitudes towards Science?

Further investigations were undertaken to ascertain whether the results were also related to the gender of the students. This gave rise to the fourth research question.

If students enjoyed Science by the time they left school, statistical tests generated for the third research question would reveal significant positive grade-level differences. Positive gender differences obtained from the fourth research question would show that the results obtained in the third research question were related to gender of the students.

Research Question 5

a. What associations are there between students' perceptions of their Science environment and their attitudes towards Science?

b. What associations are there between students' perceptions of their Science environment and their achievement in Science?

c. What associations are there between teacher-student interactions and their attitudes towards Science?

d. What associations are there between teacher-student interactions and their achievement in Science?

The fifth research question was formed to confirm associations between learning environment and attitudes towards Science and performance in the subject and associations between teacher-student interactions and attitudes towards Science and performance in the subject. These associations could help to confirm results from the second research question.

Simple and multiple regressions would be carried out to investigate such associations. Results from this question would help to support literature reviews that emphasize the importance of improving classroom learning environments and teacher-student interpersonal relationships.

Research Question 6

In a neighbourhood school in Singapore, what are students' opinions about their school, Science and what makes Science lessons enjoyable?

All the preceding research questions cover the quantitative component of the study until now. The sixth and final research question was derived to cover the qualitative component of the study.

Besides comprising of the Attitudes scales, the GTKY questionnaire also provided the qualitative aspects of the study in which students were asked about their opinions on Science, workload and school and to elaborate their answers.

To find out more about the students' views on Science, open-ended questions like 'Explain why you like or do not like Science in general now', 'Explain why you like or do not like Science when you were in Primary school' and 'What would you like to see more of in your Science lessons?' were included in GTKY. The middle question was asked to filter out students who never liked Science when they were in Primary school.

To gain insight on whether students were coping with their studies, they were also asked for their opinions on workload, if they had free time on weekdays and weekends, and how they spent their free time if any.

Finally, to gain insight on students' views on schooling in general, students were asked whether they liked school and to elaborate on their answers. They were also asked to comment on anything about school in general.

The findings obtained from the last research question with the embedded qualitative component would triangulate the findings of the quantitative component from the preceding research questions. Positive triangulated results obtained would mean that students were enjoying Science in a neighbourhood Secondary school in Singapore.

3.6 THE DEVELOPMENT OF THE QUESTIONNAIRES

From the literature review in Chapter Two, it can be concluded that it is not unusual for different instruments to be used in conjunction in order to explore different aspects of the environment. For example, the MCI was used in conjunction with the QTI by Goh and Fraser (1997). This study made use of three different instruments to obtain a more holistic picture of the learning environment by exploring different aspects of the environment.

The first and foremost instrument that was selected was the WIHIC (Actual and Preferred versions) to measure the Science learning environment per se (see Appendices 7 and 8). The WIHIC questionnaire was selected as it is one of the most established instruments with a history of being a reliable and valid tool for investigating classroom environments worldwide, including those in Singapore.

Short versions of the WIHIC for both the Actual and Preferred versions are also available. These Short versions have 25 questions each, which is about half the length of the original versions. However, according to McMillan and Schumacher (1993), it is generally recognised that the more items there are in an instrument, the higher the reliability. Because the pilot tests (see Section 3.7) showed that the students could cope with the longer versions and that survey fatigue was not an issue, the original versions were selected for use in this study to enhance reliability.

Again from the literature review, student-teacher interactions could be yet another area that could provide insight into classroom dynamics. The QTI was selected as it is also an established instrument that could be used to capture students' perceptions of their teachers. Like the WIHIC, the QTI also has a history of being a reliable and valid tool for investigating teacher-student interactions worldwide, including Singapore. To find out about this aspect of the learning environment, the QTI (Student version) was the second instrument selected for use in this study (see Appendix 9).

To capture the Attitude component in a more comprehensive manner, the three affective outcome scales of the TROFLEI were employed, namely, Attitude to Subject, Attitude to Computer and Academic Efficacy. From the literature review, it was observed that a number of studies have used the WIHIC in conjunction with two or three attitude scales (Dorman, Fisher, & Waldrip, 2006; Hoang, 2008). In this study, these three scales were incorporated into a self-designed GTKY questionnaire (see Appendix 10). This comprised the third instrument for use in this study.

The first section of the GTKY consisted of some open-ended questions while the second section consisted of the three Attitude scales. The qualitative component embedded in this questionnaire would provide some background knowledge of the students as well as help to provide a more in-depth understanding of why some of the options in the quantitative data in this questionnaire were selected. The results from the qualitative component would also triangulate results from the quantitative component.

All the instruments were administered online using computers.

3.7 PILOT TESTING

Two pilot tests were conducted - the first one in 2010 on two Secondary Four Normal Academic (NA) classes and the second in 2011 on two Secondary One NA classes. NA classes were selected as these students are of middle-ability when compared to the Express and Normal Technical classes. Testing on these students would provide a good gauge to check for language difficulties that may arise in the wordings of the questionnaire items. Of these students, a total of 37 Secondary 4NA students and 33 Secondary One NA students consented to participate in the pilot testing.

The aim of the first pilot test was to find out the possible problems that could be encountered in the data collection process using computers and the approximate length of time that would be needed for the students to complete the questionnaires. It helped to confirm if the whole survey process was too lengthy for the students, resulting in survey fatigue. The first pilot test would be able to indicate if adjustments were needed to shorten the questionnaires (i.e. if Short versions of the questionnaires should be used). More importantly, the pilot test would be able to indicate if the single data collection session had to be broken up into a few data collection sessions.

The questionnaires were successfully uploaded onto a web portal in Google and the results were successfully retrievable. From this pilot test, it was discovered that the amount of time the students needed was approximately one hour, which was a far cry from the suggested timings provided on the questionnaires.

As the four questionnaires were to be given consecutively one after the other for ease of administration, I was especially concerned if this would be too much for the students to take in one data collection session. Most of the students in the pilot test completed the questionnaires, with very few students stopping halfway through the process, showing that the combination of four questionnaires did not seem to be a problem. However, the first pilot test did reveal and indicate some language difficulties which impaired understanding of the questionnaire items.

The aim of the second pilot test was to check if the younger students in Secondary One could also take the long survey process, understand the wordings of the questionnaires, and to see if the one hour survey time that the older students needed was sufficient for them as well. The results of the second pilot test indicated that even Secondary One NA students could successfully finish the four questionnaires consecutively one after another. It also revealed no further language difficulties and confirmed that the one hour time needed for answering the questionnaires was sufficient.

As the pilot tests showed that the students could cope with the longer versions and that survey fatigue was not an issue, the longer original versions rather than the Short versions were selected for use in this study to increase reliability.

3.8 DATA COLLECTION AND ANALYSES

Permission was sought from the school principal before collecting data from students (see Appendix 3). With the approval from the principal, the classes involved in the study were then scheduled into various computer laboratories so students could give their consent and gain access to the questionnaires (see Appendix 4). Armed with the knowledge gleaned from the pilot tests, 70-minute sessions were allocated to each class, with five minutes to log in and five minutes to log out of the computers. A maximum of two computer laboratories was used at each session to minimize technical problems. This also enabled me to move from laboratory to laboratory to assist the teachers and clarify doubts.

The teachers involved were given instructions to guide their classes so students would know where to get the information on the study, where to give their consent before participating in the study, and finally where to access the questionnaires (see Appendix 5). Students who consented to take part in the study had to click on the information and consent page (see Appendix 6) before they commenced the first questionnaire. They were informed that they could drop out of the research at any time without being penalized.

Once consent was given, the students answered questions in the GTKY questionnaire (which included the qualitative component and the attitude scales) first, followed by the WIHIC (Actual version), then the WIHIC (Preferred version) and finally the QTI (Student version) (see Appendices 7 to 10 again for the online questionnaires). As the data collection was carried out in May as part of the post-examinations activities, the achievement scores in Science were obtained from the mid-year examinations that occurred in the same month. The use of mid-year examinations results was selected to give a more accurate portrayal of the students' achievement scores at the time when the environment and other classroom dynamics were measured, thereby minimizing factors that could change after the first semester, for example, changes in the time-tables, teachers or engagement of tuition in anticipation of end-of-year examinations.

The data collected were transferred into Excel spreadsheets during the data entry phase so that they could be easily imported into IBM® SPSS® Statistics Version 20. Individual responses from all the students were painstakingly cut and pasted into Excel spreadsheets so that each individual row in the spreadsheet comprised of an individual student's responses for all the four questionnaires. The responses were then coded. As all items in the WIHIC (Actual and Preferred) and the QTI scales were designed for a Likert-scale response using a five interval scale of almost never, to almost always, the coding was quite straight forward. For the Attitude Scales of the GTKY questionnaire, there were negative items. Coding had to be reversed for these negative items in these scales. After the coding, the data Excel spreadsheets containing all the students' responses were finally ready in April 2014 and imported into SPSS.

Statistical computations and data analyses were next carried out using SPSS. A point to note was that for the computation of the scale means for the QTI, as the 48 items of the QTI are arranged in a cyclic order, in blocks of eight, with one item in each block measuring a different scale, careful allocation of the items into the correct scales had to be checked carefully.

The quantitative data analyses focused on three objectives. Reliability and validity of the instruments were obtained in order to check their suitability for my study. As the instruments used are all established instruments, reporting on the Cronbach's alpha reliability would suffice to establish reliability. Inter-scale correlations were conducted to establish discriminant validity of the instruments.

Once the scales from the instruments were found to be reliable and valid, paired *t*-tests to check for significant differences were conducted. First, this was carried out on the Actual and Preferred WIHIC means for the school as a whole. Next, the data were split so that two paired *t*-tests were carried out separately on the two different levels.

To investigate grade-level differences and gender differences for each scale, ANOVAs were conducted. Finally, simple correlation and multiple regression techniques were conducted to look for associations and relationships between the learning environment scales and attitude scales and achievement in Science. They were also conducted to look for associations and relationships between the QTI scales and attitude scales and achievement in Science.

Some items of the questionnaires carried no responses so items with no responses were left blank in the data entry phase. In SPSS, entries with blank values were automatically deleted, resulting in different N values during the analyses.

For the qualitative component, to make the analysis easier, the responses for pertinent questions were summarized into main categories. From the summarized responses, it was then easier to see not only the ranking but the number of responses for each of the categories, giving us an indication of how much weighting each category had. Only the top few major categories of responses are tabulated.

3.9 ETHICAL CONSIDERATIONS

Ethical considerations included the first level of seeking approval from the Curtin University Ethics Committee to carry out research involving people (see Appendix 1). With this first level of approval obtained, the next level was to obtain the consent of the participants themselves. The participants were first asked to visit and read an online information page followed by the consent page.

The information page included the aim of the research, the participants' roles, and the procedures of the information gathering. Participants were also reassured that participation was on a voluntary basis and that they could withdraw at any stage of the data collection without affecting their rights or responsibilities. They were reassured that the information gathered would be strictly confidential and any materials obtained from them would be kept safely for five years before they were destroyed. After this, the participants were asked to click on the consent if they wanted to participate in the study.

This research involved no more risk than 'low risk' other than the risk of discomfort and inconvenience. Participant anonymity and confidentiality were maintained so that the risk to the participants was minimized. In the data analyses stage, sensitive information such as achievement scores and some of their responses about their home background and their views on the school would be private. Thus, student participants were only be re-identifiable through linked codes to preserve anonymity. As the data collection was carried out as a post-examinations activity, lessons were not disrupted. To avoid disruption to participants' time, 70 minutes were allocated for each class to complete the whole process.

3.10 SUMMARY

A mixed-method design was selected to gain a more complete picture of the Science learning environment using both quantitative and qualitative methods. The quantitative component was achieved through the use of four instruments and middle-of-the year examination results while the qualitative component played a supportive role through the use of open-ended questions in the first part of the self-designed GTKY instrument.

Having decided on the design, the methodology of the research was next planned. Suitable instruments, namely, the widely-used WIHIC and QTI, were selected for use in this study as they had established validity. The Attitude scales in the TROFLEI were incorporated into the second part of the GTKY questionnaire as it measures attitude comprehensive set of scales to measure attitude.

To determine if students were able to enjoy Science in a neighbourhood Secondary school, two levels of students were selected - the entry level which consists of students from Secondary One level entering the school while the exit level consists of Secondary Four and Five students graduating from the school. If students were still enjoying Science by the time they left school, it would mean that enjoying Science in a Singapore school is not an oxymoron.

A pilot test in two phases was conducted to check if the combination of the questionnaires would result in survey fatigue, to check for an appropriate length of timings for the data collection, and to see if the language used posed any difficulty to the different levels of students. As desired, the pilot tests confirmed the feasibility of collecting the data online using computers.

The methodology outlined in this chapter aligns with the theoretical framework for this study, recognizing that learning is situated in context, and that studying the complex and dynamic environment of the classrooms involves interactions between the learner, teacher and subject.

Ethical issues related to data collection and storage were strictly adhered to. Finally, analyses of the quantitative data were conducted using IBM® SPSS® Statistics Version 20. The results for both quantitative and qualitative data collected are presented in the following chapter, with the qualitative component embedded in the quantitative component to provide in-depth results.

CHAPTER 4

RESULTS AND ANALYSES

4.1 INTRODUCTION

This chapter begins with an introduction in Section 4.1, followed by results and analyses in Section 4.2, and ends with a summary in Section 4.3.

Section 4.1 is further broken down into six sub-sections. Section 4.2.1 provides a description of how the validity and reliability of the questionnaires were established. The What Is Happening In this Class? (WIHIC) for both Actual and Preferred versions, the Questionnaire on Teacher Interaction (QTI) for the Student version, and the Attitude scales in the Getting to Know You (GTKY) questionnaire have proven reliability and validity. Nevertheless, for my sample, I checked the internal consistency reliability and discriminant validity so that results derived from the questionnaires could be used with confidence.

Once the validity and reliability of the instruments were established using IBM® SPSS® Statistics Version 20, the rest of the results generated through SPSS for the quantitative component are then presented from Sections 4.2.2 to 4.2.5. An explanation of what the results in each table mean is provided in the relevant sections. From these results, the research questions are answered at the end of each of the relevant sections.

In Section 4.2.6, the last research question, comprising the qualitative component, is answered by summarizing the responses of the students to the opened-ended questions in the GTKY questionnaire, with statistics obtained from the online portal. These results help to triangulate findings obtained in the preceding research questions from Sections 4.2.2 to 4.2.5.

The final section presented in Section 4.3 summarises the information presented in this chapter with a condensed version of the answers to the research questions.

4.2 RESULTS AND ANALYSES

4.2.1 Research Question 1

Are the instruments used, namely, the WIHIC (Actual and Preferred), the QTI (Student version), and the Attitude Scales in GTKY, reliable and valid instruments for studying Science learning environments in a Singapore Secondary school?

To establish the reliability of the instruments, Cronbach's alpha reliability was estimated for each of the questionnaire scales. Generally, an alpha coefficient of greater than 0.8 is typically employed to denote an acceptable level of internal reliability (Bryman, 2012). McMillan and Schumacher (1993) suggested a value of greater than 0.5 would suffice for exploratory research. The higher the value of this coefficient, the better the internal consistency of the scales and the better the instrument is in measuring constructs consistently. In this study, the alpha coefficients of all the scales are all above 0.6, confirming that the instruments can be used with confidence in Singapore and with this sample of students.

To establish the discriminant validity for the WIHIC and Attitude scales, analyses were run to explore inter-scale correlations in the instruments. These estimate the degree to which any two scales are related to each other. For a questionnaire with good discriminant validity, theoretically dissimilar scales should have mean correlation values of considerably less than 1.

To further check the validity for the QTI scales, analyses were also run to explore the inter-scale correlations in the QTI. For the QTI, the Leary model predicts that correlations between two adjacent scales are expected to be highest, then gradually decrease until scales on the opposite end of the interpersonal circle are strongly negatively correlated; this is referred to as the circumplex model. The validity for the QTI scales is enhanced if the circumplex model applies to the data.

Table 4.1

Internal Consistency Reliability (Cronbach Alpha Coefficient), Discriminant Validity (Mean Correlation with Other Scales) and ANOVA eta^2 for the WIHIC (Actual)

Scale	Alpha Reliability	Mean Correlation with other Scales	ANOVA eta^2
Student Cohesiveness	0.89	0.45	0.05
Teacher Support	0.93	0.53	0.08***
Involvement	0.91	0.61	0.05
Investigation	0.93	0.54	0.03
Task Orientation	0.91	0.54	0.07**
Cooperation	0.94	0.57	0.10***
Equity	0.95	0.61	0.06**

**$p<0.01$ ***$p<0.001$

The sample consisted of 504 students in 16 classes.
The eta^2 statistic represents the proportion of variance explained by class membership.

Table 4.1 shows the reliability of the WIHIC (Actual) instrument. All the scale reliabilities are well above 0.80, which shows that the WIHIC (Actual) is a very reliable instrument for use in Singapore. The mean correlation of a scale with other scales for this instrument ranges from 0.45 to 0.61. Although the mean correlations with other scales for this instrument are less than 1, the means are relatively high, showing that there is some overlap of the scales. However, this is still acceptable as the scales are all aspects of the learning environment and the results low enough to indicate a reasonable level of scale independence

To further establish validity and in keeping with established traditions of learning environment research, the eta^2 statistic was measured for this instrument, which is basically the ratio of 'between' to 'total' sums of squares. This measure provides an estimate of the strength of the association between class membership and a WIHIC scale, or how much scale scores depend on the class the students are in. The ability to differentiate between classrooms is another desirable characteristic of any environment scale. If the within-class responses of the students from the same class are similar and greater than between-class perceptions, it would show that the instrument is valid. In order to investigate this characteristic, an ANOVA was used for each WIHIC Actual scale with class membership as the main effect.

The eta^2 generated (Table 4.1) showed significant differences between classes for four scales - Teacher Support, Task Orientation, Equity and Cooperation. The percentage of variance attributed to class membership was 6 to 10%, showing the WIHIC scale ability to differentiate significantly between students' perceptions in different classes on these four scales (Teacher Support, Task Orientation, Cooperation and Equity). Compared to previous research, this is a little lower as the sample used in this study is from the same school. Further, scales like Student Cohesiveness might not be as different between classes as it is potentially more influenced by peer relationships than by what takes place in a classroom.

Table 4.2
Internal Consistency Reliability (Cronbach Alpha Coefficient), Discriminant Validity (Mean Correlation with Other Scales) for the WIHIC (Preferred)

Scale	Alpha Reliability	Mean Correlation with other Scales
Student Cohesiveness	0.94	0.55
Teacher Support	0.94	0.57
Involvement	0.93	0.63
Investigation	0.96	0.53
Task Orientation	0.94	0.57
Cooperation	0.97	0.51
Equity	0.97	0.61

N=491

Table 4.2 shows the reliability of the WIHIC (Preferred) instrument. All the scales have alpha coefficients well above 0.80, which shows that the WIHIC (Preferred) can also be used with confidence in Singapore and with this sample of students. The mean correlation of a scale with other scales for this instrument ranges from 0.51 to 0.63. Again, although these mean values are less than 1, the means are on the higher side, showing that there is some overlap between the scales. However, these values are still low enough to indicate a reasonable level of scale independence.

Table 4.3
Internal Consistency Reliability (Cronbach Alpha Coefficient) for the QTI

Scale	Alpha Reliability
Leadership	0.88
Helpful and Friendly	0.77
Understanding	0.73
Student Responsibility	0.61
Uncertain	0.83
Dissatisfied	0.67
Admonishing	0.80
Strict	0.67

N=512

Table 4.3 shows the reliability of the QTI instrument. The alpha coefficients of the scales ranged from an acceptable value of 0.61 for Student Responsibility to a strong value of 0.88 for the Leadership scale. As all the scales are above the acceptable value of 0.60, this confirms that the QTI (Student version) can be reliably used in Singapore and on this sample of students.

As mentioned in the literature review in Chapter Two and in the introduction in this chapter, because the scales of the QTI are arranged to form a circumplex model, scale intercorrelations were checked with these data. Correlations should be highly positive with neighbouring scales, decreasing as it moves around the model until the scales become strongly negative with scales on the opposite end of the interpersonal circle. Table 4.4 shows the results of the inter-correlations between the QTI scales.

Table 4.4

Intercorrelations Between QTI Scales

QTI scale	Leader (DC)	Help/F (CD)	Under (CS)	S Resp (SC)	Uncer (SO)	Dissat (OS)	Admon (OD)	Strict (DO)
Leader (DC)	1	0.84**	0.30**	0.15**	-0.89**	-0.71**	-0.36**	0.19**
Help/F (CD)		1	0.10*	0.06	-0.80**	-0.76**	0.15**	0.11*
Under (CS)			1	0.58**	0.28**	-0.03	-0.83**	0.54**
S Resp (SC)				1	0.07	0.09*	-0.58**	-0.74**
Uncer (SO)					1	0.70**	0.33**	0.13**
Dissat (OS)						1	0.01	0.16**
Admon (OD)							1	0.57**
Strict (DO)								1

N = 503, **p*<0.05, **p*<0.01

For example, the scale of Leadership correlates closely and positively with Helpful/Friendly (0.84). This number decreases with other scales until it reaches the lowest value of -0.89 for the Uncertainty scale, which is the scale on the opposite end of the Leadership scale in the circumplex model. Similar trends can be seen for the other QTI scales, with the Understanding scale being at opposite ends with the Admonishing scale and the Student Responsibility scale being at opposite ends with the Strict scale. QTI scale inter-scale correlations satisfy this assumption with minor discrepancies, thereby establishing discriminant validity for the QTI scales in this study.

The last table, Table 4.5, shows the reliability of the Attitude scales embedded in the GTKY questionnaire.

Table 4.5
Internal Consistency Reliability (Cronbach Alpha Coefficient) and Discriminant Validity (Mean Correlation with Other Scales) for the Attitude Scales in the GTKY

Scale	Alpha Reliability	Mean Correlation with other Scales
Attitude to Subject	0.79	0.30
Academic Efficacy	0.82	0.32
Attitude to Computers	0.80	0.06

N=404

As the Attitudes scales from the GTKY questionnaire were obtained from an established instrument with good reliability and validity, factor analysis was not necessary and reporting of alpha coefficients suffices. The alpha coefficients of the Attitude scales in the GTKY are all well above 0.6, showing that the Attitude instrument was reasonably good, and could be used with confidence in Singapore and on this sample of students as well.

The mean correlation of a scale with other scales for Attitude ranges from 0.06 to 0.32. The scales therefore measure distinct although somewhat overlapping aspects of attitudes.

Answer to Research Question 1:

Are the instruments used, namely, the WIHIC (Actual and Preferred), the QTI (Student version), and the Attitude Scales in GTKY, reliable and valid instruments for studying Science learning environments in a Singapore Secondary school?

All the scales had alpha coefficients above 0.80 for both the WIHIC (Actual) and WIHIC (Preferred). For the WIHIC (Actual), the eta^2 statistic showed significant differences between classes for Teacher Support, Task Orientation, Equity and Cooperation. For the QTI, the alpha coefficients of the scales were above 0.6, ranging from 0.61 for Student Responsibility to 0.88 for the Leadership scale. For the Attitude instrument, the alpha coefficients of the scales were all well above 0.6.

As for discriminant validity, the mean correlations with other scales for the WIHIC and Attitude instruments were less than 1, low enough to indicate a reasonable level of scale independence. For the QTI, inter-scale correlations followed the circumplex model with minor discrepancies.

Therefore, the reliability and validity of each of the instruments suggest that there is internal consistency and acceptable mean correlation values between scales with this sample of Secondary school students. This shows that the instruments used in this study can be used with confidence for studying science learning environments in a Singapore Secondary school setting and on this sample of students.

4.2.2 Research Question 2

a. What are students' perceptions of the actual Science learning environment in a neighbourhood Secondary school?

b. What are students' preferred Science learning environments in a neighbourhood Secondary school?

c. Are there any differences between students' perceptions of the actual learning environment and what they would prefer it to be?

d. What are students' perceptions of their teacher-student interactions?

e. What are students' attitudes towards Science in a neighbourhood Secondary school?

Having established the reliability and validity of the instruments, the instruments could then be used with confidence. The WIHIC (Actual) and WIHIC (Preferred) questionnaires were used to investigate students' perceptions of the actual as well as preferred science classes, the QTI was used to investigate students' interactions with their science teachers in these classes, and the Attitude scales in the GTKY questionnaire were used to investigate students' attitude.

To answer the first three parts of this research question, students' perceptions of the actual as well as preferred science classes were obtained. A paired samples *t*-test was used to compare the WIHIC (Actual) average item means with the average item means of the WIHIC (Preferred) for each scale. The average item mean is the scale mean divided by the number of items in the scale. The closer the actual means are to the preferred means, the happier the students are.

To find out which grade level contributed to the differences, the data were split. Splitting the data, another two paired *t*-tests were generated for each scale to compare the Actual and Preferred differences for both the Secondary One students (Entry level) and Secondary Four/Five students (Exit level).

Table 4.6 shows results obtained for whole sample; Table 4.7 shows the results obtained at the Secondary One level; and Table 4.8 shows the results obtained at the Secondary Four/Five level.

Table 4.6
Mean Values and Standard Deviations for the Preferred and the Actual Learning Environment (Whole School)

Scale	Mean Value		Standard Deviation		Difference Preferred-Actual	*t* value
	Act	Pref	Act	Pref		
Student Cohesiveness	3.76	3.70	0.75	0.84	0.06	2.30*
Teacher Support	3.14	3.26	0.89	0.87	-0.12	-3.90***
Involvement	3.01	3.14	0.84	0.84	-0.13	-4.77***
Investigation	2.93	3.09	0.86	0.90	-0.16	-4.95***
Task Orientation	3.59	3.62	0.77	0.83	-0.02	-0.96
Cooperation	3.51	3.56	0.85	0.88	-0.05	-1.75
Equity	3.34	3.45	0.93	0.92	-0.11	-3.39**

N=487 *p<0.05 **p<0.01 ***p<0.001

For the school as a whole, except for Investigation, the average item means for all the scales of the WIHIC are all above 3, which corresponds to a response between 3 ‘Sometimes’ and 4 ‘Often’ in the questionnaire.

Significant differences between the Actual and Preferred means are observed for the whole sample for five out of seven scales, namely, Student Cohesiveness, Teacher Support, Involvement, Investigation and Equity.

To find out which level contributed to the differences, the data were split. Table 4.7 shows the results obtained for the Secondary One level, while Table 4.8 shows the results obtained for the Secondary Four/Five level.

Table 4.7
Comparison of the Preferred with the Actual Learning Environment (Secondary One Sample)

Scale	Mean Value		Standard Deviation		Difference Preferred-Actual	*t* value
	Act	Pref	Act	Pref		
Student Cohesiveness	3.72	3.67	0.80	0.92	0.06	1.35
Teacher Support	3.12	3.24	0.95	0.91	-0.12	-2.43*
Involvement	3.00	3.11	0.88	0.91	-0.12	-2.64**
Investigation	2.94	3.12	0.96	0.95	-0.19	-3.74***
Task Orientation	3.63	3.63	0.86	0.89	0.00	0.13
Cooperation	3.50	3.53	0.91	0.95	-0.04	-0.84
Equity	3.34	3.51	0.99	0.97	-0.16	-3.18**

N=227 **p*<0.05 ***p*<0.01 ****p*<0.001

At the Secondary One entry level, once again, except for Investigation, the means for all the scales of the WIHIC are all above 3, corresponding to between 3 ‘Sometimes’ and 4 ‘Often’ in the questionnaire.

Table 4.8

Comparison of the Preferred with the Actual Learning Environment (Secondary Four/Five Sample)

Scale	Mean Value		Standard Deviation		Difference Preferred-Actual	*t* value
	Act	Pref	Act	Pref		
Student Cohesiveness	3.79	3.73	0.70	0.77	0.06	1.93
Teacher Support	3.16	3.28	0.83	0.82	-0.12	-3.17**
Involvement	3.02	3.17	0.80	0.78	-0.15	-4.18***
Investigation	2.93	3.06	0.77	0.84	-0.13	-3.25**
Task Orientation	3.56	3.61	0.70	0.76	-0.05	-1.38
Cooperation	3.52	3.58	0.80	0.82	-0.06	-1.63
Equity	3.34	3.40	0.87	0.88	-0.06	-1.52

N=260 *p<0.05 **p<0.01 ***p<0.001

At the Secondary Four/Five exit level, again except for Investigation, the means for all the scales of the WIHIC are all above 3, corresponding to between 3 ‘Sometimes’ and 4 ‘Often’ in the questionnaire.

Next, to provide more insight into classroom dynamics, analyses were conducted on the QTI scales to investigate student-teacher interactions. These results answer the fourth part in this research question.

Table 4.9
Mean Values and Standard Deviations for the QTI (Whole School)

Scale	No. of items	Mean Value	Standard Deviation
Leadership	6	3.45	0.87
Helpful/Friendly	6	3.48	0.75
Understanding	6	3.40	0.82
Responsibility	6	2.81	0.67
Uncertain	6	2.29	0.72
Dissatisfied	6	2.54	0.62
Admonishing	6	2.47	0.77
Strict	6	3.10	0.70

N = 503

As shown in Table 4.9, the means for Leadership, Helpful/Friendly, and Understanding are all relatively high, indicating that students on the whole as a school perceived their teachers as displaying cooperative behaviours. The mean score of 3.45 for the Leadership scale corresponds to the questionnaire response between 3 'Sometimes' and 4 'Often' and shows teachers' tendency to lead and hold students' attention in class. Similarly, the mean score of 3.48 for the Helpful/Friendly scale shows teachers' tendency to be helpful and friendly towards students, and the mean score of 3.40 for the Understanding scale shows teachers' tendency to be understanding and caring towards students. Although relatively high, the mean score of 2.80 for the Responsibility scale corresponds to between 2 'Seldom' and 3 'Sometimes' in the questionnaire, showing teachers' tendency not to give opportunities for students to assume personal responsibilities, albeit tilted more towards 3 'Neutral'.

As Teacher Behaviour follows a circumplex model, except for the Strict scale, the mean scores obtained for the scales on the opposite ends of the interpersonal circle (the Uncertain, Dissatisfied, and Admonishing scales) are correspondingly lower. These mean scores correspond to between 2 'Seldom' and 3 'Sometimes' in the questionnaire, showing teachers' tendency of not being uncertain, of not displaying a dissatisfied behaviour, and of not displaying anger or impatience in class. Although falling into the same category, it should be noted that the means of the Uncertain and

Admonishing scales tilted more towards 2 'Seldom' while that of Dissatisfied tilted towards the 3 'Neutral'. Lastly, the mean score of 3.10 for the Strict scale corresponds to between 3 'Sometimes' and 4 Sometimes' in the questionnaire, showing teachers' tendency of being strict in class.

To summarize, the means are correspondingly higher on one side of the circumplex model than on the other side, with slightly higher means for the Strict scale. This indicates that, although students perceived their teachers as cooperative, they also viewed them as strict during lessons. Figure 4.1 shows the profile of the science teacher based on responses of both levels of students as a school.

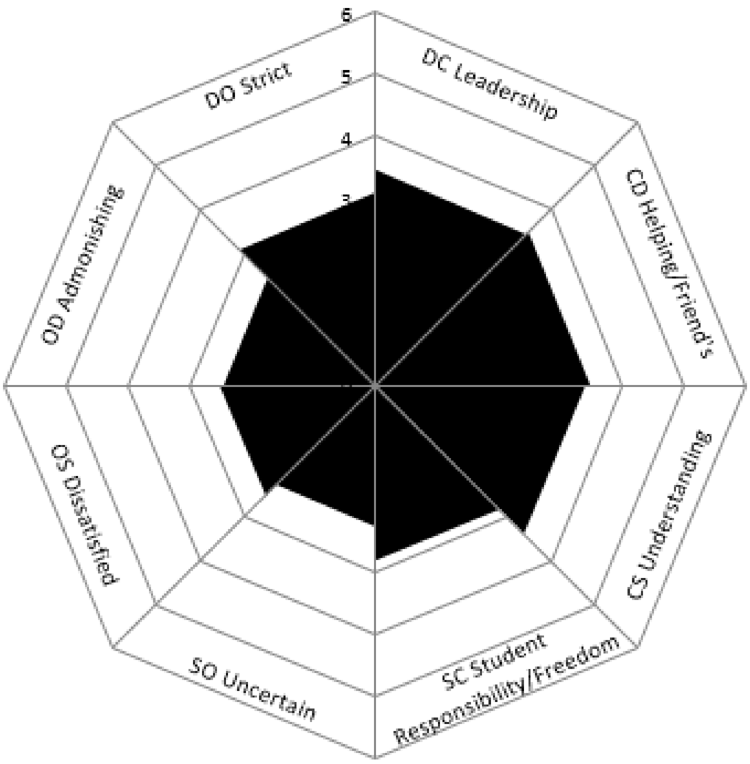

Figure 4.1. Profile of teachers' interpersonal behaviour as a school (*N*=499).

To provide more insight into classroom dynamics, analyses were conducted on the scales measuring Attitudes in the incorporated into the GTKY questionnaire. These results answer the fifth part in this research question. Results to establish more information on students' attitude are presented in Table 4.10.

Table 4.10

Mean Values and Standard Deviations for Attitude Scales in the GTKY

Scale	*N*	No of items	Mean Value	Standard Deviation
Attitude to Science	410	8	3.22	0.72
Academic Efficacy	413	8	2.74	0.77
Attitude to Computers	407	8	3.66	0.72

The mean score of 3.22 for the Attitude to Science scale correspond to between 3 ‘Sometimes’ and 4 ‘Often’ in the questionnaire, showing that students had favourable attitudes towards Science as a subject. The mean score of 3.66 for the Attitude to Computers scale correspond to between 3 ‘Sometimes’ and 4 ‘Agree’ in the questionnaire, showing that students had favourable attitudes towards computer usage for lessons. The mean score of 2.74 for the Academic Efficacy scale corresponds to between 2 ‘Disagree’ and 3 ‘Sometimes’ in the questionnaire, showing that students did not really feel confident about their ability to do well for Science.

Answers to Research Question 2:

a. What are students’ perceptions of the actual Science learning environment in a neighbourhood Secondary school?

b. What are students’ preferred Science learning environments in a neighbourhood Secondary school?

c. Are there any differences between students’ perceptions of the actual learning environment and what they would prefer it to be?

Results obtained for the WIHIC as a whole school showed that, except for the Investigation scale, the means for all other scales of the WIHIC (Actual) were above 3 corresponding to ‘Neutral’, which showed that students’ perceptions of the actual science learning environment in a favourable light. When the data were split, similar results were obtained, showing that students at both grade levels perceived the science classroom environment favourably. This finding is consistent with results obtained from the qualitative component in Research Question 6 and is discussed later in Section 4.3.6.

At the whole school level, there were significant differences between the Actual and Preferred means for five out of seven scales, namely, Student Cohesiveness, Teacher Support, Involvement, Investigation and Equity. The closer the actual means are to the preferred means, the happier the students are. The data were split to find out which level contributed most to these differences.

At the Secondary One entry level, the WIHIC results showed significant differences between the Actual and Preferred means for four out of seven scales, namely, Teacher Support, Involvement, Investigation and Equity. The WIHIC results for the Secondary Four/Five exit level revealed significant differences between the Actual and Preferred means for only three out of seven scales, namely, Teacher Support, Involvement, and Investigation. Differences between the actual and preferred environments usually indicate that improvements are necessary to narrow these differences. This suggests that Secondary Four/Five students seem to be happier when compared to their juniors at the Secondary One level as there are less significant differences for the graduating level between their actual and preferred learning environments.

Results seemed to indicate that Secondary One students wanted more help from the teacher, or friendlier teachers who trust and show a personal interest in them. They also wanted more participation in discussions and opportunities to enjoy the class. They wanted teachers to treat them more equally. But most of all, Secondary One students wanted lessons that gave emphasis on skills and their use in problem solving and investigations.

Results also seemed to indicate that students from the graduating level wanted more help from the teacher, or friendlier teachers who trust and show a personal interest in them. Like the Secondary One students, they also wanted lessons that gave emphasis to the skills and their use in problem solving and investigations but, unlike the Secondary One students, the graduating level of students wanted mostly to participate in discussions and opportunities to enjoy the class.

d. What are students' perceptions of their teacher-student interactions?

The means for Leadership, Helpful/Friendly, Understanding are all relatively high, indicating that students perceived their teachers as displaying cooperative behaviours. The mean score of 3.45 for the Leadership scale corresponds to between 3 'Sometimes' and 4 'Often' in the questionnaire, showing teachers' tendency to lead and hold students' attention in class. Similarly, the mean score of 3.48 for the Helpful/Friendly scale shows teachers' tendency to be helpful and friendly towards students, and the mean score of 3.40 for the Understanding scale shows teachers' tendency to be understanding and caring towards students. Although relatively high, the mean score of 2.80 for the Responsibility scale corresponds to between 2 'Seldom' and 3 'Sometimes' in the questionnaire, showing teachers' tendency not to give opportunities for students to assume personal responsibilities, albeit tilted more towards 3 'Neutral'.

As these measures assess teacher behaviour following a circumplex model, except for the Strict scale, the mean scores obtained for the scales on the opposite ends of the interpersonal circle, namely, the Uncertain scale, Dissatisfied scale, and Admonishing scale are correspondingly lower. These mean scores correspond to between 2 'Seldom' and 3 'Sometimes' in the questionnaire, showing teachers' tendency of not being uncertain, of not displaying a dissatisfied behaviour, and of not displaying anger or impatience in class. Although falling into the same category, it should be noted that the means of the Uncertain and Admonishing scales tilted more towards 2 'Seldom' while that of Dissatisfied tilted towards the 3 'Neutral'. Lastly, the mean score of 3.10 for the Strict scale corresponds to between 3 'Sometimes' and 4 'Sometimes' in the questionnaire, showing teachers' tendency of being strict in class.

This indicates that, although students perceived their teachers as cooperative, they also viewed them as strict when it came to lessons. Finally, the lower mean for the Student Responsibility scale shows that more opportunities can be given to students to assume responsibilities for their own learning.

e. What are students' attitudes towards Science in a neighbourhood Secondary school?

The mean score of 3.22 for the Attitude to Science scale correspond to between 3 'Sometimes' and 4 'Often' in the questionnaire, showing that students had favourable attitudes towards Science as a subject, albeit to a degree that is nearer to the 3. The mean score of 3.66 for the Attitude to Computers scale correspond to between 3 'Sometimes' and 4 'Agree' in the questionnaire, showing that students had favourable attitudes towards computers use for lessons, to a degree that is nearer to the 4. The mean score of 2.74 for the Academic Efficacy scale corresponds to between 2 'Disagree' and 3 'Sometimes' in the questionnaire, which is less than 3 'Neutral'. This shows that students did not feel as confident about their ability to do well for Science.

These findings for attitude are consistent with results from the qualitative component showing why students liked or disliked Science and what they wanted to see more of in Science lessons (see Research Question 6).

4.2.3 Research Question 3

Are there differences between the graduating classes and Secondary One classes in students' perception of the actual Science learning environment, preferred Science learning environment, teacher-student interactions, and students' attitudes towards Science?

To compare students who just joined the school at the Secondary One level and students who are graduating and leaving the school at the Secondary Four/Five level, ANOVAs for both the actual and preferred learning environments, for the QTI, as well as for attitude scales in the GTKY questionnaires, were conducted.

Results of the tests are reported in Table 4.11 for the actual learning environments, Table 4.12 for the preferred learning environments, in Table 4.13 for teacher-student interactions, and in Table 4.14 for students' attitudes.

Table 4.11

Grade Level Differences for Actual Learning Environment

Scale	Mean Value		Standard Deviation		*F* Value
	Sec 1	Sec 4/5	Sec 1	Sec 4/5	
Student Cohesiveness	3.72	3.77	0.80	0.70	0.55
Teacher Support	3.10	3.16	0.95	0.82	0.57
Involvement	2.99	3.02	0.88	0.79	0.16
Investigation	2.92	2.93	0.96	0.77	0.02
Task Orientation	3.61	3.55	0.87	0.71	0.70
Cooperation	3.48	3.50	0.91	0.80	0.07
Equity	3.32	3.32	0.99	0.88	0.01

N (Sec 1) = 233, *N* (Sec 4/5) = 271

The values of the average item mean for all WIHIC (Actual) scales range from 2.92 to 3.72 for the Secondary One level and from 2.93 to 3.77 for the Secondary Four/Five level, which correspond to between 3 ‘Sometimes’ and 4 ‘Often’.

None of the seven scales of the actual learning environment were found to have statistically significant differences between the two levels.

Table 4.12

Grade Level Differences for Preferred Learning Environment

Scale	Mean Value		Standard Deviation		*F* Value
	Sec 1	Sec 4/5	Sec 1	Sec 4/5	
Student Cohesiveness	3.67	3.72	0.91	0.77	0.43
Teacher Support	3.24	3.28	0.91	0.83	0.26
Involvement	3.11	3.17	0.91	0.78	0.61
Investigation	3.12	3.06	0.95	0.84	0.54
Task Orientation	3.62	3.62	0.89	0.77	0.00
Cooperation	3.53	3.58	0.94	0.82	0.39
Equity	3.50	3.39	0.97	0.88	1.71

N (Sec 1) = 229, *N* (Sec 4/5) = 262

The values of the average item mean for all WIHIC (Preferred) scales range from 3.11 to 3.67 for the Secondary One level and from 3.06 to 3.72 for Secondary Four/Five level. These results correspond to between 3 ‘Sometimes’ and 4 ‘Often’ for each grade level.

None of the seven scales of the preferred learning environment were found to have statistically significant differences between the levels.

Next, for insights on grade level differences with regards to teacher-student interactions, a one-way ANOVA was carried out for each QTI scale. Results of the test are reported in Table 4.13.

Table 4.13

Grade Level Differences for the QTI

Scale	Mean Value		Standard Deviation		*F* Value
	Sec 1	Sec 4/5	Sec 1	Sec 4/5	
Leadership	3.35	3.54	0.88	0.76	6.57**
Helpful/Friendly	3.40	3.54	0.95	0.83	3.05
Understanding	3.28	3.51	0.97	0.84	7.94**
Responsibility	2.84	2.79	0.75	0.54	0.71
Uncertain	2.45	2.15	0.81	0.77	18.06***
Dissatisfied	2.69	2.41	0.88	0.81	13.62***
Admonishing	2.52	2.43	0.78	0.75	1.72
Strict	3.04	3.16	0.70	0.61	4.13**

N (Sec 1) = 232, *N* (Sec 4/5) = 271 *$p<0.05$ **$p<0.01$ ***$p<0.001$

The values of the average item mean for the QTI scales range from 2.45 to 3.35 for the Secondary One level and 2.15 to 3.54 for Secondary Four/Five level. These results correspond to 2 ‘Seldom’, 3 ‘Sometimes’ and 4 ‘Often’.

The means are correspondingly higher on one side of the circumplex model than on the other side, with slightly higher means for the strict scale, indicating that students perceived their science teachers are mostly cooperative albeit strict.

Five of the scales were found to have statistically significant differences between the levels, namely, Leadership (F=6.57, p<0.01), Understanding (F=7.94, p<0.01), Uncertain (F=18.06, p<0.001), Dissatisfied (F=13.62, p<0.001) and Strict (F=4.13, p<0.01). The Secondary One students had higher means for the Uncertain and Dissatisfied scales while the Secondary Four/Five students had higher means for the Leadership, Understanding and Strict scales. This indicates that students in the Secondary Four/Five levels viewed their teachers as having more leadership behaviour while students in the Secondary One level viewed their teachers as more uncertain and dissatisfied.

The circumplex model in Figure 4.2 shows the profile of the science teacher for the Secondary One level. Means were higher for the cooperative quadrants, showing that Secondary One students thought of their Science teachers as authoritative but helpful and understanding.

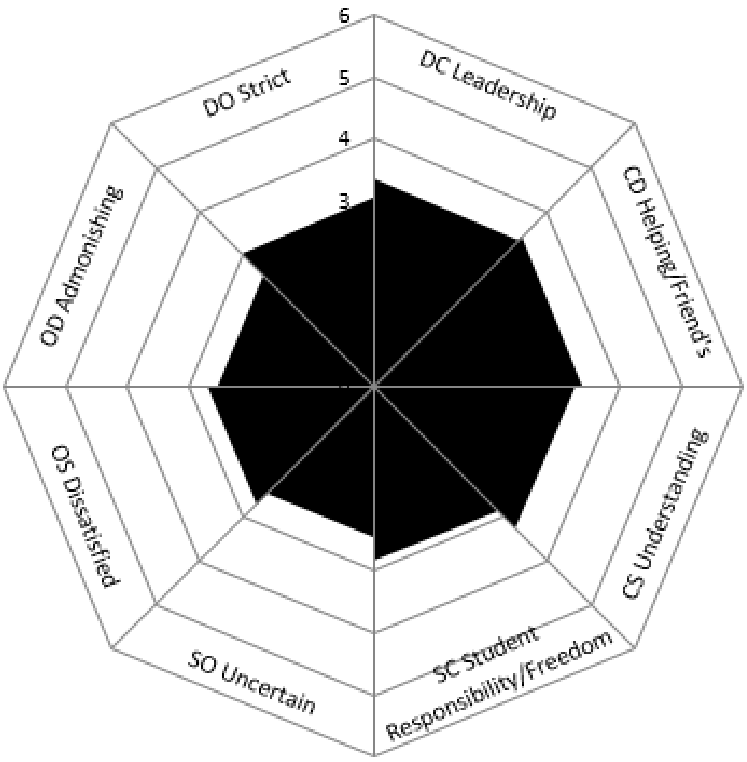

Figure 4.2. Profile of teachers' interpersonal behaviour for Secondary One (*N*=230).

The circumplex model in Figure 4.3 shows the profile of the science teacher for the Secondary Four/Five level. The means are also higher for the cooperative quadrants, as well as for the Strict quadrant, showing that Secondary Four/Five students thought of their Science teachers as authoritative but helpful and understanding.

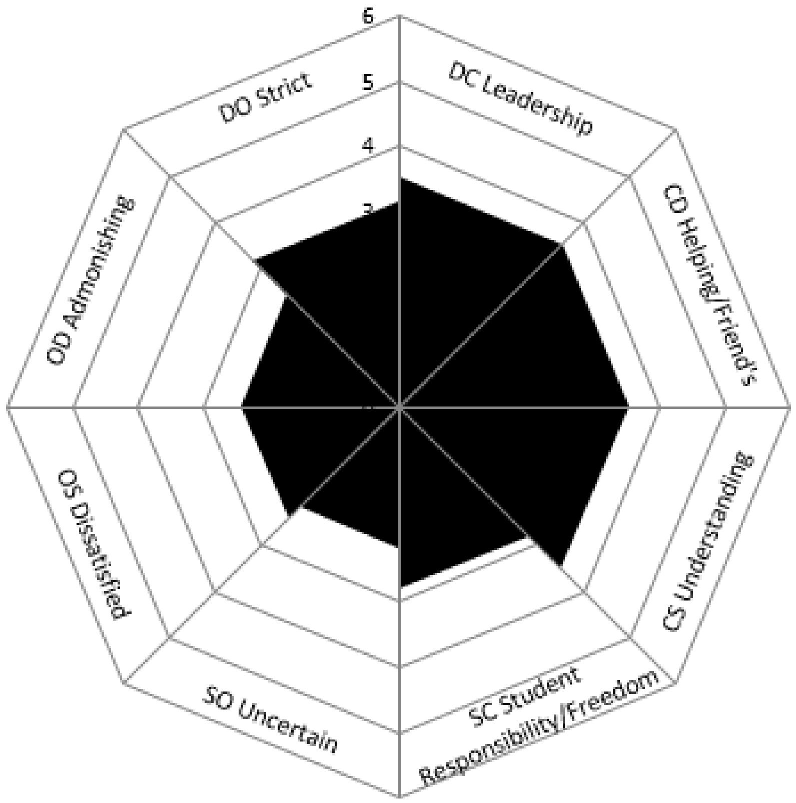

Figure 4.3. Profile of teachers' interpersonal behaviour for Secondary Four/Five (*N*=269).

Lastly, for insights on level differences with regards to Attitudes, a one-way ANOVA was carried out on the three Attitude Scales in the GTKY questionnaire. Results are presented in Table 4.14.

Table 4.14

Grade Level Differences for Attitude Scales in the GTKY

Scale	*N*		Mean Value		Standard Deviation		*F* Value
	Sec 1	Sec 4/5	Sec 1	Sec 4/5	Sec 1	Sec 4/5	
Attitude to Science	193	217	3.22	3.22	0.75	0.67	0.00
Academic Efficacy	190	223	2.77	2.71	0.81	0.73	0.62
Attitude to Computers	190	217	3.89	3.46	0.73	0.66	38.43***

****p*<0.001

The mean values for all the attitude scales range from 2.77 to 3.46 for the Secondary One level and from 2.71 to 3.89 for the graduating level. Figure 4.4 shows the means of the three Attitude scales for both levels.

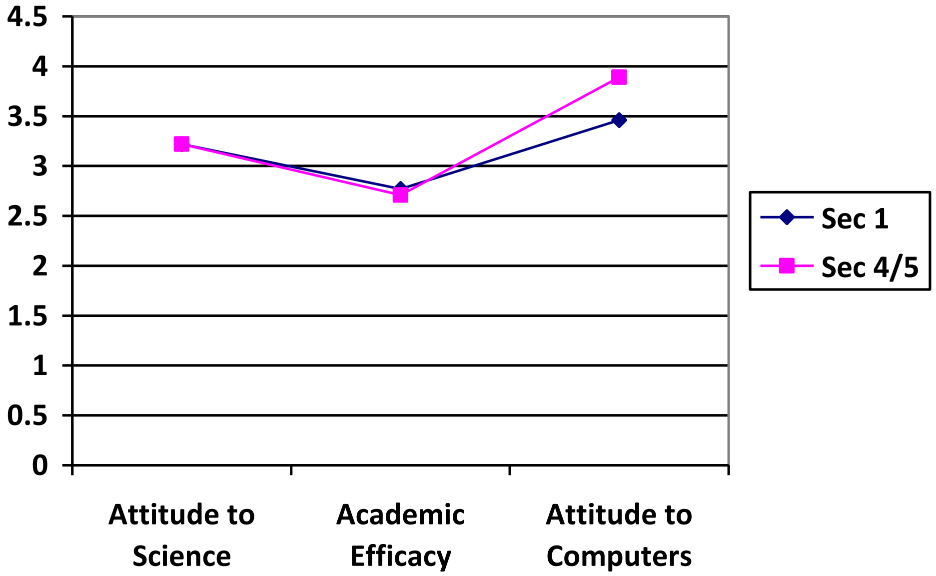

Figure 4.4. Grade level differences on Attitude scales in the GTKY.

Out of the three scales, only the Attitude to Computers scale (F=38.43, p<0.001) was found to have a statistically significant difference between the Secondary Four/Five level and Secondary One level. Secondary One students had higher means for this scale.

Answer to Research Question 3:

Are there differences between graduating classes and Secondary One classes in students' perceptions of the actual Science learning environment, preferred Science learning environment, teacher-student interactions, and students' attitudes towards Science?

None of the seven scales for both the actual and the preferred learning environments were found to have statistically significant differences between grade levels. On the whole, it seems that students from both levels are fairly satisfied with the science learning environment. The findings from the WIHIC (Actual) are consistent with results from the qualitative component (Research Question 6) for which many of the responses from the students were similarly positive.

Five of the scales were found to have statistically significant differences between grade levels, namely, Leadership (F=6.57, p<0.01), Understanding (F=7.94, p<0.01), Uncertain (F=18.06, p<0.001), Dissatisfied (F=13.62, p<0.001) and Strict (F=4.13, p<0.01). The Secondary One students had higher means for the Uncertain and Dissatisfied scales while the Secondary Four/Five students had higher means for the Leadership, Understanding and Strict scales. This indicates that students at the Secondary Four/Five levels viewed their teachers had more leadership behaviour and were more understanding although strict, while students in the Secondary One level viewed their teachers as more uncertain and dissatisfied.

With regards to attitudes, out of the three scales, only the Attitude to Computers scale (F=38.43, p<0.001) was found to have statistically significant difference between the graduating level and the Secondary One level.

4.2.4 Research Question 4

Are there gender differences in students' perceptions of the actual Science learning environment, preferred Science learning environment, teacher-student interactions, and students' attitudes towards Science?

Gender differences were investigated by running one-way ANOVA tests for all the scales in the WIHIC (Actual and Preferred) questionnaire, the QTI and the Attitude component of the GTKY questionnaire. The results obtained are presented in Tables 4.15 to 4.18.

Table 4.15

Gender Differences for Actual Learning Environment

Scale	Mean Value		Standard Deviation		*F* Value
	Male	Female	Male	Female	
Student Cohesiveness	3.73	3.76	0.81	0.67	0.21
Teacher Support	3.16	3.09	0.88	0.90	0.76
Involvement	3.06	2.93	0.88	0.72	3.32
Investigation	3.03	2.80	0.87	0.84	9.00**
Task Orientation	3.59	3.57	0.80	0.77	0.08
Cooperation	3.48	3.51	0.90	0.80	0.16
Equity	3.32	3.32	0.95	0.91	0.00

N (males) = 286, *N* (females) = 218   ** $p<0.01$

The values for all WIHIC (Actual) scales range from 2.93 to 3.76 for girls and from 3.03 to 3.73 for boys, which correspond to between 3 'Sometimes' and 4 'Often'. Students of both genders are thus fairly satisfied with the science learning environment.

Only one out of seven scales was found to have statistically significant gender differences and that was the scale of Investigation (F=9.00, $p<0.01$), with the average item means being higher for boys than for girls. Such differences can inform us about the way in which males and females differ in their views of various components of the learning environment.

Table 4.16

Gender Differences for Preferred Learning Environment

Scale	Mean Value		Standard Deviation		*F* Value
	Male	Female	Male	Female	
Student Cohesiveness	3.69	3.71	0.87	0.81	0.07
Teacher Support	3.29	3.22	0.91	0.80	0.82
Involvement	3.22	3.04	0.89	0.75	5.90*
Investigation	3.20	2.95	0.92	0.83	9.94**
Task Orientation	3.61	3.62	0.86	0.77	0.02
Cooperation	3.48	3.51	0.90	0.80	0.14
Equity	3.44	3.45	0.97	0.86	0.02

N (males) = 280, *N* (females) = 211 *$p<0.05$ **$p<0.01$

The values for all WIHIC (Preferred) scales range from 2.95 to 3.71 for girls and from 3.22 to 3.69 for boys, which correspond to between 3 ‘Sometimes’ and 4 ‘Often’.

Two out of seven scales were found to have statistically significant gender differences, namely, Student Involvement (F=5.90, $p<0.05$) and Investigation (F=9.94, $p<0.01$), with the average item means for boys higher than those for girls.

It can be also be observed that Investigation has the largest gender gap, followed by the Involvement scale. Boys also had higher means when compared to girls.

Next, for insights on gender differences with regards to teacher-student interactions, a One-way ANOVA was also carried out for each QTI scale. Results are presented in Table 4.17.

Table 4.17

Gender Differences for the QTI

Scale	Mean Value		Standard Deviation		*F* Value
	Male	Female	Male	Female	
Leadership	3.46	3.44	0.87	0.80	0.07
Helpful/Friendly	3.23	3.20	0.81	0.66	0.21
Understanding	3.40	3.41	0.94	0.87	0.02
Responsibility	3.05	3.10	0.74	0.56	0.74
Uncertain	2.36	2.19	0.82	0.77	5.67*
Dissatisfied	2.95	2.76	0.67	0.54	12.40***
Admonishing	2.57	2.34	0.80	0.70	11.77***
Strict	3.19	3.00	0.70	0.58	11.06***

N (males) = 285, *N* (females) = 218   *p<0.05 ***p<0.001

The values of the average item mean for the QTI scales range from 2.36 to 3.46 for boys and from 2.19 to 3.44 for girls. These results range between responses of 2 'Seldom' and 3 'Neutral'. The means are correspondingly higher on one side of the circumplex model than on the other side, with slightly higher means for the Strict scale, indicating that both genders perceived their science teachers as displaying cooperative but strict behaviours. On the Strict scale, boys had slightly higher means than girls.

Four out of eight scales were found to have statistically significant gender differences, namely, Uncertain (F=5.67, p<0.05), Dissatisfied (F=12.40, p<0.001), Admonishing (F=11.77, p<0.001) and Strict (F=11.06, p<0.001). The results for these scales show that boys perceived their science teachers as being more uncertain, admonishing and strict and more dissatisfied with students in class than girls.

Lastly, for insights on gender differences with regards to Attitudes, a One-way ANOVA was also carried out on the three Attitude Scales in the GTKY questionnaire. Results are shown in Table 4.18.

Table 4.18

Gender Differences for Attitude Scales in the GTKY

Scale	*N*		Mean Value		Standard Deviation		*F* Value
	Male	Female	Male	Female	Male	Female	
Attitude to Science	241	169	3.31	3.09	0.76	0.61	10.52***
Academic Efficacy	240	173	2.84	2.59	0.77	0.73	11.26***
Attitude to Computers	237	170	3.76	3.52	0.69	0.75	10.83***

****p*<0.001

The mean values for all the attitude scales range from 2.59 to 3.52 for girls and from 2.84 to 3.76 for boys. Figure 4.5 shows the Attitude means for the various scales for both genders.

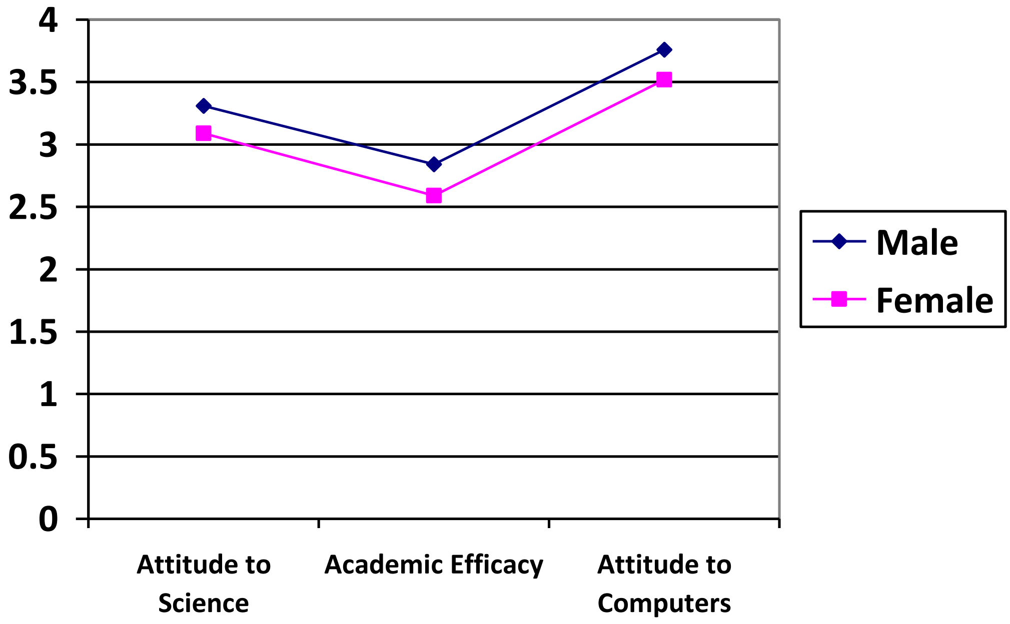

Figure 4.5. Gender differences on Attitude scales in the GTKY.

All three scales, Attitude to Science scale (*F*=10.52, *p*<0.001), Academic Efficacy scale (*F*=11.26, p<0.001) and Attitude to Computers scale (*F*=10.83, *p*<0.001) were found to have a statistically significant difference between the genders, with boys having slightly higher means.

Answer to Research Question 4:

Are there gender differences in students' perceptions of the actual Science learning environment, preferred Science learning environment, teacher-student interactions, and students' attitudes towards Science?

For the WIHIC (Actual), only one out of seven scales was found to have statistically significant gender differences, namely, Investigation (F=9.00, p<0.01), indicating that boys perceived that the science class as having more investigative opportunities than girls.

For the WIHIC (Preferred), two out of seven scales were found to have statistically significant gender differences, namely, Student Involvement (F=5.90, p<0.05), and Investigation (F=9.94, p<0.01), with the average item means for boys higher than those for girls, showing that boys preferred the science learning environment to have more opportunities for student involvement and more opportunities for investigative work.

For the QTI, four out of eight scales were found to have statistically significant gender differences, namely, Uncertain (F=5.67, p<0.05), Dissatisfied (F=12.40, p<0.001), Admonishing (F=11.77, p<0.001) and Strict (F=11.06, p<0.001). The results for these scales show that boys perceived their science teachers as being more uncertain, admonishing, strict and dissatisfied with students in class than girls. Of interest, there is no significant gender difference observed on the scale of Equity, confirming that there should be minimal gender differences in the area of equity.

For the Attitude scales, all the three scales of Attitude to Science (F=15.82, p<0.001), Academic Efficacy (F=11.26, p<0.001) and Attitude to Computers (F=10.83, p<0.001) were found to have a statistically significant difference between the genders.

4.2.5 Research Question 5

a. What associations are there between students' perceptions of their Science environment and their attitudes towards Science?

b. What associations are there between students' perceptions of their Science environment and their achievement in Science?

c. What associations are there between teacher-student interactions and their attitudes towards Science?

d. What associations are there between teacher-student interactions and their achievement in Science?

To see if there were any associations between students' perceptions of their Science environment and their attitudes towards Science and achievement in Science, simple correlation and a multiple regression analyses were performed. The simple correlation coefficient (*r*) and standardized regression coefficient (β) are reported for each of the scales in the WIHIC, and the multiple correlations (*R*) are reported for the set of WIHIC scales. These results answer the first two parts of the research question. The results are tabulated in Table 4.19.

Similarly, to see if there were any associations between teacher-student interactions and students' attitudes towards science and achievement, simple correlation and multiple regression analyses were performed. The correlation coefficient (*r*) and standardized regression coefficient (β) for each of the scales in the QTI are reported together with the multiple correlation coefficient (*R*). The results are tabulated in Table 4.20 for the set of WIHIC scales are reported.

Table 4.19

Simple Correlation and Multiple Regression Analyses of WIHIC Scales with Attitude and Achievement

Scale	Attitude to Science		Academic Efficacy		Attitude to Comp		Achievement	
	r	*β*	*r*	*β*	*r*	*β*	*r*	*β*
Student Cohesiveness	0.17**	-0.05	0.18**	0.01	0.19**	0.13	-0.03	-0.89
Teacher Support	0.39**	0.24***	0.21**	-0.05	0.10*	-0.002	-0.05	-3.22**
Involvement	0.32**	0.06	0.32**	0.25**	0.15**	0.12	0.01	-0.19
Investigation	0.29**	-0.09	0.27**	-0.01	0.07	-0.10	0.06	0.40
Task Orientation	0.47**	0.45***	0.33**	0.28***	0.13*	0.06	0.18**	6.15***
Cooperation	0.30**	-0.05	0.24**	-0.04	0.16**	0.06	0.06	-1.36
Equity	0.35**	-0.04	0.24**	-0.05	0.12*	-0.05	0.04	0.52
Multiple correlations (*R*)	0.52***		0.37***		0.22**		0.25***	
R^2	0.27		0.14		0.04		0.06	

N = 401 **p*<0.05 ***p*<0.01 ****p*<0.001

A positive correlation coefficient tells us that there is a positive association between a learning environment scale and an Attitude scale. For example, *r* = 0.17 (*p*<0.01) for Student Cohesiveness tells us that, as Student Cohesiveness increases, attitude to Science also increases. All the *r* values in Table 4.19 are positive for the Attitude scales, indicating positive associations.

For Attitude to Science, the multiple correlation coefficient (*R*) for the set of learning environment scales is significant with a value of 0.52. When relationships between WIHIC scales are considered and beta weights obtained, it can be seen that the greatest independent contributors among learning environment scales to students' attitude to Science are Teacher Support and Task Orientation, with *β* = 0.24 and 0.46, respectively. The R^2 values show that 27% of the variance in students' attitude to Science is associated with students' perceptions of their learning environment. For Teacher Support and Task Orientation, the *r* values are 0.39 and 0.47, respectively and significant at *p*<0.001.

For Academic Efficacy, the multiple correlation for the set of learning environment scales is also significant with a value of 0.37. When relationships between WIHIC scales are considered and beta weights obtained, it can be seen that the greatest independent contributors among learning environment scales to students' academic efficacy are Task Orientation and Involvement, with β = 0.25 and 0.45, respectively. The R^2 shows that 14% of the variance in students' academic efficacy is caused by students' perceptions of their learning environment. For Task Orientation and Involvement, r values are 0.33 and 0.32 respectively, significant at $p<0.01$.

For Attitude to Computers, the multiple correlation coefficient of the learning environment scales is also significant with a value of 0.22. When relationships between WIHIC scales are considered and beta weights obtained, it can be seen that there is no significant independent contributor among learning environment scales to students' attitude to computers.

For Achievement, the multiple correlation coefficient of the learning environment scales is significant with a value of 0.25. When relationships between WIHIC scales are considered and beta weights obtained, it can be seen that the greatest independent contributors among learning environment scales to students' academic performance are Teacher Support and Task Orientation, with β = -3.22 and 6.15, respectively. The R^2 shows that 6% of the variance in students' performance is associated with students' perceptions of their learning environment. For Task Orientation and Teacher Support, the r values are -0.05 and 0.18, respectively.

Next, a simple correlation and multiple regression analysis with attitude and achievement were performed and the correlation coefficient (r), standardized regression coefficient (β) for each of the scales in the QTI, the value of the multiple correlation coefficient (R) and the R^2 value were obtained. These results answer the next two parts of the research question. The results are tabulated in Table 4.20.

Table 4.20

Simple Correlation and Multiple Regression Analyses of QTI Scales with Attitude and Achievement

Scale	Attitude to Science		Academic Efficacy		Attitude to Comp		Achievement	
	r	*β*	*r*	*β*	*r*	*β*	*r*	*β*
Leadership	0.44**	0.21	0.26**	0.20	0.02	-0.02	-0.03	0.21
Helpful/Friendly	0.41**	0.11	0.25**	0.11	0.00	-0.07	-0.03	0.10
Understanding	0.42**	0.09	0.23**	0.06	0.04	0.10	-0.03	-0.03
Responsibility	0.33**	-0.02	0.18**	-0.11	0.00	0.00	-0.06	-0.96
Uncertain	-0.20**	-0.25	0.02	0.03	0.02	0.07	0.02	-1.37
Dissatisfied	-0.13**	-0.18	-0.01	-0.21	0.04	0.05	0.04	-3.35
Admonishing	-0.13**	0.22	0.02	0.12	-0.01	-0.08	0.04	0.73
Strict	-0.06	0.13	0.07	0.17	0.03	0.02	0.14**	5.59***
Multiple correlations (*R*)	0.49***		0.31***		0.09		0.18*	
R^2	0.24		0.10		0.01		0.03	

N = 401 $^*p<0.05$ $^{**}p<0.01$ $^{***}p<0.001$

There was a positive correlation between the cooperative scales of teacher behaviour and the Attitude to Science scales, while the opposition scales were negatively correlated with Attitude to Science. Except for the Strict scale, all the correlation coefficients were significant, with $p<0.01$. For Academic Efficacy, there are significant positive correlations between the cooperative scales of teacher behaviour with Academic Efficacy scales, with $p<0.01$. No significant correlation was observed between the QTI scales and Attitude to Computers. For Attitude to Subject, *r* values for the cooperative scales range from 0.33 to 0.44 while, for Academic Efficacy, *r* values for the cooperative scales range from 0.18 to 0.26.

For Achievement, the multiple correlation coefficient of the QTI scales is significant with a value of 0.18. When relationships between QTI scales are considered and beta weights obtained, it can be seen that the greatest independent contributor of QTI scales to students' academic performance is the Strict scale, with $\beta = 5.59$. The R^2 value shows that 3% of the variance in students' performance is associated with student-teacher interpersonal relationship. For the Strict scale, $r=0.14$ ($p<0.01$).

Answer to Research Question 5:

a. What associations are there between students' perceptions of their Science environment and their attitudes towards Science?

All the learning environment scales were positively correlated with the Attitude scales. Except for Investigation with Attitude to Computers, all the other correlations were significant ($p<0.05$). r values range from 0.10 to 0.47, indicating low to moderate positive correlations between students' attitudes and their perceptions of their learning environment. In addition, the main independent contributors to Attitude towards Science are Teacher Support and Task Orientation while to Academic Efficacy are Involvement and Task Orientation. These results indicate that a good way to enhance students' attitudes would be to provide more teacher support and encourage more student engagement in tasks.

b. What associations are there between students' perceptions of their Science environment and their achievement in Science?

For Achievement, the greatest independent contributors to students' academic performance are Teacher Support and Task Orientation. For Task Orientation and Involvement, r values are -0.05 and 0.18, respectively. Teacher support is negatively correlated to achievement. In a way, too much teacher support could make students less self-reliant and responsible for their own learning.

c. What associations are there between teacher-student interactions and their attitudes towards Science?

There was significant positive correlations between the cooperative scales of teacher behaviour and the Attitude to Science and Academic Efficacy scales ($p<0.01$). No significant correlation was observed between the QTI scales and Attitude to computers scales. For Attitude to Subject, r values for the cooperative scales range from 0.33 to 0.44 while, for Academic Efficacy, r values for the cooperative scales range from 0.18 to 0.26.

d. What associations are there between teacher-student interactions and their achievement in Science?

The multiple correlation coefficient for the QTI scales is significant with a value of 0.18. When relationships between QTI scales are considered and beta weights obtained, it can be seen that the greatest independent contributor to students' academic performance is the Strict scale, with β = 5.59. For the Strict scale, r=0.14 ($p<0.01$) shows that there is a positive correlation between achievement in Science and the Strict scale.

4.3.6 Research Question 6

In a neighbourhood school in Singapore, what are students' opinions about their school, Science and what makes Science lessons enjoyable?

This research question is answered by analysing the qualitative component that was embedded in the GTKY questionnaire (see Appendix 10).

To find out more about the students' views on science and workload, they were asked whether they liked Science presently and whether they liked it in primary school. They were also asked to elaborate their answers to these questions. Next, they were asked what they would like to see more of in Science lessons. They were also asked if they had free time on weekdays and weekends and to elaborate on their answers. To find out more about the students' views on school, both grade levels of students were asked for their opinions about the school in general, whether they liked the school, and to elaborate on their answers.

To make the analyses easier, the responses for each of the questions were summarized into main categories. From the summarized responses, it was then easier to see not only the ranking but the number of responses for each of the categories, giving us an indication of how much weighting each category had. The summaries for the items on Science are presented below first in Tables 4.21 to 4.23 and then followed by those on workload presented in Tables 4.24 and 4.25. These are followed by the summaries for the items on school presented in Tables 4.26 and 4.27. Only the top few major categories of responses are shown in the tabulations.

To find out more about the students' views on Science, the students were asked if they liked science presently and whether they liked it in Primary school. 160 out of 234 (68.4%) of Secondary One students and 186 out of 270 (68.9%) of Secondary Four/Five students said they enjoyed Science presently while 150 out of 183 (82.0%) of Secondary One students and 140 out of 210 (66.8%) of Secondary Four/Five students said they enjoyed Science in Primary school. The reason why students were asked if they liked it in Primary school was to take into consideration students who had never liked the subject when they were in Primary school. Figure 4.6 shows students' responses towards Science presently in Secondary school and when they were in Primary school.

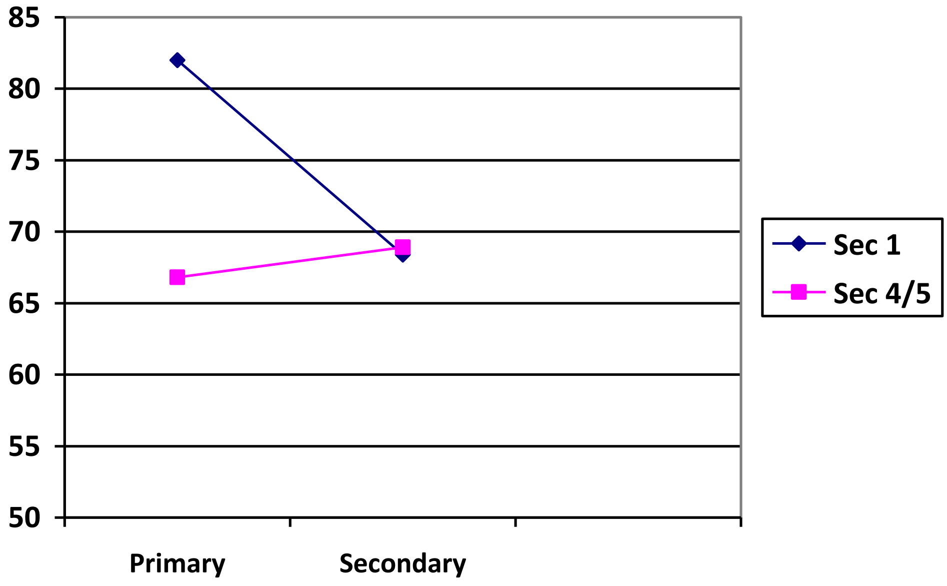

Figure 4.6. Percentage of students liking Science in Primary school and Secondary school.

These results show that the majority of students enjoy Science both presently as well as in Primary school, which are consistent to the results obtained in Research Question 2 on attitudes towards Science. However, these results revealed an unexpected sharp decline in the percentage of students liking Science when compared to the past.

Tables 4.21 and 4.22 show the summaries of students' elaborations.

Table 4.21

Summary of Responses on Why Students Like or Dislike Science Presently

Item	Level		Categories	Tally
	Sec 1		**Reasons for liking Science:**	
		1	It is fun / interesting / enjoyable	78
		2	Learn new knowledge / useful	44
		3	Lots of experiments	42
		4	Easy to understand	11
			Reasons for not liking Science:	
		1	Hard to understand	41
		2	Boring	13
Explain why you like or do not like Science in general now.		3	Do not like the teacher	10
		4	Too much effort / too many to memorize	6
	Sec 4/5		**Reasons for liking Science:**	
		1	It is fun / interesting / enjoyable	83
		2	Learn new knowledge / useful	24
		3	Just like it	14
		4	Easy to understand	10
			Reasons for not liking Science:	
		1	Hard to understand	34
		2	Boring	11
		3	Too much effort / too many to memorize	9
		4	Fail a lot / cannot score	6

For both levels, ranking first and second for reasons on why they liked Science was that it was fun and interesting and they found new knowledge obtained useful. Liking Science because it was easy to understand also made it to the list for both levels. Secondary One students also liked Science because there were lots of experiments to do.

Interestingly, liking teachers did not make it to the list for both levels of students for reasons why they liked Science. However, it did make it into the list for why students did not like Science for the Secondary One level, showing it is still more important to build stronger student-teacher interpersonal relationships at the Lower Secondary level at least.

Top of the list for both levels as to why students disliked Science revealed that Science was getting too difficult for them to understand.

Next, students were asked to elaborate why they liked or did not like Science in Primary school. Table 4.22 shows the summary of responses from those who could remember.

Table 4.22

Summary of Responses on Why Students Like or Dislike Science in Primary School

Item	Level		Categories	Tally
Explain why you like or do not like Science when you were in Primary school.	**Sec 1**		**Reasons for liking Science:**	
		1	It is fun / interesting / enjoyable	48
		2	Lots of experiments / games / activities	35
		3	Easy to understand	29
		4	Liked the teacher	24
			Reasons for not liking Science:	
		1	Boring	12
		2	Hard to understand / too much effort	10
		3	Fail a lot	3
		4	Do not like the teacher	2
	Sec 4/5		**Reasons for liking Science:**	
		1	It is fun / interesting / enjoyable	55
		2	Easy to understand	34
		3	Best subject / did well in it	13
		4	Lots of experiments / games / activities	7
			Reasons for not liking Science:	
		1	Hard to understand	22
		2	Boring	14
		3	Just don’t like it	9
		4	Fail a lot / cannot score	6

Once again, for both levels, ranking first for reasons on why they liked Science was that it was fun and interesting. Interestingly, both liking and disliking teachers made it to the lists of why students liked or disliked Science in Primary school for the Secondary One level. However, although Science was still hard to understand, the number of responses was lower for both levels and a drop in ranking for the Secondary One level.

Next, students were asked what they would like to see more of for Science lessons. The summary of these responses is appended in Table 4.23.

Table 4.23
Summary of Responses on What Students Want to Have More of in Science Lessons

Item	Level		Categories	Tally
What would you like to see more of in your Science lessons?	**Sec 1**	1	Experiment / Science lab	63
		2	Computer usage	18
		3	More fun and lively lessons	15
		4	Games etc. hands-on activities	14
		5	Choice of topics	11
		6	Project work / group work	9
		7	Better teacher relationships	8
	Sec 4/5	1	Experiment / Science lab	83
		2	More fun and lively lessons	19
		3	Clearer/simplified explanations / notes	15
		4	Use of videos and pictures	8
		5	Games etc. hands-on activities	8
		6	Choice of topics	5
		7	Computer usage	4

Opportunities to do experiments ranked a resounding first for both levels of students. Of interest, although doing experiments did not seem to rank high for the Secondary Four/Five level in Table 4.22, it still ranked very high in this list. Both levels also wanted Science lessons to be more lively and fun with more games and hands-on activities. Both levels wanted to be able to choose topics of study, although ranking was much higher for the Secondary One level. Computer usage for lessons also made it to the list for both levels, although ranking was again much higher for the Secondary One level. Secondary One students also wanted project work or group work and wanted better student-teacher relationships.

To gain insight on whether students were coping with their studies, they were also asked for their opinions on workload, if they had free time on weekdays and weekends, and how they spent their free time if any.

Five out of 183 (2.7%) of Secondary One students and five out of 210 (2.4%) of Secondary Four/Five students found their load very light; 16 out of 183 (8.7%) of Secondary One students and 12 out of 210 (5.7%) of Secondary Four/Five students found their load light; 135 out of 183 (73.8%) of Secondary One students and 141 out of 210 (67.1%) of Secondary Four/Five students found their load manageable; 27 out of 183 (14.8%) of Secondary One students and 52 out of 210 (24.8%) of

Secondary Four/Five students found their load heavy. See Figure 4.7 for a pictorial representation of responses on workload.

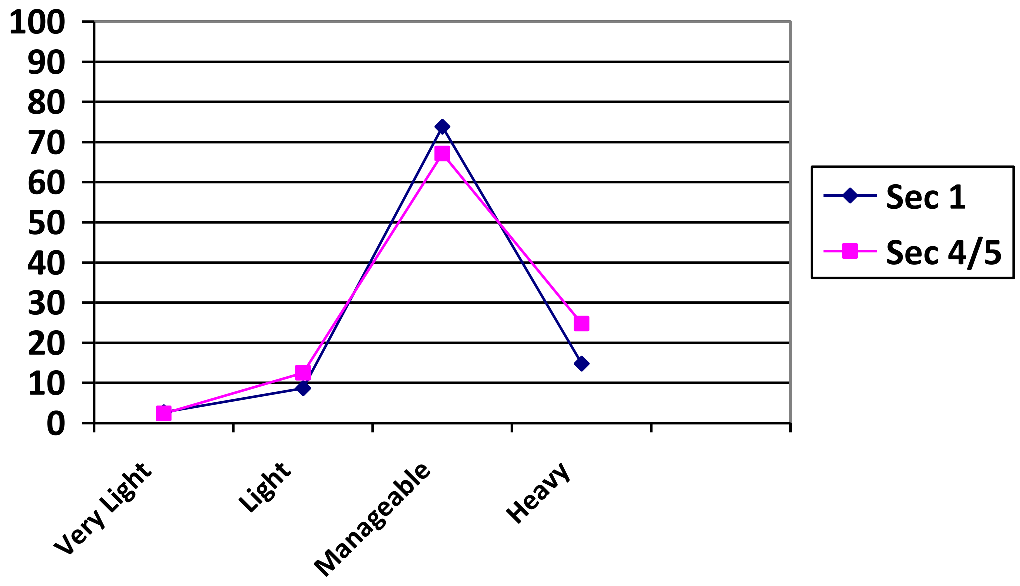

Figure 4.7. Students' responses on workload.

As can be observed Figure 4.7, the majority of students find the workload manageable. For more insight on workload, students were asked if they had free time on weekdays and then also on weekends.

One hundred and sixty four out of 208 (78.9%) of Secondary One students and 169 out of 239 (70.7%) of Secondary Four/Five students had free time on weekdays while 164 out of 196 (83.7%) of Secondary One students and 182 out of 228 (79.8%) of Secondary Four/Five students had free time on weekends. Understandably, more students had free time on weekends than on weekdays.

However, conversely, this means that 44 out of 208 (21.2%) of Secondary One students and 70 out of 239 (29.3%) of Secondary Four/Five students did not have free time on weekdays while 32 out of 196 (16.3%) of Secondary One students and 46 out of 228 (20.2%) of Secondary Four/Five students did not even have free time on weekends. Figure 4.8 is a pictorial representation of students' responses on free time on weekdays and weekends.

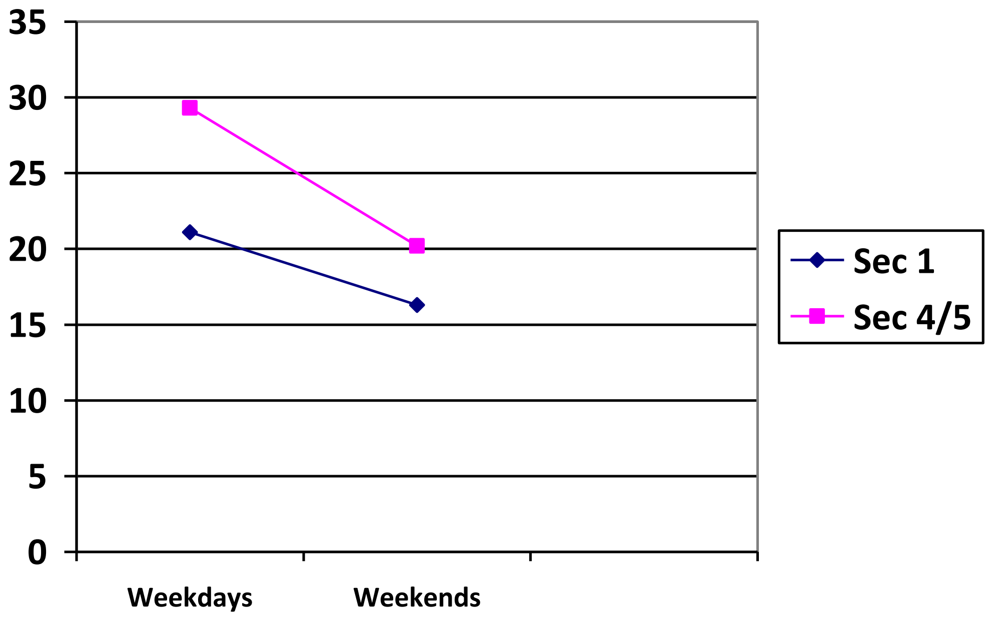

Figure 4.8. Percentage of students without free time on weekdays and weekends.

Although the percentage of students without free time on weekends is less than that on weekdays, the percentages of students without free time on weekends are still considerably high for both levels, namely 16.3% for Secondary One students and 20.2% for Secondary Four/Five students.

To gain more insight on how students used their free time, they were asked to comment on their answers. The summaries of comments on free time for weekdays and weekends respectively are presented in Tables 4.24 and 4.25.

Table 4.24
Summary of Responses on How Students Spend their Weekdays

Item	Level		Categories	Tally
Comments to elaborate their answers to if they had free time on weekdays.	**Sec 1**		**Students with free time:**	
		1	Still have time for hobbies after homework	32
		2	Very little homework	17
		3	Nothing to do/sleep/free	14
		4	Can go home early/no remedial/no CCA	10
			Students without free time:	
		1	A lot of homework	25
		2	Get home late/extra lessons/CCA	12
		3	Have tuition	10
		4	Have family responsibilities	4
	Sec 4/5		**Students with free time:**	
		1	Still have time for hobbies after homework	58
		2	Nothing to do/sleep/free	17
		3	Can go home early/no remedial/no CCA	11
		4	Very little homework	4
			Students without free time:	
		1	A lot of homework	58
		2	Get home late/extra lessons/CCA	16
		3	Have tuition	15
		4	Tight schedule	4

For students with free time on weekdays, ranking highest on the list for both levels is students still had time to do what they liked. They had time to do nothing and just sleep or hang around. For some, free time on weekdays was possible because there was no CCA or remedial lessons in the afternoons. Conversely, for students with no free time on weekdays, ranking highest on the list for both levels is the amount of homework assigned to them in school. They also got home late as these students had extra lessons or CCA in the afternoons. These students also wrote about having to go for private tuition, with more responses coming from graduating students.

However, Secondary One students do not seem to be having a much easier time. Here is one comment in verbatim from a Secondary One student: ‘I seldom have free time as my parents want me to do as much work as possible when I am at home. Although I do not have a lot of free time when I am at home, I still have a little time to play my games just before I sleep at night’.

Some comments on free time not listed in the summary included being able to manage time well, completing homework fast, and making time for rest, etc. This comment is from a student from the graduating level, also in verbatim: 'I ensure that I will have free time to enjoy to not be too stressed out.'

Table 4.25

Summary of Responses on How Students Spend Their Weekends

Item	Level		Categories	Tally
Comments to elaborate their answers to if they had free time on weekends.	**Sec 1**		**Students with free time:**	
		1	Still have time for hobbies after homework	45
		2	Time with family/stay home	21
		3	Nothing to do/sleep/free	14
		4	No tuition	14
			Students without free time:	
		1	A lot of homework	15
		2	Have tuition	18
		3	Have extra outside lessons e.g. ballet	4
		4	Have family responsibilities	3
	Sec 4/5		**Students with free time:**	
		1	Still have time for hobbies after homework	58
		2	Nothing to do/sleep/free	25
		3	Time with family/stay home	15
		4	Go out and relax	14
			Students without free time:	
		1	A lot of homework	29
		2	Have tuition	20
		3	Have extra outside lessons e.g. music	5
		4	Busy schedule	4

Similar responses can be observed from students' comments on how they use their time on weekends. Both levels still had time for their hobbies and spend time with their families. However, more students seem to be going for private tuitions. Nine students had to go for extra enrichment lessons like ballet and music classes.

To gain insight on students' views on schooling in general, students were asked whether they liked school and to elaborate on their answers. They were also asked to comment on anything about school in general. The summaries of comments on free time for weekdays and weekends respectively are presented in Tables 4.26 and 4.27.

86.2% of Secondary One students and 82.9% of Secondary Four/Five students indicated that they liked school. The summary of the responses is appended below.

Table 4.26

Summary of Responses on Reasons for Liking or Not Liking School

Item	Level		Categories	Tally
	Sec 1		**Liked school:**	
		1	Friends	84
		2	Fun/Interesting/Enjoyable lessons	35
		3	Learn	33
		4	Teachers	10
			Did not Like school:	
		1	Stressful/too much homework	7
		2	Boring	5
		3	Teachers	3
Explain why you like or do not like school.		4	Long hours/wake up early/go home late	2
	Sec 4/5		**Liked school:**	
		1	Friends	74
		2	Fun/Interesting/Enjoyable lessons	27
		3	Learn	19
		4	Environment	4
			Did not Like school:	
		1	Boring	6
		2	Long hours/wake up early/go home late	5
		3	Stressful/too much homework	3
		4	Teachers	2

From the summary of those who responded to the item to explain their responses, Friends ranked highest with the most responses for both levels. Both levels found lessons enjoyable on the whole and liked the opportunity to learn, in the same order of ranking. This is summarized nicely by a student, who wrote, ‘We get to see our classmates and learn new things in school’.

Conversely, the reasons for not liking school varied slightly between the two levels of students, with Stress ranking first for the Secondary One level and Boredom for the Secondary Four/Five level. Adverse relationships with teachers made it up the list not just for the Secondary level, but also for the Secondary Four/Five level.

Table 4.27

Summary of Responses on School in General

Item	Level		Categories	Tally
Comments about school in general.	**Sec 1**		**Positive comments:**	
		1	Like / love the school	15
		2	Found it okay	9
		3	Environment beautiful/clean	8
		4	Like teachers	3
			Negative comments:	
		1	Long hours	5
		2	Improve facilities	5
		3	Unruly students	5
		4	Unfriendly teachers	4
	Sec 4/5		**Positive comments:**	
		1	Like / love the school	10
		2	Found it okay	11
		3	Environment beautiful/clean	3
		4	Like teachers	1
			Negative comments:	
		1	Improve facilities	18
		2	Don’t like school	5
		3	More non-academic events	4
		4	Start lessons later and end earlier	4

For students who responded to this item, both levels had similar responses, with the highest ranking comment for both levels being they love the school despite the high levels of stress. However, the older students were more critical and thought that facilities in school could be further improved, for example, installing more air-conditioners as it was still hot with fans.

Of interest, liking teachers made it into the list for both levels, but with more responses from the younger Secondary One students.

For students who responded to this item, unfavourable responses were rather disparate, with the highest ranking comment for Secondary One students being the long school hours while that for Secondary Four/Five students being school facilities below their expectations.

However, there were comments that did not make it into the summary above. One unfavourable comment was on the school system, stated as follows verbatim: ‘I hate the school system. I feel that the recess period should be longer. I feel that the school should give us more freedom to do what we want. I feel that the school should not comment on our attire as at the end of the day, our attire won’t bring us any extra marks. I feel that the school should not catch us for our hair. I feel that school should let us have full mobility on where we can go at any time of school, whether it is going out of school or going to the toilet without the need for permissions. I feel that the school should not have any punishments, suspensions, or caning for late students. I feel that the school should encourage us students to feel free to do what we want and enhance our creativity. I feel that the school should have less school rules and less discipline’.

In a nutshell, it seems that the majority of students still have favourable views of the school despite the long hours and high stress. However, there are students who feel that the school is stifling with too many rules that might stunt creativity in students.

Answer to Research Question 6:

In a neighbourhood school in Singapore, what are students’ opinions about their school, Science and what makes Science lessons enjoyable?

To find out more about the students’ views on Science, the students were asked if they liked Science presently and if they liked it in Primary school. 68.4% of Secondary One students and 68.9% of Secondary Four/Five students said they enjoyed Science presently while 82.0% of Secondary One students and 66.8% of Secondary Four/Five students enjoyed Science in Primary school. Although these results are consistent with the results obtained in Research Question 2 on attitudes towards Science, they revealed an unexpected sharp decline in the percentage of students liking Science in the past.

The summaries of students’ elaborations were used to shed light on these responses. For both levels, ranking first and second for reasons on why they liked Science was that it was fun and interesting and they found that new knowledge learnt was useful. Liking Science because it was easy to understand also made it to the list for both levels. Secondary One students also liked Science because there were lots of experiments to do. These explained why the majority of students still had positive attitudes towards Science. Top of the list, for both levels, on why students disliked Science revealed that Science was getting too difficult for them to understand.

Ranking first for reasons on why students liked Science in Primary school was that it was fun and interesting. Interestingly, both liking and disliking teachers made it to the lists of why students liked or disliked Science in Primary school for the Secondary One level. However, although Science was still hard to understand, the number of responses was lower for both levels and there was a drop in ranking for the Secondary One level.

These revealed that teacher-student interpersonal relationships as well as the level of difficulty of Science could affect students' attitude towards Science as they progress from Primary school into Secondary school.

Next, students were asked what they would like to see more of in Science lessons. Responses gleaned from this section would shed light on the activities that make Science enjoyable to them. Not surprisingly, opportunities to do experiments ranked first for both levels of students. Both levels also wanted Science lessons to be more fun with more games and hands-on activities. Both levels wanted to be able to choose topics of study, although ranking for this was much higher for the Secondary One level. Computer usage for lessons also made it to the list for both levels, although ranking for this was again much higher for the Secondary One level. This indicates that more Secondary One students hoped to work more with computers in Science lessons and have more say in choice of topics of study while more students in Secondary Four/Five understandably wanted more easy-to-understand notes to help them prepare for the pending national examinations. Secondary One students also wanted project work or group work and wanted better student-teacher relationships.

To gain insight on whether students were coping with their studies, they were also asked for their opinions on workload, if they had free time on weekdays and weekends, and to elaborate on how they spent their free time if any. 73.8% of Secondary One students and 67.1% of Secondary Four/Five students found their load manageable; while 14.8% of Secondary One students and 24.8% of Secondary Four/Five students found their load heavy.

With regard to free time, although the percentage of students without free time on weekends is less than that on weekdays, the percentages of students without free time on weekends are still considerably high for both levels, namely 16.3% for Secondary One students and 20.2% for Secondary Four/Five students.

For students with free time on weekdays, ranking highest on the list for both levels is students still had time to do what they liked. For some, free time on weekdays was possible because there was no CCA or remedial lessons in the afternoons. Conversely, for students with no free time on weekdays, ranking highest on the list for both levels was the large amount of homework assigned to them, followed by having to attend remedial lessons or CCAs. They also wrote about having to go for private tuition.

Similar responses can be observed in students' comments on how they use their time on weekends. Both levels still had time for their hobbies and spend time with their families. However, as students are supposed to be freer on weekends, more students seem to be going for private tuitions and extra enrichment lessons like ballet and music classes.

To gain insight on students' views on school, both levels were asked about their opinions on school in general. 86.2% of Secondary One students and 82.9% of Secondary Four/Five students indicated that they liked school despite the workload and lack of free time.

Friends ranked highest with the most responses for both levels on why they still liked school. Students from both levels also liked school because lessons were enjoyable on the whole and they liked the opportunity to learn new knowledge, showing that students who found lessons enjoyable tend to like school, regardless of whether they were lower or upper Secondary students.

Conversely, the reasons for not liking school varied between the two levels, with stress ranking first for the Secondary One level and boredom for the Secondary Four/Five level. Adverse relationships with teachers made it up the list not just for the Secondary One level, but also for the Secondary Four/Five level, showing that good teacher-student interpersonal relationship could affect whether a student liked or did not like school, regardless of whether they were lower or upper Secondary students.

For students who responded to this item, both levels had similar responses, with the highest ranking comment for both levels being they love the school. However, the older students were more critical and thought that facilities in school could be further improved, for example, installing more air-conditioners as it was still hot with fans. Liking teachers made it into the list for both levels, but with more responses from the younger Secondary One students.

Unfavourable responses on school were rather disparate, with the highest ranking comment for Secondary One students being the long school hours while that for Secondary Four/Five students was that school facilities were below their expectations.

4.3 SUMMARY

Research Question 1:

The reliability and discriminant validity analyses for each of the three instruments suggest that there is acceptable internal consistency and mean correlation values between scales with this sample of secondary school students, showing that the instruments are reliable and valid instruments for studying science learning environments in a Singapore secondary school

Research Question 2:

Results from the WIHIC (Actual and Preferred versions) revealed that, although both grade levels of students found the Science learning environments favourable, there is room for improvements as significant differences were found between the actual and preferred environments. Results seemed to indicate that Secondary One students wanted more help from the teacher and friendlier teachers who trust and show a personal interest in them. They also wanted more participation in discussions and opportunities to enjoy the class. They wanted teachers to treat them more equally. But most of all, Secondary One students wanted lessons that gave emphasis on skills and their use in problem solving investigations. Results for students from the graduating level seemed to indicate that they wanted more help from the teacher and friendlier teachers who trust and show a personal interest in them. Like the Secondary One students, they also wanted lessons that gave emphasis to the skills and their use in problem solving investigations but, unlike the Secondary One students, the graduating level of students wanted mostly to participate in discussions and opportunities to enjoy the class.

Results of the QTI showed that the students as a whole school perceived their teachers as displaying leadership and cooperative behaviours, as well as strict behaviours, when it came to serious work. They perceived their teachers as able to lead and hold students' attention in class, as friendly and helpful, and understanding, all with responses near 3 'Sometimes' in the questionnaire. The findings from the QTI are consistent with results from the qualitative component in Research Question 6 for which very few students indicated a dislike for the Science teacher. However, the lower means for the Student Responsibility scale show that more opportunities can be given to students to assume responsibilities for their own learning.

Students' attitudes to Science as a subject and computer usage in lessons were favourable. These findings for Attitude are consistent with results from the qualitative component concerning why they liked or disliked Science and what they wanted to see more of in Science lessons in Research Question 6. With regard to Efficacy, students did not feel confident about their ability to do well for Science.

Research Question 3:

None of the seven scales of either the actual or preferred learning environments were found to have statistically significant differences between grade levels. However, when these findings were taken in conjunction with results from the qualitative component in Research Question 6, results seemed to indicate that students from both levels are fairly satisfied with the Science learning environment.

For teacher-student interaction, results seemed to indicate that students in the Secondary Four/Five levels wanted more leadership behaviour from their teachers. They thought that their teachers were more understanding but also more strict. Students in the Secondary One level, on the other hand, perceived their teachers to exhibit more uncertain behaviours. They also thought their Science teachers were more dissatisfied with them.

With regard to attitude, out of the three scales, only the Attitude to Computers scale was found to have statistically significant difference between the graduating level and the Secondary One level, with the younger students exhibiting higher means.

Research Question 4:

For the WIHIC (Actual), only one out of seven scales was found to have statistically significant gender differences and that was for the scale of Investigation (F=9.00, p<0.01), with the average item means being higher for boys than for girls. For the WIHIC (Preferred), two out of seven scales were found to have statistically significant gender differences, namely, Student Involvement (F=5.90, p<0.05) and Investigation (F=9.94, p<0.01), with the average item means for boys higher than those for girls. It was also observed that Investigation had the largest gender gap, followed by the Involvement scale. The average item means for boys were also higher than the means for girls..

For the QTI, although both genders perceived their Science teachers as displaying cooperative but strict behaviours, four out of eight scales were found to have statistically significant gender differences, namely, Uncertain (F=5.67, p<0.05), Dissatisfied (F=12.40, p<0.001), Admonishing (F=11.77, p<0.001) and Strict (F=11.06, p<0.001), with all means being higher for boys than for girls. The results for these scales show that boys perceived their Science teachers as being more uncertain, admonishing and strict and that they thought that their Science teachers were more dissatisfied with students in class. As a side note, it should be highlighted that there were no significant gender differences observed for the scale of Equity, confirming the prediction that there would be minimal gender differences in this area.

For the Attitude scales, all the three scales of Attitude to Science (F=15.82, p<0.001), Academic Efficacy (F=11.26, p<0.001) and Attitude to Computers (F=10.83, p<0.001) were found to have a statistically significant difference between the genders, with boys exhibiting higher means.

Research Question 5:

A simple correlation with attitude revealed a positive relationship with each of the scales in the WIHIC. Except for Investigation with Attitude to Computers, all the other correlations were significant (p<0.05). The main independent contributors to Attitude towards Science were Teacher Support and Task Orientation scales. The main contributors to Academic Efficacy were Involvement and Task Orientation. There was no independent learning environment contributor to Attitude towards Computers.

A simple correlation analysis with Achievement revealed negative correlations for the scales of Student Cohesiveness and Teacher Support. The main independent contributors to Achievement were also Teacher Support and Task Orientation scales.

Only Task Orientation was an independent contributor to all Attitude to Science, Academic Efficacy and Achievement in Science scales.

There were significant positive correlations between the cooperative scales of teacher behaviour and the Attitude to Science and Academic Efficacy scales ($p<0.01$). For Attitude to Subject, r values for the cooperative scales ranged from 0.33 to 0.44 while, for Academic Efficacy, r values for the cooperative scales ranged from 0.18 to 0.26. The positive association between teacher-student interpersonal relationship and students' attitudes towards Science is consistent with findings for Research Question 6. No significant correlation was observed between the QTI scales and Attitude to computers.

For Achievement, there was a significant positive correlation between achievement and the Strict scale, indicating that students need strict teachers in order to do well for examinations.

Research Question 6:

Results from the qualitative component revealed that students had positive attitudes towards Science. Students from both levels liked Science because they found the subject to be fun and enjoyable. They found new knowledge learnt during Science lessons useful and they also liked Science because it was relatively easy to understand. Students also liked Science because there was opportunity to do experiments in this subject. Results also revealed that teacher-student interpersonal relationships, as well as the level of difficulty of Science, could affect students' attitude towards Science, particularly as they progress from Primary school into Secondary school.

Both levels of students wanted more opportunities to do experiments in Science lessons. They also wanted Science lessons to be more fun with more games and hands-on activities, and they wanted to be able to choose topics of study. Computer usage for lessons also made it to the list for both levels. Secondary Four/Five students wanted easy-to-understand notes for lessons to help them to prepare for national examinations. Secondary One students also wanted project work or group work in their Science lessons and they wanted to see better student-teacher relationships.

Students also had favourable attitudes towards school on the whole. 73.8% of Secondary One students and 67.1% of Secondary Four/Five students found their load manageable, whereas 14.8% of Secondary One students and 24.8% of Secondary Four/Five students found their load heavy. With regards to free time, the percentages of students without free time on weekends were still considerably high for both levels, namely, 16.3% for Secondary One students and 20.2% for Secondary Four/Five students.

To gain insight into students' views of school, students at both levels were asked about their opinions of school in general. 86.2% of Secondary One students and 82.9% of Secondary Four/Five students indicated that they liked school, despite the heavy workload and lack of free time. Friends ranked highest for both levels for why students still liked school. Both levels also liked school because lessons were enjoyable on the whole and because they liked the opportunity to learn.

Conversely, the reasons for not liking school varied between the two levels, with stress ranking first for the Secondary One level and boredom for the Secondary Four/Five level. Adverse relationships with teachers made it up the list not just for the Secondary level, but also for the Secondary Four/Five level. Liking teachers made it into the list for both levels, but with more responses from the younger Secondary One students. Unfavourable responses about school were rather disparate, with the highest ranking comment for Secondary One students being the long school hours and for Secondary Four/Five students being that school facilities could be improved.

In a nutshell, it seems that the majority of students still have favourable views of the school despite the long hours and high stress. Conversely, there were students who felt that school was stifling with too many rules that might stunt their creativity. When both lower- and upper-Secondary students found lessons enjoyable, they tend to like the Science more and like school too. Moreover, good teacher-student interpersonal relationship tend to affect whether students liked or disliked school.

CHAPTER 5

CONCLUSION

5.1 INTRODUCTION

In this final chapter, an overview of the thesis is presented in Section 5.2. It is followed by a discussion of the findings in Section 5.3. The findings are presented research question by research question, although some of the findings from Research Questions 5 (on associations) and 6 (the qualitative component) are integrated with Research Questions 2, 3 and 4.

Next, the significance and limitations of the study are covered in Section 5.4, followed by implications of the study and recommendations for future research in Section 5.5. A final word in Section 5.6 concludes this thesis.

5.2 OVERVIEW OF THESIS

In Chapter One, an introduction to Singapore as a country was first given followed by some background information on the Singapore education system, with emphasis on secondary education. Next, the purpose and significance of the study, followed by the rationale for the study and delimitations of the study, were presented. The research questions were first introduced in this chapter, which concluded with an overview of the thesis.

In Chapter Two, the literature review covered four main areas - learning environments, Science curricula and assessment in Singapore, teaching and learning with an emphasis on that of science, and assessment with an emphasis on alternative methods of assessment. For the literature review on learning environments, a historical background of environment research and past research on how the classroom environment can be rigorously described and measured were provided. This was followed by a review of past studies carried out in Singapore. From here, instruments with good validity and reliability for use in our Singapore context were reviewed in detail. This section ended with the selection of the instruments for use in this study and how they can be used in conjunction with each other. The What Is Happening In this Class? (WIHIC) in both Actual and Preferred versions was selected for the measurement of classroom learning environment; the Questionnaire on Teacher Interaction (QTI) in its Student version was selected for added insights into student-teacher interactions in the classrooms; and the attitude scales from the Technology-Rich Outcomes-Focused Learning Environment Inventory (TROFLEI) were selected for capturing a more comprehensive picture of students' attitudes. This was incorporated into the second part of a self-designed Getting to Know You (GTKY) questionnaire. The first part of the GTKY questionnaire comprised a qualitative component with open-ended questions to find out students' attitudes and general views of school and workload. Results from this qualitative component of the GTKY offered more in-depth understanding of the results from the quantitative component and allowed for triangulation of the findings.

A section on Science curricula and assessment in Singapore was included to give more background understanding of Science education in a Singapore Secondary school.

Chapter Two continued with a section pertaining to teaching and learning, with emphasis on Science so as to provide insight into how it might be made more meaningful, and how passion in science can be ignited and maintained. Suggestions on how technology can be harnessed were included. This section concluded with a literature review on common associations of learning environments and student-teacher interactions with student attitudes and cognitive performance in the subject.

Chapter Two concluded with a literature review on assessment. An introduction to the various types of assessment was given, with particular emphasis on assessment for learning. This was followed by a literature review that focused on alternative assessments methods which are less stressful without loss of rigour. Armed with this knowledge, it was possible for me to suggest alternative methods of assessment, which could make learning less stressful and more enjoyable without losing too much of the rigour that is so important in an outcomes-based learning environment.

In Chapter Three, the methodology of the study was described and presented. The chapter began with an introduction to the different types of research methods. From here, the mixed-method research design was selected and the theoretical and conceptual frameworks derived. As the study involved the concurrent collection of qualitative and quantitative data, with the qualitative component embedded in the quantitative component, the concurrent embedded strategy was used, with more weight being given to the quantitative component. Before the actual data collection, a pilot study was conducted so that the online data-collection process could be tested, including the allocated time, wording of the instruments and survey fatigue. The selection of mid-year examinations results as a performance measure gave a more accurate portrayal of the students' achievement scores at the time when the environment was measured, thereby minimizing factors that could change after the first semester, such as the timetables, teachers, or tuition in anticipation of end-of-the-year examinations.

The data collected were carefully transferred into Excel spreadsheets during the data entry phase class by class so that they could easily be imported into IBM® SPSS® Statistics Version 20. After the data were transferred into Excel, the coding was quite straightforward for all of the questionnaire items except that for the Attitude scales of the GTKY questionnaire which included some negatively-worded items. For these, the coding of these items had to be reversed. After the coding, the data in Excel spreadsheets containing all of the students' responses were finally ready in April of the following year in 2014 and imported into SPSS for statistical computations and data analyses. In SPSS, entries with blank values were automatically deleted, resulting in different N values during the data analyses.

The qualitative component of the GTKY questionnaire that provided students' general views of school and Science as a subject were painstakingly summarized and tallied during the December vacation of 2014.

In Chapter Four, results and analyses generated by SPSS were presented, and the research questions were answered one by one. For Research Question 1, the validity and reliability of the questionnaires for use in the context of this study in Singapore were established. Next, to answer Research Question 2, student responses to the actual and the preferred versions of the WIHIC were compared. Past research was replicated in that the preferred scores and were higher than actual scores. After this, student responses to the QTI and attitude scales in the GTKY questionnaires were discussed. To answer Research Questions 3 and 4, grade level and gender differences in student responses were established and discussed. For Research Question 5, associations between learning environment scales and student outcomes (attitude and achievement) were examined and significant correlations between scales reported. It ends with Research Question 6, which captures students' opinions of science, workload and school in general, making up the qualitative aspect of the study. Answers to these research questions revealed whether there were any significant differences between the actual and preferred WIHIC means and between the students in the graduating level and Secondary One level, and if there were any associations between the learning environment scales and attitude scales and achievement in the subject, as well between student-teacher interpersonal relationship scales and attitude scales and achievement in the subject.

Chapter Five, the final chapter, focuses on the findings of the thesis and integrates them with the literature review in Chapter Two, aiming at discovering the answer to the larger objective of the study, which was to find out if students enjoy learning science in a neighbourhood Secondary school in Singapore. This chapter also includes discussion of limitations of the study and recommendations for future research. A final word concludes the chapter.

5.3 FINDINGS AND CONCLUSION

To meet the aim of the study, namely, to find out if students enjoy learning science in a neighbourhood Secondary school in Singapore, six sets of research questions were developed which then became the focus of the study.

To begin, I needed to develop an understanding of the learning environments of science classrooms in the Singapore neighbourhood Secondary school. This was captured mainly through the use of WIHIC (Actual version) and WIHIC (Preferred version) questionnaires. The QTI (Student version) was also administered which provided more insights into classroom dynamics by capturing student-teacher interactions in these classroom environments. In addition, a third questionnaire, the GTKY, comprised of a comprehensive set of Attitude scales, was administered to capture students' attitudes towards Science.

The GTKY also contained some open-ended questions that formed the qualitative component of the study to glean information on general views of school and workload, etc. The findings from the embedded qualitative component could be used to triangulate the findings of the quantitative components of the study. Positive triangulated results obtained would mean that students were enjoying Science in a neighbourhood Secondary school in Singapore.

But before these instruments could be used, their reliability and validity had to be checked in the setting used before any other results derived from the questionnaires could be used with confidence. The first research question accomplished this.

5.3.1 Findings for Research Question 1

Are the instruments used, namely, the WIHIC (Actual and Preferred), the QTI (Student version), and the Attitude Scales in GTKY, reliable and valid instruments for studying science learning environments in a Singapore Secondary school?

Cronbach's alpha reliability coefficients for all the questionnaires well above 0.80 for the scales of the WIHIC (Actual and Preferred), well above 0.60 for the Attitude scales, and more than 0.60 for the QTI scales. This was consistent with past research in which these instruments were employed.

Inter-scale correlation tests to establish discriminant validity for the WIHIC and Attitude scales in the GTKY generated mean correlation indices that were less than 1 and low enough to indicate a reasonable level of scale independence, showing that they measured distinct although somewhat overlapping aspects of the scales. To further establish validity, and in keeping with established traditions of learning environment research, the eta^2 statistic was estimated for the WIHIC instrument. The eta^2 values showed significant between-class differences on four scales - Teacher Support, Task Orientation, Equity and Cooperation. The percentage of variance attributed to class membership was 6 to 10%, showing the WIHIC scales' ability to differentiate significantly between students' perceptions in different classes on these four scales. Compared with previous research, these percentages are a little lower but the sample used in this study was from one school. Furthermore, scales such as Student Cohesiveness might not be as different between classes because it is potentially more influenced by peer relationships than by what takes place in a classroom.

The validity for the QTI scales was established because the mean correlation indices generated followed the circumplex model with minor discrepancies.

<u>Finding 1:</u>

The reliability, discriminant validity, and circumplex model analyses for each of the three instruments suggest that they are reliable and valid for studying the science learning environments in a Singapore Secondary school setting.

Once reliability and validity were established, the rest of the research questions could be answered and a comprehensive picture of the Science classroom environments in the Singapore neighbourhood Secondary school emerged. As mentioned, the findings obtained for Research Question 6 with the embedded qualitative component could be triangulated with the findings of the quantitative component from the preceding research questions, and therefore they also are integrated into the presentation of the findings for the following research questions. Likewise, some results of Research Question 5 could be integrated into preceding research questions for consolidation of the findings.

5.3.2 Findings for Research Question 2

a. What are students' perceptions of the actual Science learning environment in a neighbourhood Secondary school?

b. What are students' preferred Science learning environments in a neighbourhood Secondary school?

c. Are there any differences between students' perceptions of the actual learning environment and what they would prefer it to be?

d. What are students' perceptions of their teacher-student interactions?

e. What are students' attitudes towards Science in a neighbourhood Secondary school?

The actual and preferred Science classroom environments were measured using the WIHIC (Actual) and the WIHIC (Preferred), respectively. The first eight findings presented in this section pertain to the WIHIC. The next six findings pertain to the QTI, which gave added insights into student-teacher interactions. Finally, the last two findings pertain to the Attitude scales used in GTKY, which gave a comprehensive picture of students' attitude towards Science.

Learning environments with small differences between the actual and preferred environments and better student-teacher interpersonal relationships mean happier students in the Science classrooms. Results from the attitude scales also gave a good indication of whether students are enjoying the subject as students who enjoy a subject would tend to have better attitudes towards the subject.

Finding 2:

A first glance at the results from both the WIHIC (Actual) and WIHIC (Preferred) revealed that students found the Science learning environments favourable, with the means mostly between 3 ‘Sometimes’ and 4 ‘Often’ in the questionnaires. However, the means for the Investigation scale was lowest for both the levels, at 2.93 for the graduating level and 2.94 for the Secondary One level, indicating that opportunities for students to carry out investigations could be given more emphasis in Science lessons.

Finding 3:

Upon scrutiny, statistical tests conducted to compare the WIHIC (Actual) to the WIHIC (Preferred) revealed that there were significant differences between the Actual and Preferred means for five out of seven scales at the school level, namely, Student Cohesiveness, Teacher Support, Involvement, Investigation and Equity. The literature and a number of significant differences between the actual means and the preferred means suggest that, although the current Science learning environments are favourable, the students could be happier.

Finding 4:

When the data were split by grade level, significant differences between the Actual and Preferred means were obtained for four out of seven scales at the Secondary One entry level, namely, Teacher Support, Involvement, Investigation and Equity, while significant differences between the Actual and Preferred means were obtained for only three out of seven scales at the Secondary Four/Five exit level, namely, Teacher Support, Involvement, and Investigation. Unlike the Secondary One students, the graduating level of students did not have an issue with equity, which is the extent to which Science teachers treat their students equally.

As the graduating level, significant differences for one less scale might in fact suggest that the Secondary Four/Five students are slightly happier when compared with their juniors at the Secondary One level.

Finding 5:

Upon further scrutiny, the actual mean value for the Equity scale of 3.34 for Secondary One students is actually identical to that for the Secondary Four/Five students, except that the preferred mean is higher for the Secondary One students. Nevertheless, this value, which is nearer to 3 'Sometimes' in the questionnaires, indicated that teachers teaching Secondary One students could still do more to make their students feel that they are being treated more equally.

Finding 6:

The WIHIC results also revealed that both levels of students wanted more teacher support, that is, they wanted more help from their teacher or friendlier teachers who trust and show a personal interest in them. The means of 3.12 for Secondary One students and 3.16 Secondary Four/Five students are nearer to 3 'Sometimes' in the questionnaires, confirming that, although teachers are on the whole supportive and friendly, more can still be done in this area. Teachers could perhaps slow down a little during lessons to show more interest in their students.

Finding 7:

The WIHIC results also revealed that both levels of students wanted more involvement in class; that is, they wanted more opportunities to participate in discussions and basically just to enjoy the class. The means of 3.00 for Secondary One students and 3.02 Secondary Four/Five students fall on 3 'Sometimes' in the questionnaires, confirming that teachers could indeed do more to provide more opportunities for discussions in class. Once again, if possible, teachers could slow down the pace of lessons so students could take time to enjoy more the process of learning.

Finding 8:

The WIHIC results also revealed that both levels of students wanted more opportunities for investigations in lessons. As mentioned earlier, the means for this scale were the lowest for both levels, confirming the need for teachers to improve most in this area by providing more opportunities for students to carry out problem solving with investigations.

The school has just started the Applied Learning Programme (ALP) for lower Secondary levels in 2014 that aims to make learning more authentic and enjoyable.

With this, students have added opportunities to hone their investigative skills in the ALP on top of the usual practical sessions when students are given opportunities to carry out experiments for investigations.

<u>Finding 9:</u>

These results were next interpreted together with findings from Research Question 6, which revealed that Secondary One students liked Science because there were lots of experiments. Moreover, when asked what students wanted to see more of during their Science lessons, both levels of students wanted more opportunities to do experiments in Science lessons. This probably explained the gap between actual and preferred environments with regards to investigation.

In the light of these consolidated results, it could be interpreted that students are on the whole happy in their current Science learning environments, despite the differences found between the actual and preferred environments, with slightly better results for the graduating students in the Secondary Four/Five level.

<u>Finding 10:</u>

With regards to teacher-student interactions, results for the QTI showed that the means are correspondingly higher on one side of the circumplex model (with the slightly lower mean value of 2.81 for the Responsibility scale) than on the other side of the model (with the slightly higher mean value of 3.10 for the Strict scale), indicating that students from both levels perceived their teachers as displaying cooperative albeit strict behaviours. Students from both levels perceived their teachers as being able to lead and hold students’ attention in class and to be friendly, helpful, and understanding.

The findings from the QTI are consistent with results from the qualitative component in Research Question 6 for which very few students indicated a dislike for the Science teacher. This integrated finding indicates good teacher-student interactions, which is another observation that describes the learning environment in a positive light.

Finding 11:

Integrating results obtained for Research Question 5, the combination of teachers displaying cooperative albeit strict behaviours seems to be a positive attribute as there was a significant positive correlation between achievement and the Strict scale, with 18% of the contribution from this scale alone. This could be because classroom discipline tends to be better with strict teachers. However, this strictness must be tempered with other cooperative behaviours such as leadership, helpfulness and understanding.

Finding 12:

The lower mean value for the Responsibility scale revealed that teachers from both levels also had the tendency not to give opportunities for students to assume personal responsibilities. This is an important area of concern because teachers need to provide students with opportunities to learn how to be responsible for their own learning in order to realize the greater aim for students to be successful lifelong learners who delight in learning long after they graduate from school. Teachers must learn how to let go more and provide students with opportunities to develop into self-regulated learners. Without this opportunity to learn how to be self-regulated learners, it would be difficult for students to develop into self-directed lifelong learners of the future.

Finding 13:

Interestingly, from Research Question 6, liking teachers did not make it to the list for both levels of students for reasons why they liked Science. However, it did make it into the list for why students did not like Science for the Secondary One level, indicating that it is still important for strict teachers to build strong teacher-student interpersonal relationships, especially at the Lower Secondary level, as suggested in the literature review.

Finding 14:

Integrating results obtained from Research Question 5, significant positive correlations were found between the cooperative scales of teacher behaviour and Attitude to Science ($p<0.01$). The correlations for the cooperative scales ranged from 0.33 to 0.44, suggesting that teacher behaviour has a moderate association with students' attitude towards Science.

This means that, to enhance students' attitudes towards Science, teachers should continue to strive to develop cooperative traits, that is, to be leaders who hold students' attention in class, to be friendly and helpful, to be understanding, and to provide opportunities for students to learn how to be responsible for their own learning.

Finding 15:

Significant positive correlations were also found between the cooperative scales of teacher behaviour and the Academic Efficacy scales ($p<0.01$). The *r* values for the cooperative scales ranged from 0.18 to 0.26, indicating that teachers' cooperative behaviours have a smaller effect on students' confidence to do well in Science, compared with the effect on students' attitudes towards Science.

Although teachers' cooperative behaviours have a smaller positive effect on students' academic efficacy, it is still a positive correlation. As the building of a student's confidence in the subject is crucial for achievement in the subject, teachers should still continue to strive to develop cooperative behaviours, however small this effect may be on academic efficacy.

Finding 16:

With regard to students' attitudes, mean scores were 3.22 for the Attitude to Science scale and 3.66 for the Attitude to Computers scale, which suggest that students had favourable attitudes towards Science as a subject and the usage of computers for Science lessons, with the mean for computer usage being higher.

These findings for Attitude are consistent with results from the qualitative component in Research Question 6. Students wrote about liking Science because it was fun and interesting, it was easy to understand, and they enjoyed the opportunity to do experiments. In particular, when asked what they wanted to see more of during their Science lessons, Computer usage for lessons made it to the list for both levels of students.

Based on these results, and in line with the literature, teachers can continue to try to make Science as easy to understand as possible and to make it as much fun and as interesting as possible, for instance, by incorporating more opportunities for experiments as well as more computer usage into Science lessons.

Finding 17:

However, the mean score of 2.74 for the Academic Efficacy scale revealed that students did not feel confident about their ability to do well for Science.

This is another important area of concern because the literature review suggests that academic efficacy has direct impact not only on students' performance in the subject, but also on the other components of attitudes, namely, attitudes towards Science *per se*.

5.3.3 Findings for Research Questions 3 and 4

Are there differences between graduating classes and Secondary One classes in students' perception of the actual Science learning environment, preferred Science learning environment, teacher-student interactions, and students' attitudes towards Science?

Are there gender differences in students' perception of the actual Science learning environment, preferred Science learning environment, interpersonal behaviour of their science teachers, and students' attitudes towards Science?

Having described the learning environments comprehensively in three main areas in Research Question 2, I could next proceed to find out if there were any differences between the results obtained for the Secondary One level and the Secondary Four/Five level in order to determine if students still enjoyed Science by the time they left Secondary school. Investigations were also undertaken to ascertain whether the results depended on the gender of the students. Seven more findings are presented in this section, with the first three pertaining to the learning environments, the next three pertaining to teacher-student interactions and the last two pertaining to attitudes.

Finding 18:

Results of ANOVAs generated for the WIHIC (Actual) and WIHIC (Preferred) revealed no statistically significant differences for all the scales. This lack of any significant differences between the two levels for both the WIHIC (Actual) and the WIHIC (Preferred) in either direction confirms our previous findings that students leave school as happy as when they had entered. Findings from the qualitative component in Research Question 6, which revealed similar percentages of Secondary

Four/Five liking Science presently (68.9%) and Secondary One students liking Science presently (68.4%) confirms this finding.

Finding 19:

For the WIHIC (Actual), one of the seven scales was found to have a statistically significant gender difference, namely, Investigation (F=9.00, p<0.01), with boys perceiving the Science class as having more investigative opportunities than girls. However, despite this, results from the WIHIC (Preferred) revealed that boys wanted yet more opportunities for investigative work because a significant difference was found for the scale of Investigation (F=9.94, p<0.01), with the average item means for boys being higher than the means for girls. It was also observed that the Investigation scale had the largest gap for means. Based on this finding, teachers should try to incorporate more opportunities for students, especially in classes with more boys, to carry out investigative work, for example, by conducting more experiments.

Finding 20:

Results of the ANOVAs for the WIHIC (Preferred) not only revealed a statistically significant gender difference on the scale of Investigation, but also a significant difference was found for the scale of Student Involvement (F=5.90, p<0.05), also with the average item means for boys being higher than for girls. It was also observed that the Involvement scale had the second largest gender gap in the means. Combining results from Research Question 6, both levels of students indicated that they would like to have more opportunities to do experiments, have more hands-on activities, use the computer more, or even have more say in choice of topics. Based on this finding, for classes with more boys, teachers should try to incorporate these into Science lessons so that there is greater student involvement.

Finding 21:

Results of the ANOVAs for the QTI revealed that students in the Secondary Four/Five levels viewed their teachers as having more leadership behaviour while students in the Secondary One level viewed their teachers as more uncertain and dissatisfied. Secondary Four/Five students thought that their teachers were more understanding although strict. Combining findings from Research Question 6, a key reason why Secondary One students do not like Science is because they do not like the Science teacher. Based on this finding, teachers should balance their dissatisfaction with their students with more words of encouragement and praises.

Finding 22:

Results of ANOVAs for the QTI revealed statistically significant gender differences on four scales, namely, Uncertain (F=5.67, p<0.05), Dissatisfied (F=12.40, p<0.001), Admonishing (F=11.77, p<0.001) and Strict (F=11.06, p<0.001), with higher means for boys for all the scales. The results for these scales show that boys perceived their Science teachers as being more uncertain, admonishing and strict and being more dissatisfied with students in class than girls. Based on this finding, in classes with more boys, teachers should take more care to balance their dissatisfaction with boys with more encouragement and praise.

Finding 23:

There was no significant gender difference observed on the scale of Equity, confirming that there should be minimal gender differences in the area of equity.

Finding 24:

Results of the ANOVAs generated on the attitude scales revealed that only the Attitude to Computers scale was found to have statistically significant difference between the graduating level and the Secondary One level, with the younger students exhibiting higher means. Based on this finding, teachers should take care to incorporate more computer usage into their Science lessons, especially with newer and younger generations of students.

Finding 25:

Results of the ANOVAs generated revealed statistically significant gender differences for all the attitude scales, with boys exhibiting higher means for all the three scales. Incorporating findings from Research Question 6, for which a key reason for not liking Science for the graduating level was the inability to pass, teachers could set bite-sized tests that are more manageable so as to offer girls more opportunities to experience success.

5.3.4 Findings for Research Question 5

a. What associations are there between students' perceptions of their Science environment and their attitudes towards Science?

b. What associations are there between students' perceptions of their Science environment and their achievement in Science?

c. What associations are there between teacher-student interactions and their attitudes towards Science?

d. What associations are there between teacher-student interactions and their achievement in Science?

Results for this question would help to confirm literature reviews that emphasise the importance of improving classroom environments and teacher-student interpersonal relationships to enhance students' attitudes as well as cognitive performance in Science.

Four findings are presented in this section, with the first two pertaining to associations with the learning environment scales and the next two pertaining to associations with teacher-student interactions. Results for this research question that were integrated into the previous findings are reiterated here.

Finding 26:

All the learning environment scales were positively correlated with the Attitude scales. Except for Investigation with Attitude to Computers, all other correlations were significant ($p<0.05$). The r values ranged from 0.10 to 0.47, indicating low to moderate positive correlations between students' attitudes and the learning environment.

The learning environment scales most strongly related to Attitude towards Science were Teacher Support and Task Orientation, with 27% of the contribution coming from these two scales, indicating that a good way to enhance students' attitude towards Science would be to provide more teacher support and encourage more student engagement in tasks.

The learning environment scales most strongly to Academic Efficacy were the Involvement and Task Orientation scales, with 14% of the contribution coming from these two scales, indicating that a good way to enhance students' academic efficacy would be to provide more opportunity for students' involvement and encourage more student on-task behaviour. There was no greatest contributor of learning environment scales to students' attitude to computers.

This confirms literature reviews that emphasize the importance of improving classroom environments to enhance students' attitudes toward Science as a subject (especially in the areas of Teacher Support and Task Orientation) as well as to enhance students' academic efficacy (especially in the areas of Involvement and Task Orientation).

It is noted that Task Orientation has a double effect on students' attitude. This means that, by encouraging more student engagement in tasks, not only would the attitudes towards the subject *per se* be enhanced, but the academic efficacy of the student would also be enhanced.

Most students of this generation are technology-savvy. Further improvements in the learning environment would not significantly influence their attitudes towards the use of computers for learning.

<u>Finding 27:</u>

The simple correlation with Achievement was significant only for the learning environment scale of Task Orientation, $r = 0.18$ with $p<0.01$. The independent contributors to Achievement among the learning environment scales were also Teacher Support and Task Orientation scales, with 25% of the contribution coming from these two scales.

Again, Task Orientation was significantly and positively correlated with Achievement in Science, showing that encouraging more student engagement in tasks is also important for improving achievement in Science. This is not surprising as Task Orientation also has positive correlations to Attitude in Science and Academic Efficacy.

<u>Finding 28:</u>

As mentioned in Findings 14 and 15, there were significant positive correlations between the cooperative scales of teacher behaviour and the Attitude to Science and Academic Efficacy scales ($p<0.01$).

For Attitude to Subject, the *r* values for the cooperative scales ranged from 0.33 to 0.44, suggesting that the influence of teacher behaviour has a moderate correlation to students' attitude towards Science. For Academic Efficacy, the *r* values for the cooperative scales ranged from 0.18 to 0.26, indicating that teacher behaviour has less effect on students' confidence to do well in Science.

No significant correlation was observed between the QTI scales and Attitude to computers, indicating that teachers' behaviour has no effect on students' attitudes towards computers. When combined with findings from Research Question 6, it was observed that students of this generation already likes using technology. Students do not need further encouragement from teachers to significantly influence their attitudes towards the use of computers for learning.

Finding 29:

As mentioned in Finding 11, there was only one significant positive correlation between achievement and the QTI scales, namely, the Strict scale for this sample of students, with 18% of the contribution from this scale alone. This means that students tend to do better in examinations when teachers are strict and demanding.

Having said this, there should be a balance between this behaviour and the more cooperative behaviours. Based on the previous finding, these cooperative behaviours have a positive impact on attitudes towards Science as well as on Academic Efficacy. In particular, as revealed in Finding 12, teachers should improve Student Responsibility to help students to develop into self-regulated learners. Tight adult supervision means that students have less opportunity to learn how to make the right decisions themselves. This includes making decisions to be attentive in class and conduct independent revision that is self-initiated.

5.3.5 Findings for Research Question 6

In a neighbourhood school in Singapore, what are students' opinions about their school, Science and what makes Science lessons enjoyable?

The qualitative component of the study not only helped to triangulate results with the quantitative component, but it also helped to fill in gaps and to give a more holistic picture. Students were asked questions concerning their opinions about Science. They were asked if they liked science presently and if they liked it in Primary school and to elaborate their answers. Next, they were asked what they would like to see more of in their Science lessons.

Students were also asked additional questions on workload and school. To gauge students' workload, students were asked if they had free time on weekdays and weekends and to elaborate on their answers. To find out more about the students' views on school, students were asked for their opinions about the school in general, whether they liked the school and to elaborate on their answers.

To make the analyses easier, the responses for each of the questions were summarized into main categories. From the summarized responses, it was then easier to see not only the ranking but the number of responses for each of the categories, giving us an indication of how much weighting each category had.

Results for the preceding research questions have been integrated with findings from Research Question 6 in some of the preceding findings. This section presents six additional findings that have not been presented yet.

Finding 30:

As mentioned, 68.4% of Secondary One students and 68.9% of Secondary Four/Five students said that they enjoyed Science presently. This also means that 31.6% of Secondary One students and 31.1% of Secondary Four/Five students did not like Science. Knowing the reasons why these students did not like Science is important.

Top reasons for not liking Science for both levels were that Science is difficult, boring and involves too much effort to learn. Secondary One students also wrote about not liking the teacher while Secondary Four/Five students also wrote about failing a lot or not being able to score highly in the subject.

To help these students, it is important to try to make Science as easy to understand and as interesting as possible. Helping students to pass so they can have a feeling of success to enhance Academic Efficacy is crucial at the Upper Secondary level.

Finding 31:

The sharp drop in the percentage of students who like Science in Secondary One as compared to when they were in Primary school revealed that teacher-student interpersonal relationships, as well as the level of difficulty of Science, could affect students' attitude towards Science.

To address the sharp drop in the percentage of students who liked Science in Secondary One relative to Primary school, not only should teachers try to make Science as easy to understand and as interesting as possible, but building stronger teacher-student interpersonal relationship is crucial, especially during this transition stage as students progress from Primary school into Secondary school. Combining results from previous findings, it seems that a good way to do this might be to slow down the pace of lessons to show more personal interest in students.

Finding 32:

When asked to elaborate on what they wanted to have more of in Science lessons, students of both levels wanted more opportunities to do experiments in lessons. They also wanted Science lessons to be more fun, with more games and hands-on activities, and they wanted to be able to choose topics of study. Computer usage for lessons also made it to the list for both levels. Secondary Four/Five students wanted easy-to-understand notes for lessons to help them to prepare for national examinations while Secondary One students also wanted to see better student-teacher relationships.

Teachers should continue to do whatever they can to make Science enjoyable for students (e.g. by incorporating more computer usage into lessons). Teachers teaching lower Secondary levels should build stronger teacher-student interpersonal relationships while those teaching upper Secondary levels could provide more teacher support by providing some easy-to-understand notes or showing videos that make understanding easier.

Finding 33:

Regarding workload, 73.8% of Secondary One students and 67.1% of Secondary Four/Five students found their load manageable, while 14.8% of Secondary One students and 24.8% of Secondary Four/Five students found their load heavy. With regards to free time, the percentages of students without free time on weekends were still considerably high for both levels, namely, 16.3% for Secondary One students and 20.2% for Secondary Four/Five students.

Most students still had time to do what they liked even on weekdays. For some, free time on weekdays was possible because there were no Co-Curricular Activities (CCAs) or remedial lessons in the afternoons. Conversely, students from both levels cited the large amount of homework, going for remedial lessons and CCAs, and the need to go for private tuition as the reasons why they did not have free time on weekdays.

For weekends, most students from both levels had time for their hobbies and their families. However, there were more responses from students about having to go for private tuition. Nine students had to go for extra enrichment lessons like ballet and music classes.

Although around 70% of students find their school load manageable, 16% of students do not have free time even on weekends and at least 15% of students find their school load heavy.

Schools should refrain from holding any additional remedial lessons for students, especially on weekends.

<u>Finding 34:</u>

To gain insight into students' views of school, both levels were asked about their opinions on school in general. 86.2% of Secondary One students and 82.9% of Secondary Four/Five students indicated that they liked school, despite being in a results-oriented environment.

Friends ranked highest with the most responses for both levels focussing on why they still liked school. Both levels also liked school because lessons were enjoyable on the whole and they liked the opportunity to learn, pointing to the importance of lesson enjoyment not only for their attitude towards the subject or, but also for their attitude towards school.

Although the vast majority of students indicated that they liked school, showing that it is possible to enjoy school despite being in a results-oriented environment, we should not forget about the 15.5% of students who indicated otherwise.

<u>Finding 35:</u>

For the substantial 15.5% of students who did not like school, the reasons for this varied between the two levels, with stress ranking first for the Secondary One level and boredom ranking first for the Secondary Four/Five level. Adverse relationships with teachers made it up the list not just for the Secondary One level, but also for the Secondary Four/Five level.

Unfavourable comments on school were rather disparate also, with the highest ranking comment for Secondary One students being the long school hours, while that for Secondary Four/Five students was that school facilities could be improved (e.g. having air-conditioners instead of fans). Although not the ranked highest, poor teacher-student interpersonal relationship ranked third for the Secondary One students and fourth for the Secondary Four/Five students, showing the importance of good teacher-student interpersonal relationship for students' attitude towards school.

These findings show that stress is indeed an issue that cannot be ignored. While teachers cannot do much to reduce the syllabus or the length of schooling hours, building strong teacher-student relationships would help students to cope with the stressful environment. Meanwhile, senior administrators need to ensure that schooling hours are capped and kept to a healthy maximum.

5.3.6 Conclusion

I would like to conclude by highlighting and reiterating some of the pertinent results from the 35 findings listed in the preceding sections.

The findings revealed that students are happy in their current Science learning environments, with slightly better results obtained for the graduating students in the Secondary Four/Five level. Combining findings from the qualitative component, when students were asked to elaborate why they liked Science, both levels wrote that they liked Science because it was fun and interesting, and that they liked learning new and useful knowledge. Students also wrote that they liked Science because there were lots of experiments to do. Integrated findings also indicated good teacher-student interactions and that students had favourable attitudes towards Science.

These integrated findings from all three instruments are positive indications that students are able to enjoy Science in a neighbourhood Secondary school in Singapore despite our emphasis on results. Results from my study shows that enjoying Science in a neighbourhood Secondary school in Singapore need not be an oxymoron.

Having said this, the findings from this study revealed some areas of concern that require our attention. First, findings for Research Question 6 revealed that only 68.4% of Secondary One students and 68.9% of Secondary Four/Five students enjoyed Science. Secondly, there were a number of significant differences found between the actual means and the preferred means for the WIHIC, revealing that, although the current Science learning environments are favourable, the students could be happier.

In particular, the mean for the Investigation scale was lowest for both the levels, indicating that opportunities for students to carry out investigation should be given even more emphasis in Science lessons. Teachers could also provide more opportunities for discussions in class and slow down the pace of lessons so that students can take time to enjoy the process of learning. Findings also revealed that it is important to build strong student-teacher interpersonal relationships, especially at the Lower Secondary level. Besides this, teachers could slow down a little during lessons to show more personal interest in their students.

Next, findings revealed that teachers from both levels also had the tendency not to give opportunities for students to assume personal responsibilities. This is an important area of concern because teachers need to provide students with opportunities to learn how to be responsible for their own learning. Developing students in this area would help them become successful lifelong learners who keep learning long after they graduate from school. People must first learn how to be self-regulated learners in school before they can develop to become self-directed life-long learners of the future. From my study, giving students greater responsibility resulted in better attitudes towards the subject.

With regard to another aspect of students' attitudes, namely, academic efficacy, findings revealed that students did not feel confident about their ability to do well for Science. This is another important area of concern because academic efficacy has a direct impact not only on students' performance in the subject, but also on the other components of attitudes, namely, attitudes towards the subject *per se*. Results showed that the Task Orientation scale had a triple effect, affecting not only Attitude towards the subject and achievement, but also academic efficacy. From my study, the other contributor was Involvement. Thus, by providing more opportunity for students' involvement and by encouraging more student engagement in tasks, all three areas of academic efficacy, achievement and attitude towards the subject would be enhanced.

Besides this, there were also significant positive correlations between the cooperative scales of teacher behaviour and the attitude to Science and academic efficacy scales.

Therefore, although findings revealed that students tend to do better in examinations when teachers are strict and demanding, there must be a balance between this behaviour and more cooperative behaviours. This is because more cooperative teacher behaviours have a positive effect on students' attitudes to Science and academic efficacy, which are just as important in learning.

The qualitative component in Research Question 6 also revealed some other pertinent areas of concern. First, results pointed to the importance of lesson enjoyment not only for students' attitude towards the subject, but also for their attitude towards school. Next, to help to make lessons more enjoyable, teachers should continue to provide more opportunities for students to do experiments in Science lessons and incorporate more computer usage into lessons, because such activities help to make Science more enjoyable. Teachers should try to make Science as easy to understand as possible, especially during the transitional stage when students move from Primary school to Secondary school.

Teachers teaching Lower Secondary levels should give emphasis to building stronger teacher-student interpersonal relationships, while those teaching Upper Secondary levels could provide more teacher support by providing more easy-to-understand notes.

Although around 70% of students find their school load manageable, 16% of students do not have free time even on weekends and at least 15% of students find their school load heavy. Although the vast majority of students indicated that they liked school, showing that it is possible to enjoy school despite being in a results-oriented environment, we should not forget about the students who indicated otherwise.

What can we do to help the substantial rest of the 15.5% of students who do not like school? Top on the list of reasons why these students disliked school at both levels was stress. Stress is indeed an issue that cannot be ignored. I am reminded of the story of the frog frolicking happily in a pot of soup that was gradually being boiled. The happy frog was totally unaware of the danger that it was in. Likewise, stress that is unbridled is a silent killer.

What can teachers do? Results point to the importance of good teacher-student interpersonal relationships for students' attitude towards school. While teachers cannot do much to reduce the syllabus or reduce the length of schooling hours, the findings in this study suggest that building strong teacher-student relationships can help students to cope with the stressful environment. In addition, teachers should refrain from holding any additional remedial lessons for students, especially on weekends.

What can school management do? Long school hours was top in the list of reasons why Secondary One students disliked school. School teachers can do nothing about this. However, it is within the powers of school leaders to do something about this. School management can ensure that schooling hours are capped and kept to a healthy maximum. While many initiatives and programmes are beneficial in raising achievement scores, there should be a restraint to these activities. Only by doing so can more intangible benefits, like more family time and more personal rest time, be reaped. Even if not for personal rest time, a lot of creative ideas are generated in these 'empty' spaces. School leaders should also build strong school cultures with positive school climates in which teachers and students feel valued and happy.

5.4 LIMITATIONS OF THE STUDY

My original ambition was to see if our students were still able to enjoy the process of learning in our achievement-oriented education system. However, as this aspiration encompassed a broad and wide spectrum that would make it difficult to carry out in my study, I narrowed down my scope to encompass only one subject and only two secondary school settings.

Having narrowed down the scope to make the study even more feasible, only two schools were used for data collection - the school before my transfer for the pilot test collection and the school after my transfer for the actual data collection proper.

Although both of the schools involved are neighbourhood Secondary schools situated in HDB estates, I noticed a difference in school management style and school culture between the two neighbourhood schools. There was much greater emphasis on results in the first school where the pilot testing was carried out; for example, there were longer remedial lessons during school vacations, there was implementation of night study sessions, and school management questioned teachers who did not sign up for slots to give remedial lessons in the holidays.

There are currently 68 Secondary schools in Singapore (MOE, 2014), each with its own school management and culture. The small sample size that comes with the selection of only one school for data collection made it difficult for my findings to be generalised to the entire secondary student population in a neighbourhood school in Singapore. For the graduating level, 274 students consented to participate in this study and, for the Secondary One students entering the school, 238 students consented to participate. Of these, there were participants who stopped halfway through the data collection, further reducing the already small sample pool.

Even though every effort was made to take care that background variables did not come into play in the study, there nevertheless could be some that could prevent the generalizations of some of the findings to a wider context (e.g. the findings may not necessarily be transferred to learning environments of other subjects).

In addition, findings of the research would have been more accurate if a longitudinal study was conducted instead. To start off with, we could already see some differences between the two levels of students from their attitudes towards Science. In their responses to whether they liked Primary School Science, only 66.8% of Secondary Four/Five students said that they enjoyed Science in Primary school, compared to 82.0% of Secondary One students. However, a longitudinal study using the same batch of students was not carried out because this would have involved waiting for another three years before data collection for the Secondary One students to reach Secondary Four for Express students or four years to reach Secondary Five for NA students.

5.5 RECOMMENDATIONS FOR FURTHER RESEARCH

In the previous section, a few limitations of this study were discussed. These limitations lead to the need for further research.

To address the small sample size that was available with the selection of only one school for the data collection, future research could be carried out in more neighbourhood schools to confirm the findings obtained in this study. In fact, further research may be extended to include prestigious schools because enjoying learning in these schools is just as important.

To address the narrow scope of including only one subject area, future research involving other subjects could be carried out.

On this note, to see if our students are able to enjoy the process of learning in our achievement-oriented education system, not only would more schools and more subjects need to be encompassed, but different institutional levels should also be included, ranging from kindergarten to tertiary levels, because the passion for learning is important regardless of education level.

At the Kindergarten and Primary levels, checks should be incorporated to ensure that children are allowed to learn through play so that their innate curiosity may be developed and satisfied. In secondary and tertiary levels, checks should be introduced so that students learn and study hard for the right reasons. Further research that includes all these levels would make it possible for us to obtain a more complete understanding of what is happening at all the various stages of education in order to better monitor what is happening at the ground level.

With the luxury of time, further research involving a longitudinal study using the same batch of students could be carried out so that other factors can be minimized. Results for Research Question 6 revealed that 68.4% of Secondary One students and 68.9% of Secondary Four/Five students said that they enjoyed Science presently, while 82.0% of Secondary One students and 66.8% of Secondary Four/Five students said that they enjoyed science in Primary school, indicating that we have very different cohorts of students for the two levels.

On a lesser but important note, although the pilot testing showed that survey fatigue was not an issue, it seemed to have occurred during the actual data collection. The response rates for some items were as low as 401. With the luxury of time, further research could be done so that the data collection involving different questionnaires may be carried out on different days, or using a short versions of the WIHIC instead for the actual and preferred questionnaires. Further research in this area would reveal if the short version would have been more appropriate.

In addition, although the aim of the pilot testing did not include collecting data for analyses, the actual data collection in the second school revealed a difference in school management and culture. Further research into associations between the school culture and attitudes, teacher-student interactions and achievement could be carried out.

With regards to instrumentation, although the instruments selected had been established in past research, factor analyses could be incorporated in future research.

Streaming and the effects of streaming seem to be an overlooked area in the local education arena. Further research to see if there are any differences in the various streams could also be carried out. As Singapore is a multiracial society, further research could also be carried out to see if there are differences in perceptions among the various different races.

As I was writing this thesis, two new programmes were introduced during the Work Plan Seminar in 2013 (MOE, 2013b). One of the programmes is the Applied Learning Programme, which aims to make academic learning authentic, and the other one is the Learning for Life Programme, which aims to provide authentic experiential learning to develop students' character and values. These two programmes are currently being pilot tested in eight Secondary schools and could soon be introduced to all the schools in Singapore, but they were introduced after data collection was carried out for this study. With the myriads of changes that have taken place, what is happening at the ground level in classrooms in our schools should be studied now to see the impact of these new initiatives and in the future as we continue to fine-tune our education system. Have these initiatives helped to make school life less stressful and more enjoyable for our children? Further research to find out how classroom environments are affected after their implementation should be carried out.

Finally, as we have the infrastructure of a technology rich-environment that many countries do not yet have, further research may also be conducted to see if more use of technology in the classroom could help to make learning more enjoyable in our achievement-oriented environment. Further research could also reveal if the use of technology for learning can develop more independent self-regulated learners, which is an essential first step towards having lifelong learners.

5.6 FINAL COMMENTS

When I started this study in 2010, I was aghast to see how our drive for excellence and accolades of achievements seemed to be robbing our students of something just as valuable - a carefree and enjoyable childhood. Being in the middle of the rat race, I was concerned that our emphasis on achievement might be killing our students' joy for learning.

I embarked on a study that would help to describe objectively what was happening in such results-oriented learning environments. To make my study feasible, the scope was narrowed down to encompass only the subject of Science. Some other pertinent aspects of the environment such as teacher-student interactions were also studied to help to give a more complete picture of what was happening in the classrooms. In addition, a qualitative component was added to fill in gaps and triangulate results.

The results from my study revealed that, despite our high-stress environment that comes with an emphasis on achievement, enjoying Science in a Singapore neighbourhood Secondary school was not found to be an oxymoron.

On the contrary, a majority of students seemed happy in their current Science learning environments, with slightly better results obtained for the graduating students in the Secondary Four/Five level. This indicated that, by the time when students left Secondary school, they enjoyed Science more than when they first entered. Of course, more accurate results would have been obtained if a longitudinal study using the same batch of students had been carried out.

However, combining findings from the qualitative component, when students were asked to elaborate why they liked Science, both levels wrote that they liked Science because it was fun and interesting and because they liked learning new and useful knowledge. On top of these reasons, students from both levels also wrote that they liked Science because there were lots of experiments. The use of ICT and good teacher-student relationships also helped to make lessons enjoyable.

In addition, findings from the qualitative component of my study also confirmed that students liked school. Besides good teaching pedagogies and teacher rapport, top and middle management in the school play a crucial role in making this possible. In some schools, although results are also emphasized, there is better school culture and climate. Schools with many good initiatives that often lead to better results may reap intangible costs which might only be visible many years down the road.

As there are only 24 hours in a day, more time spent in school would naturally mean less time spent with family, less time for rest and less time for hobbies, or even less time to do simply nothing. Just as there are intangible costs, there are intangible benefits or less tangible benefits. The freedom to do simply nothing may sound like a luxury in a highly competitive environment, but it has less tanglible benefits such as creating white space for creative juices to flow. Such opportunities to do simply nothing also allows our bodies to recuperate and recharge which is beneficial to both mental as well as physical health.

As intangible benefits are not usually immediately reaped, they are easily sacrificed for the more visible immediate benefits, namely, school achievements. Yet it is precisely these intangible costs and benefits that have far-reaching implications affecting all levels of society, the effects of which are compounded as our population ages.

Only senior management in schools can ensure that competition does not become unhealthy and that a healthy balance is maintained. Thus, it is important for school leaders to ensure that the school climate remains healthy so that both students and teachers can be happy. Happy students are better learners and happy teachers are better teachers.

To me, learning should be fun and enjoyable whenever possible. We do not always have to be number one and there are finer things that life has to offer which are just as important. We must learn to take time to smell the roses. After all, the nation that had ranked first in terms of quality in its education system seemed to have achieved their good records without the stress that marks an achievement-oriented education system. It would be wonderful if we could achieve our outstanding results likewise, and without so much stress.

One important way to reduce stress is to reduce class size. The class size in a typical Secondary classroom is still large, easily hovering around 40 students per class. A number of neighbourhood schools were recently merged, thereby freeing and creating a number of ‘excess’ teachers. This is now the perfect time for class size to be reduced. A first-world nation should be able to have smaller teacher-students ratio.

Another important way to make school less stressful would be to incorporate alternative forms of assessments. Not only do they tend to make assessment more authentic, these less-stressful forms of assessment can also make learning more meaningful to our students. Self-assessment and keeping study logs give opportunities for students to develop the capacity to be self-reflective and critical, which are attributes that are just as important for work in the 21st century. Promoting alternative forms of assessment ‘for learning’ and ‘as learning’ would be an important step towards preparing our students for learning throughout their lives long after graduation.

To cultivate lifelong learning in our students, it is important to cultivate students who enjoy learning. Only then would we have passionate learners who will grow up to be independent, self-motivated lifelong learners.

Like Prime Minister Lee Hsien Loong mentioned, Singapore’s success came at a cost (CNA, 2014b). One important reason cited by Singaporeans emigrating out of Singapore is the stressful education system in Singapore. Unlike what happened in the Transportation sector, we should not depend only on 20-20 hindsight vision to address this pressing issue in Education. Do our students enjoy learning? Will our students continue to enjoy learning? Classroom dynamics in our schools need to be constantly monitored objectively to see what is happening in our results-oriented learning environments. Only then can we ensure that it is in a healthy balance.

I started the thesis with a quote from Prof Barry Fraser, and I would like to end it with the same quote. With the plethora of programmes that are developed with good intentions, what truly happens in the classrooms still remains the most important.

It is the quality of life lived out in classrooms
that determines many of the things we hope
for from education. -- Barry Fraser

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APPENDICES

APPENDIX 1

SMEC-11-12 Ethics Approval

Curtin University

Memorandum

To	Ng U Khoon, SMEC
From	Pauline Howat, Administrator, Human Research Ethics Science and Mathematics Education Centre
Subject	Protocol Approval **SMEC-11-12**
Date	7 March 2012
Copy	Darrell Fisher, SMEC

Office of Research and Development

Human Research Ethics Committee

Telephone 9266 2784
Facsimile 9266 3793
Email hrec@curtin.edu.au

Thank you for your "Form C Application for Approval of Research with Low Risk (Ethical Requirements)" for the project titled "*Enjoying science in a Singapore neighbourhood secondary school: An oxymoron?*". On behalf of the Human Research Ethics Committee, I am authorised to inform you that the project is approved.

Approval of this project is for a period of twelve months **3rd March 2012** to **2nd March 2013**.

The approval number for your project is **SMEC-11-12**. *Please quote this number in any future correspondence*. If at any time during the twelve months changes/amendments occur, or if a serious or unexpected adverse event occurs, please advise me immediately.

Pauline

PAULINE HOWAT
Administrator
Human Research Ethics
Science and Mathematics Education Centre

Please Note: The following standard statement must be included in the information sheet to participants:
This study has been approved under Curtin University's process for lower-risk Studies (Approval Number SMEC-11-12). This process complies with the National Statement on Ethical Conduct in Human Research (Chapter 5.1.7 and Chapters 5.1.18-5.1.21).
For further information on this study contact the researchers named above or the Curtin University Human Research Ethics Committee. c/- Office of Research and Development, Curtin University, GPO Box U1987, Perth 6845 or by telephoning 9266 9223 or by emailing hrec@curtin.edu.au.

J:\SAE\SMEC\office\Pauline\ETHICS\Ethics Approval Letter 2012 Ng.docx CRICOS Provider Code 00301J

Curtin University

Memorandum

To	Ng Li Khoon, SMEC
From	Mun Yin Cheong, Form C Ethics Co-ordinator, Faculty of Science and Engineering
Subject	Protocol Extension Approval **SMEC-11-12**
Date	16 April 2014
Copy	Darrell Fisher, SMEC

Office of Research and Development
Human Research Ethics Committee

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

Thank you for keeping us informed of the progress of your research. The Human Research Ethics Committee acknowledges receipt of your progress report for the project *"Enjoying science in Singapore neighbourhood secondary school: An oxymoron?"*.

Approval for this project is extended to **2nd March 2016.**

Your approval has the following conditions:

(i) Annual progress reports on the project must be submitted to the Ethics Office.

Your approval number remains **SMEC-11-12**. Please quote this number in any further correspondence regarding this project.

Yours sincerely

Mun Yin

MUN YIN CHEONG
Form C Ethics Co-ordinator
Faculty of Science and Engineering

APPENDIX 2

Ranking of School 2010

No.	Secondary School	Mean	Upper	Lower	Median
1	Raffle's Girl	271	266	285	271
2	Raffles Institution	269	263	287	268
3	Nanyang Girls	269	265	285	268
4	Hwa Chong	266	261	284	265
5	Dunman High	264	260	289	263
6	Singapore Chinese Girls	260	257	268	260
7	Methodist Girl's School	260	255	275	259
8	River Valley	259	254	277	258
9	CHIJ St Nicohlas	257	250	281	257
10	Anglo Chinese Independent	257	252	267	256
11	Catholic High	254	248	272	253
12	Victoria	252	246	272	251
13	Cedar Girls	252	244	271	251
14	Nan Hua	251	247	271	251
15	Anglician High	251	242	274	250
16	Xinmin	250	245	269	248
17	Crescent Girl	249	243	277	248
18	St. Joseph	249	243	272	248
19	Bukit Panjang Govt	248	243	264	246
20	Chung Cheng Main	248	241	264	246
21	Commonwealth	243	239	261	242
22	St Andrew's	242	237	250	242
23	St. Margaret's	242	240	249	242
24	Tanjong Katong	241	237	261	240
25	Swiss Cottage	241	238	255	240
26	Zhonghua	241	238	253	240
27	Tanjong Katong Girls	240	234	263	239
28	Fairfield Methodist	240	237	250	239
29	Ngee Ann	240	232	260	238
30	Yishun Town	238	231	265	237
31	Chung Cheng Branch	238	231	260	237
32	Dunman Secondary	238	233	264	236
33	Fuhua	237	232	256	236
34	Presbyterian High	237	231	251	236
35	Temasek	237	232	254	235
36	Maris Stella	236	230	257	235
37	CHIJ St. Theresa's	236	232	240	235
38	Nan Chiau	236	230	254	234
39	Clementi Town	235	232	243	235
40	Kranji	235	230	249	234
41	Gan Eng Seng	234	227	256	233
42	Riverside	234	227	265	232
43	St. Hilda's	233	230	247	232
44	CHIJ St Joseph	233	228	243	232

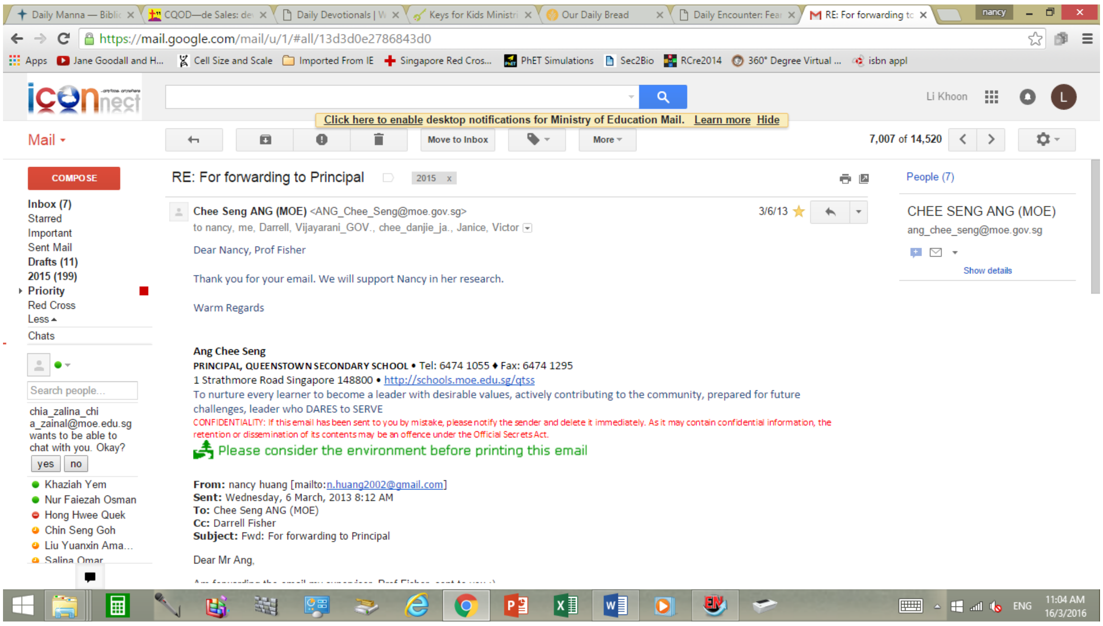
45	Ang Mo Kio	232	224	256	231
46	Jurong	232	227	259	230
47	Hai Sing Catholic	231	228	246	231
48	CHIJ Katong Convent	231	226	238	231
49	St Anthony Canossian	231	225	245	229
50	Kuo Chuan	230	226	250	229
51	Bukit Batok	229	225	240	228
52	Geylang Methodist	229	224	235	228
53	Pasir Ris	228	224	270	227
54	Holy Innocent	227	222	245	227
55	Hua Yi	227	223	247	226
56	Bowen	227	222	244	226
57	Pasir Ris Crest	226	222	247	226
58	Ahmad Ibrahim	226	222	244	226
59	Bedok View	226	222	234	226
60	West Spring	226	219	255	225
61	Mayflower	225	221	242	225
62	Unity	225	219	241	224
63	CHIJ Toa Payoh	223	190	266	224
64	Paya Lebar Methodist	223	194	274	222
65	Beatty	223	216	246	222
66	St. Gabriel's	222	217	243	222
67	Evergreen	221	214	245	220
68	Compassvale	221	216	244	220
69	New Town	220	210	236	220
70	Bedok South	220	215	232	220
71	Orchid Park	219	212	244	219
72	Chua Chu Kang	219	211	236	219
73	Queensway	219	211	235	219
74	Queenstown	219	210	232	219
75	Coral	219	215	231	219
76	Woodlands Ring	219	213	239	218
77	Anglo Chinese Barker	218	195	258	219
78	Deyi	218	213	236	218
79	East Spring	217	212	247	216
80	Bedok Green	217	211	243	215
81	Hougang	216	211	242	215
82	Yuan Ching	216	210	231	215
83	Peirce	215	206	230	215
84	Westwood	215	206	240	213
85	Zhenghua	214	207	240	213
86	Bukit View	214	206	238	212
87	Jurongville	213	198	231	214
88	Dunearn	213	206	235	212
89	Damai	213	206	232	211
90	Greenview	212	207	232	211

91	Tampines	211	203	228	210
92	North Vista	211	203	250	209
93	Yishun	211	203	234	209
94	Admiralty	211	205	233	209
95	Whitley	210	205	225	210
96	Seng Kang	210	203	237	209
97	St. Patrick's	210	189	234	209
98	Guangyang	209	203	237	207
99	Woodgrove	208	202	227	207
100	Greenridge	208	203	238	206
101	Telok Kurau	207	188	256	205
102	Junyuan	207	200	231	205
103	Bendemeer	207	196	241	204
104	Pei Hwa	206	188	231	205
105	Hillgrove	205	197	233	203
106	Canberra	205	197	229	203
107	Bartley	204	188	251	203
108	Outram	204	188	233	203
109	Loyang	204	195	227	203
110	Bishan Park	204	188	264	202
111	Christ Church	204	194	237	202
112	Broadrick	204	188	227	202
113	Pioneer	203	188	232	202
114	Yuhua	203	195	223	202
115	Macpherson	203	188	235	201
116	Juying	203	188	232	201
117	Tanglin	202	189	241	202
118	Henderson	202	188	231	202
119	Marsiling	202	188	251	201
120	Bukit Merah	202	188	233	201
121	Chai Chee	202	188	232	201
122	Chestnut	202	188	231	201
123	North View	202	188	242	200
124	Yuying	202	188	236	200
125	Balestier Hill	202	188	233	200
126	Manjusri	202	188	230	200
127	Northland	202	190	229	200
128	NorthBrooks	201	188	230	201
129	Assumption English	201	188	230	200
130	Changkat Changi	201	191	229	200
131	Jurong West	201	189	238	199
132	Kent Ridge	200	188	222	201
133	Ping Yi	200	188	239	200
134	Regent	200	189	229	200
135	First Toa Payoh	200	188	260	199
136	Serangoon Garden	200	188	233	199

137	Bedok North	200	188	226	199
138	Yusok Ishak	200	188	253	198
139	Greendale	200	189	239	198
140	Naval Base	200	188	239	198
141	Chong Boon	200	188	234	198
142	Boon Lay	200	188	241	197
143	Pei Cai	200	188	237	197
144	Yio Chu Kang	199	188	234	199
145	Springfield	199	188	232	198
146	Teck Whye	199	190	226	198
147	Bedok Town	199	188	225	198
148	Fajar	199	188	255	197
149	Siglap	199	188	240	197
150	Woodlands Ring	199	188	235	197
151	Hong Kah	199	188	245	196
152	East View	198	188	222	197
153	Fuchun	198	188	227	196
154	Serangoon	198	188	245	195
155	Sembawang	197	188	224	195
156	Shuqun	196	188	222	195
157	Punggol	196	188	233	194
158	Si Ling	0	0	0	0

APPENDIX 3

Principal's Approval



RE: For forwarding to Principal

Chee Seng ANG (MOE) <ANG_Chee_Seng@moe.gov.sg> 3/6/13

to nancy, me, Darrell, Vijayarani_GOV., chee_danjie_ja., Janice, Victor

Dear Nancy, Prof Fisher

Thank you for your email. We will support Nancy in her research.

Warm Regards

Ang Chee Seng
PRINCIPAL, QUEENSTOWN SECONDARY SCHOOL • Tel: 6474 1055 ♦ Fax: 6474 1295
1 Strathmore Road Singapore 148800 • http://schools.moe.edu.sg/qtss
To nurture every learner to become a leader with desirable values, actively contributing to the community, prepared for future challenges, leader who DARES to SERVE

CONFIDENTIALITY: If this email has been sent to you by mistake, please notify the sender and delete it immediately. As it may contain confidential information, the retention or dissemination of its contents may be an offence under the Official Secrets Act.

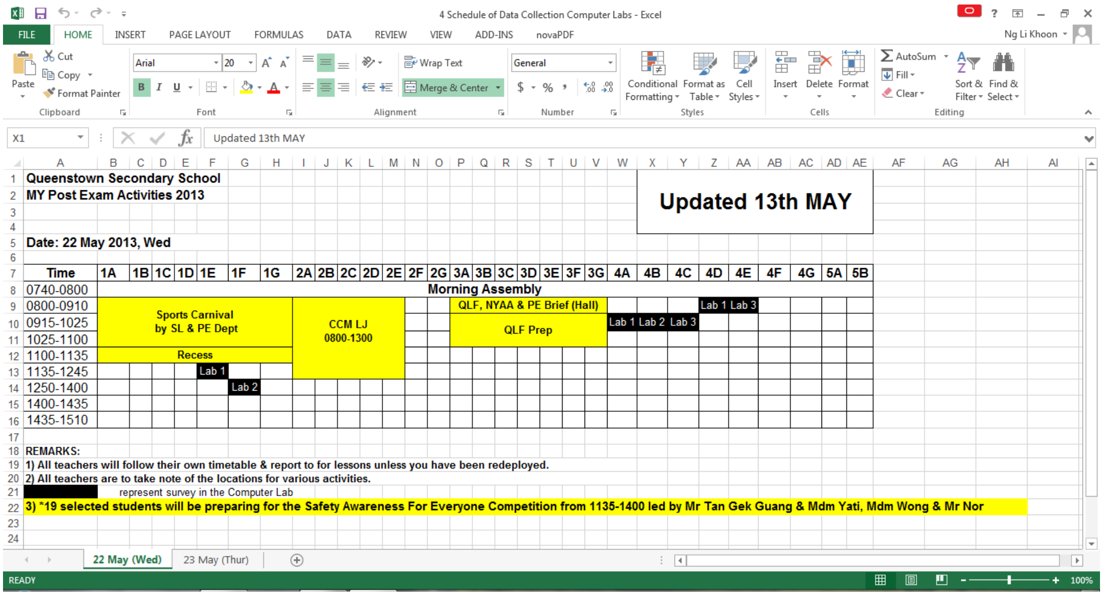
Please consider the environment before printing this email

From: nancy huang [mailto:n.huang2002@gmail.com]
Sent: Wednesday, 6 March, 2013 8:12 AM
To: Chee Seng ANG (MOE)
Cc: Darrell Fisher
Subject: Fwd: For forwarding to Principal

Dear Mr Ang,

APPENDIX 4

Schedule of the Computer Laboratory for the Surveys



4 Schedule of Data Collection Computer Labs - Excel

Queenstown Secondary School

MY Post Exam Activities 2013

Updated 13th MAY

Date: 22 May 2013, Wed

Time	1A	1B	1C	1D	1E	1F	1G	2A	2B	2C	2D	2E	2F	2G	3A	3B	3C	3D	3E	3F	3G	4A	4B	4C	4D	4E	4F	4G	5A	5B
0740-0800	Morning Assembly																													
0800-0910	Sports Carnival by SL & PE Dept							CCM LJ 0800-1300							QLF, NYAA & PE Brief (Hall)										Lab 1	Lab 3				
0915-1025															QLF Prep							Lab 1	Lab 2	Lab 3						
1025-1100																														
1100-1135	Recess																													
1135-1245					Lab 1																									
1250-1400						Lab 2																								
1400-1435																														
1435-1510																														

REMARKS:

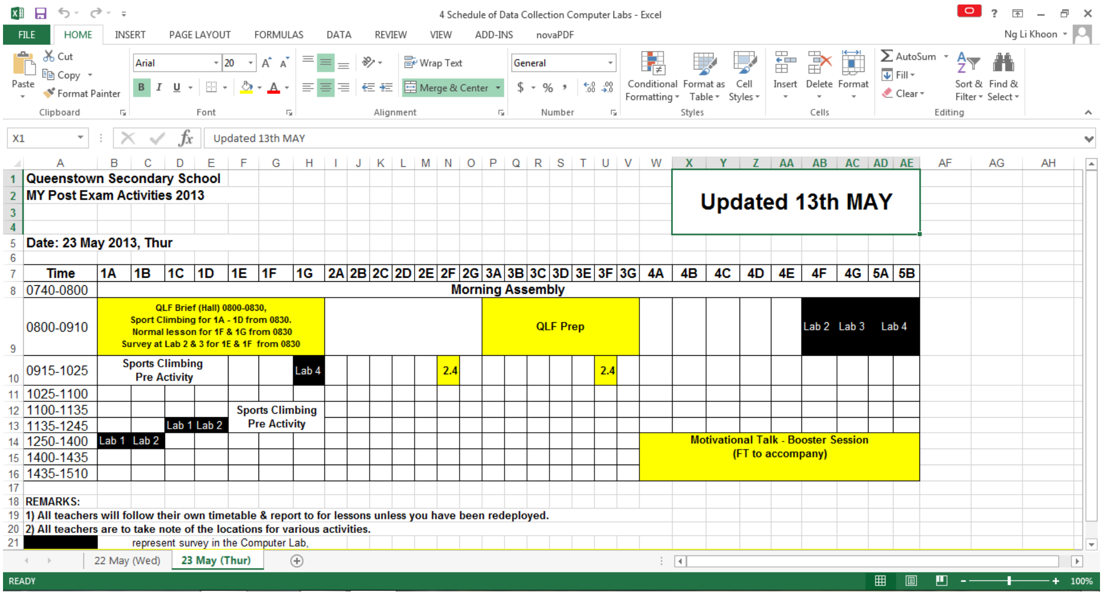
1) All teachers will follow their own timetable & report to for lessons unless you have been redeployed.

2) All teachers are to take note of the locations for various activities.

represent survey in the Computer Lab

3) *19 selected students will be preparing for the Safety Awareness For Everyone Competition from 1135-1400 led by Mr Tan Gek Guang & Mdm Yati, Mdm Wong & Mr Nor

22 May (Wed) | 23 May (Thur)



4 Schedule of Data Collection Computer Labs - Excel

Queenstown Secondary School

MY Post Exam Activities 2013

Updated 13th MAY

Date: 23 May 2013, Thur

Time	1A	1B	1C	1D	1E	1F	1G	2A	2B	2C	2D	2E	2F	2G	3A	3B	3C	3D	3E	3F	3G	4A	4B	4C	4D	4E	4F	4G	5A	5B
0740-0800	Morning Assembly																													
0800-0910	QLF Brief (Hall) 0800-0830, Sport Climbing for 1A - 1D from 0830. Normal lesson for 1F & 1G from 0830 Survey at Lab 2 & 3 for 1E & 1F from 0830														QLF Prep												Lab 2	Lab 3	Lab 4	
0915-1025	Sports Climbing Pre Activity						Lab 4						2.4							2.4										
1025-1100																														
1100-1135					Sports Climbing Pre Activity																									
1135-1245			Lab 1	Lab 2																										
1250-1400	Lab 1	Lab 2																				Motivational Talk - Booster Session (FT to accompany)								
1400-1435																														
1435-1510																														

REMARKS:

1) All teachers will follow their own timetable & report to for lessons unless you have been redeployed.

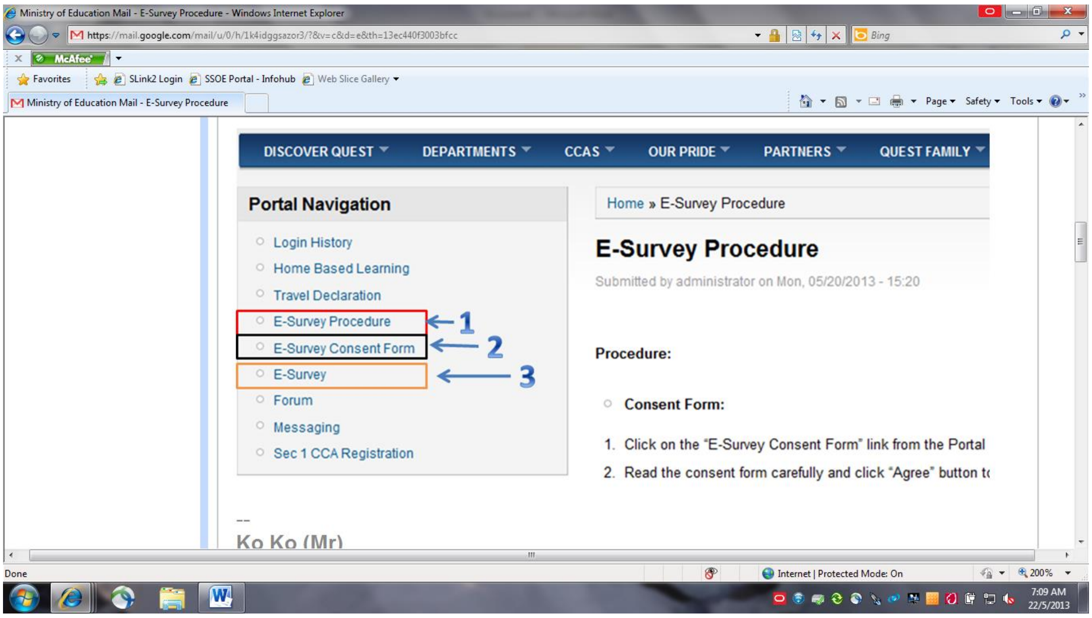
2) All teachers are to take note of the locations for various activities.

represent survey in the Computer Lab,

22 May (Wed) | 23 May (Thur)

APPENDIX 5

Instructions to Teachers


Ministry of Education Mail - E-Survey Procedure - Windows Internet Explorer
DISCOVER QUEST
DEPARTMENTS
CCAS
OUR PRIDE
PARTNERS
QUEST FAMILY
Portal Navigation
Login History
Home Based Learning
Travel Declaration
E-Survey Procedure
E-Survey Consent Form
E-Survey
Forum
Messaging
Sec 1 CCA Registration
1
2
3
Home » E-Survey Procedure
E-Survey Procedure
Submitted by administrator on Mon, 05/20/2013 - 15:20
Procedure:
Consent Form:
1. Click on the "E-Survey Consent Form" link from the Portal
2. Read the consent form carefully and click "Agree" button t
Ko Ko (Mr)

APPENDIX 6

Information and Consent Pages in the Web Portal

Queenstown
Secondary School

Login | Fr

QQMS DEPARTMENTS DISCOVER QUEST OUR PRIDE PARTNERS QUEST FAMILY EVENTS GALLERY CALENDAR ADM

Home » Survey Participant Information Sheet

Survey Participant Information Sheet

Submitted by [illegible] on Thu, 04/10/2012 - 09:50

Curtin University
Science and Mathematics Education Centre

Participant Information Sheet

My name is Ng Li Khoon. I am currently completing a piece of research for my Doctor of Science Education at Curtin University of Technology.

Purpose of Research
I am investigating the Science classroom learning environment of Secondary students from neighbourhood schools in Singapore and how this learning environment is affecting these attitude in Science.

Your Role
I am in the process of learning more about learning environments and would be interested in knowing your views on this topic. To do this, I would need your help to complete four que [illegible] What happens in my Science classroom Questionnaire, What is Happening in My Class (Actual), What is Happening in My Class (Preferred), and Student-Teacher Questionnaire (ust [illegible] teacher under surveyand class as the class being surveyed). These questionnaires should take around 60 minutes to complete.

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 con [illegible] assure 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 only have access to this. The interview transcript will not have you [illegible] 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 [illegible] 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 No. SMEC-11-12). If you would like further inf [illegible] the study, please feel free to contact me at 65-65401978 or by email: n_huang2002@gmail.com. Alternatively, you may wish to contact my supervisor Professor Darrell Fisher at 61 [illegible] by email: D.Fisher@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.

Agree Decline

APPENDIX 7

The online WIHIC Personal questionnaire (Actual)

Queenstown Secondary School

Logged in as S6821…

HOME DEPARTMENTS DISCOVER QUEST OUR PRIDE PARTNERS QUEST FAMILY EVENTS GALLERY CALENDAR ADM

Portal Navigation

- Login History
- Online Booking
- Travel Declaration
- Reset Student Password
- Announcement
- Messaging
- Forum
- Group Settings
- Home Based Learning
- Fault Report
- PE Assessment
- Temperature Declaration
- Sec 1 CCA Registration
- E-Survey
- CASA Analysis from Ccolpt
- SMS File Sys

S6821755E

- My account
- Create content
- Log out

Home » E-Survey

E-Survey

Back to E-survey main page

What Is Happening in Your Science Class? (Actual)

This questionnaire contains statements about practices which could take place in your class. You will be asked how often each takes place.

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

Think about how well each statement describes what this class is like for you. Be sure to give an answer for all questions.

Some statements in this questionnaire are fairly similar to other statements. Don't worry about this. There are 56 statements a[…] Simply give your opinion about all statements.

1. I make friends among students in this class.
   - 1 (Almost never)
   - 2
   - 3
   - 4
   - 5 (Almost always)
2. I know other students in this class.
   - 1 (Almost never)
   - 2
   - 3
   - 4
   - 5 (Almost always)
3. I am friendly to members of this class.
   - 1 (Almost never)
   - 2
   - 3
   - 4
   - 5 (Almost always)
4. Members of the class are my friends.
   - 1 (Almost never)
   - 2
   - 3
   - 4
   - 5 (Almost always)
5. I work well with other class members.
   - 1 (Almost never)
   - 2
   - 3
   - 4
   - 5 (Almost always)
6. I help other class members who are having trouble with their work.
   - 1 (Almost never)
   - 2
   - 3
   - 4
   - 5 (Almost always)
7. Students in this class like me.
   - 1 (Almost never)
   - 2

- 3
- 4
- 5 (Almost always)

8. In this class I get help from other students.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

9. The teacher takes a personal interest in me.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

10. The teacher goes out of his/her way to help me.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

11. The teacher considers my feelings.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

12. The teacher helps me when I have trouble with the work.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

13. The teacher talks with me.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

14. The teacher is interested in my problems.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

15. The teacher moves about the class to talk with me.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

16. The teacher's questions help me to understand.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

17. I discuss ideas in class.

- 1 (Almost never)
- 2

- 3
- 4
- 5 (Almost always)

18. I give my opinions during class discussions.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

19. The teacher asks me questions.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

20. My ideas and suggestions are used during classroom discussions.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

21. I ask the teacher questions.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

22. I explain my ideas to other students.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

23. Students discuss with me how to go about solving problems.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

24. I am asked to explain how I solve problems.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

25. I carry out investigations to test my ideas.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

26. I am asked to think about the evidence for statements.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

27. I carry out investigations to answer questions coming from discussions.

- 1 (Almost never)
- 2

- 3
- 4
- 5 (Almost always)

28. I explain the meaning of statements, diagrams and graphs.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

29. I carry out investigations to answer questions which puzzle me.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

30. I carry out investigations to answer the teacher's questions.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

31. I find out answers to questions by doing investigations.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

32. I solve problems by using information obtained from my own investigations.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

33. Getting a certain amount of work done is important to me.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

34. I do as much as I set out to do.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

35. I know the goals for this class.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

36. I am ready to start this class on time.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

37. I know what I am trying to accomplish in this class.

- 1 (Almost never)
- 2

- 3
- 4
- 5 (Almost always)

38. I pay attention during this class.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

39. I try to understand the work in this class.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

40. I know how much work I have to do.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

41. I cooperate with other students when doing assignment work.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

42. I share my books and resources with other students when doing assignments.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

43. When I work in groups in this class there is teamwork.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

44. I work with other students on projects in this class.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

45. I learn from other students in this class.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

46. I work with other students in this class.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

47. I cooperate with other students on class activities.

- 1 (Almost never)
- 2

- 3
- 4
- 5 (Almost always)

48. Students work with me to achieve class goals.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

49. The teacher gives as much attention to my questions as to other students' questions.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

50. I get the same amount of help from the teacher as do other students.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

51. I have the same amount of say in this class as other students.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

52. I am treated the same as other students in this class.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

53. I receive the same encouragement from the teacher as other students do.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

54. I get the same opportunity to contribute to class discussions as other students.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

55. My work receives as much praise as other students' work.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

56. I get the same opportunity to answer questions as other students.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

Submit

APPENDIX 8

The online WIHIC Personal questionnaire (Preferred)

Queenstown Secondary School

Logged in as S68217

CCAS DEPARTMENTS DISCOVER QUEST OUR PRIDE PARTNERS QUEST FAMILY EVENTS GALLERY CALENDAR ADM

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E-Survey

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What Is Happening In Your Science Class? - Preferred

This questionnaire contains statements about practices which could take place in this class but may not be happening. You wi asked how often you would prefer each practice to take place.

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

Think about how well each statement describes what your preferred class would be like for you.

STUDENT COHESIVENESS

1. I would make friendships among students in the class.
   - 1 (Almost never)
   - 2
   - 3
   - 4
   - 5 (Almost always)
2. I would know other students in the class.
   - 1 (Almost never)
   - 2
   - 3
   - 4
   - 5 (Almost always)
3. I would be friendly to members of the class.
   - 1 (Almost never)
   - 2
   - 3
   - 4
   - 5 (Almost always)
4. Members of the class would be my friends.
   - 1 (Almost never)
   - 2
   - 3
   - 4
   - 5 (Almost always)
5. I would work well with other class members.
   - 1 (Almost never)
   - 2
   - 3
   - 4
   - 5 (Almost always)
6. I would help other class members who were having trouble with their work.
   - 1 (Almost never)
   - 2
   - 3
   - 4
   - 5 (Almost always)
7. Students in the class would like me.
   - 1 (Almost never)
   - 2
   - 3
   - 4

5 (Almost always)

8. In the class I would get help from other students.

1 (Almost never)
2
3
4
5 (Almost always)

TEACHER SUPPORT

9. The teacher would take a personal interest in me.

1 (Almost never)
2
3
4
5 (Almost always)

10. The teacher would go out of his/her way to help me.

1 (Almost never)
2
3
4
5 (Almost always)

11. The teacher would consider my feelings.

1 (Almost never)
2
3
4
5 (Almost always)

12. The teacher would help me when I had trouble with the work.

1 (Almost never)
2
3
4
5 (Almost always)

13. The teacher would talk with me.

1 (Almost never)
2
3
4
5 (Almost always)

14. The teacher would be interested in my problems.

1 (Almost never)
2
3
4
5 (Almost always)

15. The teacher would move about the class to talk with me.

1 (Almost never)
2
3
4
5 (Almost always)

16. The teacher's questions would help me to understand.

1 (Almost never)
2
3
4
5 (Almost always)

INVOLVEMENT

17. I would discuss ideas in class.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

18. I would give my opinions during class discussions.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

19. The teacher would ask me questions.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

20. My ideas and suggestions would be used during classroom discussions.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

21. I would ask the teacher questions.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

22. I would explain my ideas to other students.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

23. Students would discuss with me how to go about solving problems.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

24. I would be asked to explain how I solve problems.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

INVESTIGATION

25. I would carry out investigations to test my ideas.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

26. I would be asked to think about the evidence for statements.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

27. I would carry out investigations to answer questions coming from discussions.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

28. I would explain the meaning of statements diagrams and graphs.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

29. I would carry out investigations to answer questions which puzzled me.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

30. I would carry out investigations to answer the teacher's questions.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

31. I would find out answers to questions by doing investigations.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

32. I would solve problems by using information obtained from my own investigations.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

TASK ORIENTATION

33. Getting a certain amount of work done would be important to me.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

34. I would do as much as I set out to do.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

35. I would know the goals for this class.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

36. I would be ready to start this class on time.

- 1 (Almost never)
- 2
- 3
- 4

5 (Almost always)

37. I would know what I was trying to accomplish in the class.

1 (Almost never)
2
3
4
5 (Almost always)

38. I would pay attention during the class.

1 (Almost never)
2
3
4
5 (Almost always)

39. I would try to understand the work in the class.

1 (Almost never)
2
3
4
5 (Almost always)

40. I would know how much work I had to do.

1 (Almost never)
2
3
4
5 (Almost always)

COOPERATION

41. I would cooperate with other students when doing assignment work.

1 (Almost never)
2
3
4
5 (Almost always)

42. I would share my books and resources with other students when doing assignments.

1 (Almost never)
2
3
4
5 (Almost always)

43. When I work in groups in the class there would be teamwork.

1 (Almost never)
2
3
4
5 (Almost always)

44. I would work with other students on projects in the class.

1 (Almost never)
2
3
4
5 (Almost always)

45. I would learn from other students in the class.

1 (Almost never)
2
3
4
5 (Almost always)

46. I would work with other students in the class.

1 (Almost never)
2

- 3
- 4
- 5 (Almost always)

47. I would cooperate with other students on class activities.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

48. Students would work with me to achieve class goals.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

EQUITY

49. The teacher would give as much attention to my questions as to other students' questions.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

50. I would get the same amount of help from the teacher as do other students.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

51. I would have the same amount of say in the class as other students.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

52. I would be treated the same as other students in the class.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

53. I would receive the same encouragement from the teacher as other students did.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

54. I would get the same opportunity to contribute to class discussions as other students.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

55. My work would receive as much praise as other students' work.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

56. I would get the same opportunity to answer questions as other students.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

Submit

APPENDIX 9

The online QTI questionnaire (Student)

Queenstown Secondary School

(Logged in as S6821)

CCAS DEPARTMENTS DISCOVER & QUEST OUR PRIDE PARTNERS QUEST FAMILY EVENTS GALLERY CALENDAR ADM

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Questionnaire onStudent-Teacher Interaction

This questionnaire asks you to describe the behaviour of your teacher.

This is NOT a test. Your opinion is what is wanted.

Please answer all questions. Thank you very much for your cooperation.

1. You may provide your Science teacher's name here. (Optional)

2. This teacher talks enthusiastically about her/his subject.

   1 (Almost never)
   2
   3
   4
   5 (Almost always)

3. This teacher trusts us.

   1 (Almost never)
   2
   3
   4
   5 (Almost always)

4. This teacher seems uncertain.

   1 (Almost never)
   2
   3
   4
   5 (Almost always)

5. This teacher gets angry unexpectedly.

   1 (Almost never)
   2
   3
   4
   5 (Almost always)

6. This teacher explains things clearly.

   1 (Almost never)
   2
   3
   4
   5 (Almost always)

7. If we don't agree with this teacher we can talk about it.

   1 (Almost never)
   2
   3
   4
   5 (Almost always)

8. This teacher is hesitant.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

9. This teacher gets angry quickly.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

10. This teacher holds our attention.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

11. This teacher is willing to explain things again.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

12. This teacher acts as if she/he does not know what to do.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

13. This teacher is too quick to correct us when we break a rule.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

14. This teacher knows everything that goes on in the classroom.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

15. If we have something to say this teacher will listen.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

16. This teacher lets us boss her/him around.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

17. This teacher is impatient.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

18. This teacher is a good leader.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

19. This teacher realises when we don't understand.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

20. This teacher is not sure what to do when we fool around.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

21. It is easy to pick a fight with this teacher.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

22. This teacher acts confidently.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

23. This teacher is patient.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

24. It's easy to make this teacher appear unsure.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

25. This teacher makes mocking remarks.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

26. This teacher helps us with our work.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

27. We can decide some things in this teacher's class.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

28. This teacher thinks that we cheat.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

29. This teacher is strict.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

30. This teacher is friendly.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

31. We can influence this teacher.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

32. This teacher thinks that we don't know anything.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

33. We have to be silent in this teacher's class.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

34. This teacher is someone we can depend on.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

35. This teacher lets us decide when we will do the work in class.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

36. This teacher puts us down.

- This teacher puts us down.
- 2
- 3
- 4
- 5 (Almost always)

37. This teacher's tests are hard.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

38. This teacher has a sense of humour.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

39. This teacher lets us get away with a lot in class.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

40. This teacher thinks that we can't do things well.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

41. This teacher's standards are very high.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

42. This teacher can take a joke.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

43. This teacher gives us a lot of free time in class.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

44. This teacher seems dissatisfied.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

45. This teacher is severe when marking papers.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

46. This teacher's class is pleasant.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

47. This teacher is lenient.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

48. This teacher is suspicious.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

48. We are afraid of this teacher.

- 1 (Almost never)
- 2
- 3
- 4
- 5 (Almost always)

Submit

APPENDIX 10

The online GTKY questionnaire (with the Attitude Scales)

Queenstown Secondary School

Logged in as S6821

HOME DEPARTMENTS DISCOVER QUEST OUR PRIDE PARTNERS QUEST FAMILY EVENTS GALLERY CALENDAR ADM

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View Result

Edit the survey details below:

Survey title*: Getting to Know You

Survey description: <h2>Getting to Know You</h2>

This questionnaire seeks information that will help me get to know you better.
There are no 'right' or 'wrong' answers. Your option is what is

Expiry date*: 2013-11-01

Participants: All users

[Update Survey] [Reset Form]

You can group the survey questions into different sections by creating sections in the survey.

Questions in this survey:

No. Question — Type — Ac

1. What is your race?
   1. Malay
   2. Indian
   3. Chinese
   4. Eurasian
   5. Others
2. How many siblings (brothers and sisters) do you have?
   1. None
   2. 1
   3. 2
   4. 3
   5. 4
   6. More than 4
3. What is your position at Home?
   1. Youngest
   2. 2nd youngest
   3. Somewhere in the middle
   4. 2nd oldest
   5. Oldest
4. Do you come from a single-parent family?
5. Do you live with your mother or father?
   1. Mother
   2. Father
   3. Both parents
   4. Relatives
   5. Other
6. Do you like Science?
7. Please explain your answer in Question 6.
8. How well did you do for Science last year?
   1. A
   2. B
   3. C
   4. Fail
   5. Ungraded
9. How well did you do for Science this year?
   1. A
   2. B
   3. C
   4. Fail
   5. Ungraded
10. Do yo like school?
11. Please explain your answer in Question 10.
12. How do you find your school schedule?
    1. Very light
    2. Light
    3. Manageable
    4. Heavy
13. How do you find school?
14. What is your subject combination?
    Sci (Bio)
    Sci (Chem)

Sci (Phy)
Home Economics
Music
Art
Literature
D & T
MT
Social Studies
Comb Hum (Geo)
Comb Hum (Hist)
E Maths
A Maths

15. What are your favourite subjects?
    English
    Mother Tongue
    E Maths
    A Maths
    Science
    Sci (Phy)
    Sci (Bio)
    Sci (Chem)
    Physics
    Biology
    Chemistry
    Literature
    Social Studies
    Comb Hum (Geo)
    Comb Hum (Hist)
    Art
    D & T
    Home Economics
    Music
    PE
16. How would you describe yourself as a student?
17. What is your CCA(s)?
    NCC (LAND)
    NPCC
    SEA SCOUTS
    RED CROSS
    GIRL GUIDES
    WUSHU
    VOLLEYBALL
    INFOCOMM CLUB
    FOOTBALL
    TABLE-TENNIS
    CONCERT BAND
    CHOIR
    MALAY DANCE
    CHINESE DANCE
    DRAMA CLUB
18. Do you have free time by the time you get home on weekdays?
19. Please explain your answer in Question 18.
20. Do you have time for yourself on weekends?
21. Please explain your answer in Question 20.
22. How do you normally spend your free time?
23. How much time do you spend on the computer each day?
    1. Less than 1 hour
    2. 1 to 2 hours
    3. More than 2 hours
24. How much time do you spend on the computer on your studies each day?
    1. Less than 1 hour
    2. 1 to 2 hours
    3. More than 2 hours
25. Do you have internet access at home?
26. Would you like to use more of computers for your Science lessons?
27. What would you like to see more for your Science lessons?
28. Any other comments about school?
29. I look forward to Science lessons.
    1. 1 (never)
    2. 2
    3. 3
    4. 4
    5. 5 (always)
30. Lessons in Science are fun.
    1. 1 (never)
    2. 2
    3. 3
    4. 4
    5. 5 (always)

31. I dislike lessons in Science.
    1. 1 (never)
    2. 2
    3. 3
    4. 4
    5. 5 (always)
32. Lessons in Science bore me.
    1. 1 (never)
    2. 2
    3. 3
    4. 4
    5. 5 (always)
33. Science is one of the most interesting subjects in school subjects.
    1. 1 (never)
    2. 2
    3. 3
    4. 4
    5. 5 (always)
34. I enjoy lessons in Science.
    1. 1 (never)
    2. 2
    3. 3
    4. 4
    5. 5 (always)
35. Lessons in Science are a waste of time.
    1. 1 (strongly disagree)
    2. 2
    3. 3
    4. 4
    5. 5 (strongly agree)
36. Science lessons make me interested in Science.
    1. 1 (strongly disagree)
    2. 2
    3. 3
    4. 4
    5. 5 (strongly agree)
37. I find it easy to get good grades in Science.
    1. 1 (strongly disagree)
    2. 2
    3. 3
    4. 4
    5. 5 (strongly agree)
38. I am good at Science in general.
    1. 1 (strongly disagree)
    2. 2
    3. 3
    4. 4
    5. 5 (strongly agree)
39. My friends ask me for help in Science.
    1. 1 (strongly disagree)
    2. 2
    3. 3
    4. 4
    5. 5 (strongly agree)
40. I find Science easy.
    1. 1 (strongly disagree)
    2. 2
    3. 3
    4. 4
    5. 5 (strongly agree)
41. I perform better than my classmates in Science.
    1. 1 (strongly disagree)
    2. 2
    3. 3
    4. 4
    5. 5 (strongly agree)
42. I have to work hard to pass Science.
    1. 1 (strongly disagree)
    2. 2
    3. 3
    4. 4
    5. 5 (strongly agree)
43. I am an intelligent student.
    1. 1 (strongly disagree)
    2. 2
    3. 3
    4. 4
    5. 5 (strongly agree)
44. I help my friends with their homework in Science.
    1. 1 (strongly disagree)

2. 2
3. 3
4. 4
5. 5 (strongly agree)

45. I am good with computers.
    1. 1 (strongly disagree)
    2. 2
    3. 3
    4. 4
    5. 5 (strongly agree)
46. I like working with computers.
    1. 1 (strongly disagree)
    2. 2
    3. 3
    4. 4
    5. 5 (strongly agree)
47. Working with computers makes me nervous.
    1. 1 (strongly disagree)
    2. 2
    3. 3
    4. 4
    5. 5 (strongly agree)
48. I am comfortable trying new software on the computer.
    1. 1 (strongly disagree)
    2. 2
    3. 3
    4. 4
    5. 5 (strongly agree)
49. Working with computer is stimulating.
    1. 1 (strongly disagree)
    2. 2
    3. 3
    4. 4
    5. 5 (strongly agree)
50. I get a sinking feeling when I think of using a computer.
    1. 1 (strongly disagree)
    2. 2
    3. 3
    4. 4
    5. 5 (strongly agree)
51. I do as little work as possible using computer.
    1. 1 (strongly disagree)
    2. 2
    3. 3
    4. 4
    5. 5 (strongly agree)
52. I feel comfortable using a computer.
    1. 1 (strongly disagree)
    2. 2
    3. 3
    4. 4
    5. 5 (strongly agree)
53. What do you want to be when you grow up?

Add more question

APPENDIX 11

Sample pages of Lower Secondary NT Science Syllabus (2013)

LOWER SECONDARY NORMAL (TECHNICAL) SCIENCE

Module 1: **Gadgets Work Wonders (I)** ▪ Exploring Forces ▪ Discovering Energy ▪ Investigating Heat ▪ Investigating Electricity	**Overview** Gadgets are tools or machines that perform different functions. They occupy a central role in our daily lives. In this module, students will learn about forces and energy needed for gadgets to work. When gadgets are in use, energy conversions take place. Two common forms of energy are heat and electrical energy. Energy sources such as fossil fuels are limited resources; it is therefore important for us to conserve the use of energy where possible.			**Key Inquiry Questions** • How do gadgets use force and energy to make our lives better? • How do energy conversions affect our lives? • Why is heat important? • Why is it important to conserve the use of energy? • How does electricity work and how can it be used safely?
	Learning Outcomes			
Topic Description	**Knowledge with Understanding and Applications**	**Skills and Processes**	**Ethics and Attitudes**	**Suggested Lesson Ideas**
Exploring Forces Although forces cannot be seen, many of their effects are observed in our daily lives. These effects of forces have useful and important applications. Simple machines such as levers and pulleys operate on forces. Many of these simple machines allow us to use a small force to overcome a large load. These simple machines are good examples of how technology and gadgets have made our work easier and increased our productivity.	▪ state that a force can change the shape, size, state of rest and motion of a body ▪ use newton as the unit of force ▪ give examples of different forces: pushing, lifting, stretching, twisting, pressing, gravitational, frictional and magnetic forces ▪ describe the effects of friction on the motion of an object ▪ identify the different types of simple machines (levers, inclined planes and pulleys) and give everyday examples of their use	▪ infer the effects of forces such as: - change in state of rest of motion of a body - change in size and /or shape of a body ▪ use a spring balance to measure force ▪ investigate the effort used when the following is used to raise a load: - lever - inclined plane - pulley	▪ appreciate science for its usefulness in improving quality of life: knowledge about force has allowed human to design many useful tools such as the simple machines	<u>**Sports Shoe Design**</u> Students can investigate the grip of different brands of sports shoes by using a spring balance to measure the force needed to pull a stationary shoe across a surface. <u>**Make It Move**</u> Students can be given a toy car and discuss in groups how to change the motion of the toy car, e.g. move a car at rest, make a moving car go faster or make the car change direction.

Topic Description	Learning Outcomes			Suggested Lesson Ideas
	Knowledge with Understanding and Applications	Skills and Processes	Ethics and Attitudes	
Discovering Energy Different gadgets require different forms of energy to work. When gadgets are in use, energy is changed from one form to another. Currently, the main source of energy for our country comes from fossil fuels, a non-renewable source of energy. Fossil fuels are limited resources which will be depleted one day. It is thus important to conserve energy where possible. There is also an urgent need to find and use alternative and renewable sources of energy.	▪ recognise and give examples of different forms of energy in everyday life (potential energy, kinetic energy, light energy, heat energy, electrical energy and sound energy)	▪ investigate energy conversion from one form to another ▪ compare the differences between renewable sources of energy (solar, wind, biomass, hydro) and non-renewable sources of energy (coal, oil and natural gas), and their limitations	▪ appreciate that fossil fuels are exhaustible and the need and ways to reduce energy wastage ▪ appreciate the importance of conserving energy in our daily lives because Singapore is dependent on imported fossil fuels to meet its energy needs	**Alternative Sources of Energy** Teacher can present a scenario where fossil fuels have run out in the year 2030. In groups, students refer to resources to prepare a presentation on alternative sources of energy (include benefits, limitations, effect on environment and cost) **Solar Cooker** Teacher can organise a competition to build a simple solar cooker using aluminium foil to see which group of students can heat a fixed volume of water at room temperature to the highest temperature within a given time. Students can be asked to explain the limitations of such a cooker.

Topic Description	Learning Outcomes			Suggested Lesson Ideas
	Knowledge with Understanding and Applications	Skills and Processes	Ethics and Attitudes	
Investigating Heat Heat is important to human life. Heat is used to cook food and to keep people warm. We detect heat using our sense of touch. Thermometers are used to measure temperature to determine how hot or cold an object is. Effects of heat such as expansion and contraction have many important applications in our daily lives. However, some of these effects are undesirable as they can cause damages to buildings and structures.	▪ explain that heat is a form of energy that flows from a hotter to a colder region ▪ state the importance of heat energy in our life ▪ understand that temperature is a measure of the degree of hotness and coldness of an object ▪ recognise that when the temperature of a substance increases, the substance has absorbed heat; when the temperature of a substance decreases, the substance has lost heat ▪ recognise that there are different types of thermometers (digital thermometer, laboratory thermometer and temperature sensors) ▪ describe some consequences and applications of expansion and contraction in everyday life	▪ infer that generally, solids, liquids and gases expand when heated and contract when cooled ▪ measure temperature using a thermometer or a datalogger with temperature sensors	▪ appreciate science for its usefulness in improving quality of life: knowledge of heat allows us to tap on its usefulness and reduce its harmful effects	**<u>The Hotter the Better?</u>** Teacher can show a picture of heat being put into good use (e.g. cooking) and a picture of harmful effect of excessive heat (e.g. drought) and get students to discuss and suggest other uses and harmful effects of heat. **<u>'Repair' Ping Pong Ball</u>** Teacher can show students a deformed ping pong ball returning to original shape when placed in a beaker of hot water. The students can then be asked to propose possible explanations. **<u>How long does it take for water to boil?</u>** Teacher can help students better understand the difference between heat and temperature by getting them to measure the time needed to boil two different masses of water from room temperature. Teacher can then get students to discuss and propose possible explanations on why the time taken is different though the increase in temperature is the same.

APPENDIX 12

Sample pages of Lower Secondary NA/Express Science Syllabus (2013)

1. THE SCIENTIFIC ENDEAVOUR

Description	This introduction builds on students' learning of Primary Science as a way of exploring and understanding the physical and natural world. It aims to deepen students' understanding of what Science is and how it is practised and applied, i.e. the nature of Science.		**Key Inquiry Questions in the Scientific Endeavour include:** • Why did this event, phenomenon or problem happen? • What is Science? • How does Science affect our lives?
Essential takeaways	**SE 1:** Science is a study of the physical and natural world.	**SE 2:** Scientific knowledge is derived partly from systematic observation, experimentation and analysis and partly from human imagination and creativity. Scientific knowledge is subject to change.	**SE 3:** Scientific knowledge can be applied to bring benefits and harm.
Learning Outcomes	• Show an awareness that Science is not confined to the laboratory, but is manifested in all aspects of our lives • Show a healthy curiosity about the natural and physical world.	• Show an appreciation of Science being a human endeavour, with scientific knowledge contributed by different civilizations over the centuries • Understand how scientific knowledge is built from systematic collection and analyses of evidence and rigorous reasoning based on the evidence • Show an awareness that scientific evidence is subject to multiple interpretations • Recognise that scientific evidence can be quantitative or qualitative, and can be gathered through one's senses or instruments as extensions of one's senses • Use scientific inquiry skills such as <u>posing questions</u>, <u>planning and carrying out investigations</u>, <u>evaluating</u> experimental results and <u>communicating</u> findings *(Estimation and measurement skills, knowledge of S.I units, and using appropriate units for the respective physical quantities, should be infused into the respective topics)* • Show attitudes such as creativity, objectivity, integrity, open-mindedness and perseverance in carrying out scientific inquiry	• Discuss the uses and benefits of science and technology to society. • Relate applications of science to some social and ethical issues • State some current limitations of science and technology in solving societal problems • Recognise the need to be responsible towards society and the environment in using technology and scientific knowledge. • Demonstrate safety consciousness and adopt safe practices when carrying out investigations.

**optional for* Normal (Academic) syllabus

Theme: Diversity There is a great variety of living and non-living things in the world. Such diversity in the natural and man-made world helps to maintain a balance in the ecosystem and provide Man with useful resources. This complexity may be organised through common characteristics and unifying factors to better understand the world we live in. The study of living and non-living things in terms of their properties and changes is greatly facilitated by putting them into groups. **Essential Takeaways:** - The diversity of the rich resources in the natural world is important for the continual survival of living things. - Humans have to use the rich resources in nature responsibly and sustainably. - Man continually seeks to understand the complexity in the natural world by studying it in a systematic manner.	**Key Inquiry Questions in Diversity include:** • How does the diversity of living and non-living things contribute to our lives? • How do we classify things in our world? • How do we find out the properties and characteristics of the things around us?

Learning Outcomes		
Knowledge, Understanding and Application	**Skills and Processes**	**Ethics and Attitudes**
2. Exploring Diversity of Matter by their Physical Properties • explain the choice of the main classes of materials (metals, ceramics, glass, plastics, fibres) in the production of common household items, in terms of their properties, e.g. - density - strength - hardness - flexibility - electrical conductivity - thermal conductivity - boiling/melting point	• make estimations and measure accurately length, volume and mass (including volume and mass of liquids and solids but not of gases) of matter using appropriate instruments (metre rule, measuring tape, vernier calipers, measuring cylinder, displacement can, electronic balance) and methods • calculate density using the formula (density = mass/volume) and use the appropriate unit • predict whether an object will sink or float by comparing its density with that of its surrounding medium • classify a number of common everyday objects and recognise that there are many ways of classifying the same group of objects • use data on the properties of different materials to evaluate their uses • communicate their findings on classification and justify their reasons	• display the habit of sustainable use of materials, e.g. preferential choice of products made from biodegradable materials, practising the 3Rs: reduce, reuse, recycle • evaluate the environmental impact of excessive use of paper and disposal of plastics • demonstrate precision and accuracy in making measurements (taking into consideration parallax and zero errors)

**optional for* Normal (Academic) syllabus

Learning Outcomes		
Knowledge, Understanding and Application	**Skills and Processes**	**Ethics and Attitudes**
3. Exploring Diversity of Matter by its Chemical Composition • recognise that substances can be classified as elements, compounds and mixtures • distinguish among elements, compounds and mixtures • state that elements are the basic building blocks of living and non-living matter • recognise that elements are classified according to their properties • show an understanding that compounds are substances consisting of two or more chemically combined elements • show an understanding that mixtures are made up of two or more elements and/or compounds that are not chemically combined • distinguish among solute, solvent and solution • show an understanding that solutions and suspensions are mixtures	• classify elements as metals and non-metals based on their characteristic properties • investigate the factors that affect the solubility and rate of dissolving of substances	• evaluate how the disposal of harmful pure substances (e.g. mercury) and mixtures (e.g. sewage) impact the environment
4. Exploring Diversity of Matter Using Separation Techniques • show an awareness of basic principles involved in the following separation techniques: magnetic attraction, filtration, evaporation, distillation and paper chromatography • explain how the constituents of a mixture can be separated based on their properties, using the following techniques: magnetic attraction, filtration, evaporation, distillation, paper chromatography. • state some examples of the applications of the various separation techniques in everyday life and industries • show an awareness of the techniques involved in	• separate constituents of mixtures using the appropriate separation techniques	• show an appreciation of why water is a precious resource and the need to conserve it • show objectivity and accuracy in systematic investigations involved in the separation of mixtures

**optional for* Normal (Academic) syllabus

APPENDIX 13

Sample pages of GCE 'N' Level Science Syllabus T (2015)

CONTENT STRUCTURE

	Module	Topics
I.	Gadgets Work Wonders (II)	1.1 Energy and its Uses
		1.2 Energy transfer through Waves
		1.3 Effects of Forces
		1.4 Electricity
		1.5 Sources of Electricity
II.	Food Matters	2.1 Sources of Food
		2.2 Food Chemistry
		2.3 Food Health and Safety
III.	Wonders of My Body (II)	3.1 Digestion
		3.2 Breathing
		3.3 Fitness and Cardiac Health
		3.4 Staying Healthy

SYLLABUS CONTENT

MODULE I: GADGETS WORK WONDERS (II)

1.1 Energy and its Uses

Content

- energy may be converted to different forms

Learning Outcomes

Candidates should be able to:

(a) show understanding that kinetic energy, elastic potential energy, gravitational potential energy, chemical potential energy and thermal energy are examples of different forms of energy

(b) show understanding that thermal energy is transferred from a region of higher temperature to a region of lower temperature

(c) understand and apply the principle of the conservation of energy to daily situations

(d) relate Power to energy transferred and time taken, using appropriate examples and the equation; Power = Energy / time in simple systems

1.2 Energy transfer through Waves

Content

- waves transfer energy
- types of waves used for communications

Learning Outcomes

Candidates should be able to:

(a) describe what is meant by wave motion as illustrated by vibrations in ropes and springs (the terms transverse and longitudinal are not required)

(b) show understanding that waves transfer energy

(c) understand the terms frequency, wavelength, and amplitude of a wave

(d) state how the following types of waves are used for daily situations
  (i) radiowave (e.g. radio and television communications)
  (ii) microwave (e.g. microwave oven and satellite communication)
  (iii) infra-red (e.g. remote control devices)
  (iv) light (e.g. optical fibres for telecommunication)
  (v) ultra-violet (e.g. sunbeds and sterilisation)
  (vi) X-ray (e.g. radiological and engineering applications)

1.3 Effects of Forces

Content

- a force can change the motion of a body
- a force can cause a body to turn

Learning Outcomes

Candidates should be able to:

(a) use the following instruments for measuring length: rulers and measuring tape

(b) use digital stopwatches for measuring time intervals

(c) explain what is meant by speed and acceleration

(d) calculate the average speed and acceleration

(e) plot and interpret a distance-time graph of real situations

(f) understand that a force can change the state of rest, and motion of a body

(g) predict changes in speed and direction when a force acts on an object

(h) understand what is meant by moment of a force and apply this to everyday examples (calculations are **not** required)

1.4 Electricity

Content

- electrical components can be connected in series or parallel circuits
- electricity consumption can be reduced in many ways
- electrical safety precautions must be observed when using electricity

Learning Outcomes

Candidates should be able to:

(a) measure current, voltage and resistance using a multimeter

(b) draw simple series and parallel circuits for daily applications (e.g. table lamps use series circuits, ceiling lamps use parallel circuits)

(c) label and interpret circuit diagrams which include cells, switches, resistors (fixed and variable), voltmeters, ammeters, bells, bulbs, lamps and fuses

(d) state that current is the same at every point of a series circuit

(e) state that the total current is equal to the sum of the currents of the individual branches in a parallel circuit

(f) state that a voltage is required to cause a current flow

(g) state that the effective resistance increases when in series circuit

(h) state that the effective resistance decreases when in parallel circuit

(i) identify situations in which series and parallel circuits are used in daily electrical circuitry systems

(j) use information on a label of an electrical appliance to determine its power consumption

(k) give examples of ways to reduce electrical energy wastage at home

(l) use the equations: Power, $P = V \times I$; Energy, $E = P \times t$

(m) calculate the cost of using an electrical appliance where the energy unit is kW h

(n) understand and use information in electricity bills

(o) identify the potential dangers in the use of electricity at home, such as
  (i) damaged insulation
  (ii) overheating of cables
  (iii) poor or loose connections

(p) state precautions to be taken for safe electricity use at home, such as
  (i) use of fuses
  (ii) earthing metal casings
  (iii) double insulating wires
  (iv) use of circuit breakers

APPENDIX 14

Sample pages of GCE 'N' Level Science (Chemistry) Syllabus (2015)

SECTION II: ATOMIC STRUCTURE AND MOLE CONCEPT

Overview

For over 2000 years, people have wondered about the fundamental building blocks of matter. As far back as 440 BC, the Greek Leucippus and his pupil Democritus coined the term *atomos* to describe the smallest particle of matter. It translates to mean something that is indivisible. In the eighteenth century, chemist, John Dalton, revived the term when he suggested that each element was made up of unique atoms and the atoms of an element are all the same. At that time, there were about 35 known elements. This simple model could explain the millions of different materials around us.

Differences between atoms give elements their different chemical properties. Atoms of one or more substances (reactants) undergo some 'rearrangements' during a chemical change (reaction). These rearrangements form new and different substances (products). After the chemical reaction, all the atoms of the reactants are still present in the products. Balanced chemical equations can be written because of the *law of conservation of mass*. These equations make it possible to predict the masses of reactants and products involved in chemical reactions.

In this section, the idea of atoms and chemical bonding being the most important fundamental concept in chemistry is introduced. The knowledge of atomic structure opens the door for students to understand the world of chemical reactions. Students are also introduced to the use of models and theories in the study of the structures of atoms, molecules and ions, and the bonding in elements and compounds.

2. The Particulate Nature of Matter

Content

2.1 Kinetic particle theory

2.2 Atomic structure

2.3 Structure and properties of materials

2.4 Ionic bonding

2.5 Covalent bonding

Learning Outcomes

Candidates should be able to:

2.1 Kinetic particle theory

(a) describe the solid, liquid and gaseous states of matter and explain their interconversion in terms of the kinetic particle theory and of the energy changes involved

2.2 Atomic structure

(a) state the relative charges and approximate relative masses of a proton, a neutron and an electron

(b) describe, with the aid of diagrams, the structure of an atom as containing protons and neutrons (nucleons) in the nucleus and electrons arranged in shells (energy levels)

(Knowledge of s, p, d and f classification is **not** required; a copy of The Periodic Table of the Elements will be available in the examination)

(c) define *proton (atomic) number* and *nucleon (mass) number*

(d) interpret and use symbols such as ${}^{12}_{6}C$

(e) define the term *isotopes*

(f) deduce the numbers of protons, neutrons and electrons in atoms and ions given proton and nucleon numbers

2.3 Structure and properties of materials

(a) describe the differences between elements, compounds and mixtures

2.4 Ionic bonding

(a) describe the formation of ions by electron loss/gain in order to obtain the electronic configuration of a noble gas

(b) describe the formation of ionic bonds between metals and non-metals, e.g. $NaCl$; $MgCl_2$

(c) relate the physical properties (including electrical property) of ionic compounds to their lattice structure

2.5 Covalent bonding

(a) describe the formation of a covalent bond by the sharing of a pair of electrons in order to gain the electronic configuration of a noble gas

(b) describe, using 'dot and cross' diagrams, the formation of covalent bonds between non-metallic elements, e.g. H_2; O_2; H_2O; CH_4 and CO_2

(c) deduce the arrangement of electrons in other covalent molecules

(d) relate the physical properties (including electrical property) of covalent substances to their structure and bonding

3. Formulae and Mole Concept

Learning Outcomes

Candidates should be able to:

(a) state the symbols of the elements and formulae of the compounds mentioned in the syllabus

(b) deduce the formulae of simple compounds from the relative numbers of atoms present and vice versa

(c) deduce the formulae of ionic compounds from the charges on the ions present and vice versa

(d) interpret chemical equations with state symbols

(e) construct chemical equations, with state symbols, including ionic equations

(f) define *relative atomic mass*, A_r

(g) define *relative molecular mass*, M_r, and calculate relative molecular mass (and relative formula mass) as the sum of relative atomic masses

(h) perform calculations involving the relationship between the amount of substance in moles, mass and molar mass (calculations of stoichiometric reacting masses and volumes of gases are **not** required)

SECTION III: CHEMISTRY OF REACTIONS

Overview

Chemists like Svante Arrhenius played an important role in providing a comprehensive understanding of what happens in chemical reactions. In 1887, the Swedish chemist, Svante Arrhenius proposed the theory that acids, bases, and salts in water are composed of ions. He also proposed a simple yet beautiful model of neutralisation – the combination of hydrogen and hydroxyl ions to form water.

In this section, candidates examine the chemical characteristic properties of acids, bases and salts, and also their reactions with substances. Candidates should be able to value the knowledge of the hazardous nature of acids/alkalis and the safe handling, storing and disposing of chemicals.

4. Acids, Bases and Salts

Content

4.1 Acids and bases

4.2 Salts

Learning Outcomes

Candidates should be able to:

4.1 Acids and bases

(a) describe the meanings of the terms *acid* and *alkali* in terms of the ions they produce in aqueous solution and their effects on Universal Indicator

(b) describe how to test hydrogen ion concentration and hence relative acidity using Universal Indicator and the pH scale

(c) describe the characteristic properties of acids as in reactions with metals, bases and carbonates

(d) describe the reaction between hydrogen ions and hydroxide ions to produce water, $H^+ + OH^- \rightarrow H_2O$ as neutralisation

(e) describe the importance of controlling the pH in soils and how excess acidity can be treated using calcium hydroxide

(f) describe the characteristic properties of bases as in reactions with acids and with ammonium salts

(g) classify oxides as acidic, basic, amphoteric or neutral based on metallic/non-metallic character

4.2 Salts

(a) describe the techniques used in the preparation, separation and purification of salts as examples of some of the techniques specified in Sections **1.2**(a)

(Methods for preparation should include precipitation and titration, together with reactions of acids with metals, insoluble bases and insoluble carbonates.)

(b) suggest a method of preparing a given salt from suitable starting materials, given appropriate information

APPENDIX 15

Sample pages of GCE 'O' Science (Chemistry) Syllabus (2015)

SUBJECT CONTENT

SECTION I: EXPERIMENTAL CHEMISTRY

Overview

Chemistry is typically an experimental science and relies primarily on practical work. It is important for students to learn the techniques of handling laboratory apparatus and to pay special attention to safety while working in the laboratory. Accidents happened even to German chemist, Robert Bunsen, while working in the laboratory. Robert Bunsen spent most of his time doing experiments in the laboratory and at the age of 25, he lost an eye in a laboratory explosion due to the lack of proper eye protection.

In this section, students examine the appropriate use of simple apparatus and chemicals, and the experimental techniques. Students need to be aware of the importance of purity in the electronic, pharmaceutical, food and beverage industries, and be allowed to try out different methods of purification and analysis in school science laboratories. Students should be able to appreciate the need for precision and accuracy in making readings and also value the need for safe handling and disposing of chemicals.

1. Experimental Chemistry

Content

1.1 Experimental design

1.2 Methods of purification and analysis

1.3 Identification of ions and gases

Learning Outcomes:

Candidates should be able to:

1.1 Experimental design

(a) name appropriate apparatus for the measurement of time, temperature, mass and volume, including burettes, pipettes, measuring cylinders and gas syringes

(b) suggest suitable apparatus, given relevant information, for a variety of simple experiments, including collection of gases and measurement of rates of reaction

1.2 Methods of purification and analysis

(a) describe methods of separation and purification for the components of mixtures, to include:
(i) use of a suitable solvent, filtration and crystallisation or evaporation
(ii) distillation and fractional distillation (see also **10.1**(b))
(iii) paper chromatography

(b) suggest suitable separation and purification methods, given information about the substances involved in the following types of mixtures:
(i) solid-solid
(ii) solid-liquid
(iii) liquid-liquid (miscible)

(c) interpret paper chromatograms (the use of R_f values is **not** required)

(d) deduce from the given melting point and boiling point the identities of substances and their purity

1.3 Identification of ions and gases

(a) describe the use of aqueous sodium hydroxide and aqueous ammonia to identify the following aqueous cations: ammonium, calcium, copper(II), iron(II), iron(III), lead(II) and zinc (formulae of complex ions are **not** required)

(b) describe tests to identify the following anions: carbonate (by the addition of dilute acid and subsequent use of limewater), chloride (by reaction of an aqueous solution with nitric acid and aqueous silver nitrate), nitrate (by reduction with aluminium and aqueous sodium hydroxide to ammonia and subsequent use of litmus paper) and sulfate (by reaction of an aqueous solution with nitric acid and aqueous barium nitrate)

(c) describe tests to identify the following gases: ammonia (using damp red litmus paper), carbon dioxide (using limewater), chlorine (using damp litmus paper), hydrogen (using a burning splint), oxygen (using a glowing splint) and sulfur dioxide (using acidified potassium manganate(VII))

SECTION II: ATOMIC STRUCTURE AND STOICHIOMETRY

Overview

For over 2000 years, people have wondered about the fundamental building blocks of matter. As far back as 440 BC, the Greek Leucippus and his pupil Democritus coined the term atomos to describe the smallest particle of matter. It translates to mean something that is indivisible. In the eighteenth century, chemist, John Dalton, revived the term when he suggested that each element was made up of unique atoms and the atoms of an element are all the same. At that time, there were about 35 known elements. This simple model could explain the millions of different materials around us.

Differences between atoms give elements their different chemical properties. Atoms of one or more substances (reactants) undergo some "rearrangements" during a chemical change (reaction). These rearrangements form new and different substances (products). After the chemical reaction, all the atoms of the reactants are still present in the products. Balanced chemical equations can be written because of the law of conservation of mass. These equations make it possible to predict the masses of reactants and products involved in chemical reactions.

In this section, the idea of atoms and chemical bonding being the most important fundamental concept in Chemistry is introduced. The knowledge of atomic structure opens the door for students to understand the world of chemical reactions. Students are also introduced to the use of models and theories in the study of the structures of atoms, molecules and ions, and the bonding in elements and compounds. Calculations for chemical reactions involving chemical formulae, reacting masses and volumes, and concentrations introduce students to the fundamentals of stoichiometry.

2. The Particulate Nature of Matter

Content

2.1 Kinetic particle theory

2.2 Atomic structure

2.3 Structure and properties of material

2.4 Ionic bonding

2.5 Covalent bonding

Learning Outcomes:

Candidates should be able to:

2.1 Kinetic particle theory

(a) describe the solid, liquid and gaseous states of matter and explain their interconversion in terms of the kinetic particle theory and of the energy changes involved

2.2 Atomic structure

(a) state the relative charges and approximate relative masses of a proton, a neutron and an electron

(b) describe, with the aid of diagrams, the structure of an atom as containing protons and neutrons (nucleons) in the nucleus and electrons arranged in shells (energy levels)

(knowledge of s, p, d and f classification is **not** required; a copy of the Periodic Table will be available in the examination)

(c) define *proton number* (*atomic number*) and *nucleon number* (*mass number*)

(d) interpret and use symbols such as $^{12}_{6}C$

APPENDIX 16

Sample pages of GCE 'O' Level Pure Chemistry Syllabus (2015)

SUBJECT CONTENT

SECTION I: EXPERIMENTAL CHEMISTRY

Overview
Chemistry is typically an experimental science and relies primarily on practical work. It is important for students to learn the techniques of handling laboratory apparatus and to pay special attention to safety while working in the laboratory. Accidents happened even to German chemist, Robert Bunsen, while working in the laboratory. Robert Bunsen spent most of his time doing experiments in the laboratory and at the age of 25, he lost an eye in a laboratory explosion due to the lack of proper eye protection.

In this section, students examine the appropriate use of simple apparatus and chemicals, and the experimental techniques. Students need to be aware of the importance of purity in the electronic, pharmaceutical, food and beverage industries, and be allowed to try out different methods of purification and analysis in school science laboratories. Students should be able to appreciate the need for precision and accuracy in making readings and also value the need for safe handling and disposing of chemicals.

1 Experimental Chemistry

Content

1.1 Experimental design

1.2 Methods of purification and analysis

1.3 Identification of ions and gases

Learning Outcomes

Candidates should be able to:

1.1 Experimental design

(a) name appropriate apparatus for the measurement of time, temperature, mass and volume, including burettes, pipettes, measuring cylinders and gas syringes

(b) suggest suitable apparatus, given relevant information, for a variety of simple experiments, including collection of gases and measurement of rates of reaction

1.2 Methods of purification and analysis

(a) describe methods of separation and purification for the components of mixtures, to include:
- (i) use of a suitable solvent, filtration and crystallisation or evaporation
- (ii) sublimation
- (iii) distillation and fractional distillation (see also **11.1**(b))
- (iv) use of a separating funnel
- (v) paper chromatography

(b) suggest suitable separation and purification methods, given information about the substances involved in the following types of mixtures:
- (i) solid-solid
- (ii) solid-liquid
- (iii) liquid-liquid (miscible and immiscible)

(c) interpret paper chromatograms including comparison with 'known' samples and the use of R_f values

(d) explain the need to use locating agents in the chromatography of colourless compounds (knowledge of specific locating agent is **not** required)

(e) deduce from the given melting point and boiling point the identities of substances and their purity

(f) explain that the measurement of purity in substances used in everyday life, e.g. foodstuffs and drugs, is important

1.3 Identification of ions and gases

(a) describe the use of aqueous sodium hydroxide and aqueous ammonia to identify the following aqueous cations: aluminium, ammonium, calcium, copper(II), iron(II), iron(III), lead(II) and zinc (formulae of complex ions are **not** required)

(b) describe tests to identify the following anions: carbonate (by the addition of dilute acid and subsequent use of limewater); chloride (by reaction of an aqueous solution with nitric acid and aqueous silver nitrate); iodide (by reaction of an aqueous solution with nitric acid and aqueous silver nitrate); nitrate (by reduction with aluminium in aqueous sodium hydroxide to ammonia and subsequent use of litmus paper) and sulfate (by reaction of an aqueous solution with nitric acid and aqueous barium nitrate)

(c) describe tests to identify the following gases: ammonia (using damp red litmus paper); carbon dioxide (using limewater); chlorine (using damp litmus paper); hydrogen (using a burning splint); oxygen (using a glowing splint) and sulfur dioxide (using acidified potassium manganate(VII))

SECTION II: ATOMIC STRUCTURE AND STOICHIOMETRY

Overview

For over 2000 years, people have wondered about the fundamental building blocks of matter. As far back as 440 BC, the Greek Leucippus and his pupil Democritus coined the term atomos to describe the smallest particle of matter. It translates to mean something that is indivisible. In the eighteenth century, chemist, John Dalton, revived the term when he suggested that each element was made up of unique atoms and the atoms of an element are all the same. At that time, there were about 35 known elements. This simple model could explain the millions of different materials around us.

Differences between atoms give elements their different chemical properties. Atoms of one or more substances (reactants) undergo some 'rearrangements' during a chemical change (reaction). These rearrangements form new and different substances (products). After the chemical reaction, all the atoms of the reactants are still present in the products. Balanced chemical equations can be written because of the law of conservation of mass. These equations make it possible to predict the masses of reactants and products involved in chemical reactions.

In this section, the idea of atoms and chemical bonding being the most important fundamental concept in Chemistry is introduced. The knowledge of atomic structure opens the door for students to understand the world of chemical reactions. Students are also introduced to the use of models and theories in the study of the structures of atoms, molecules and ions, and the bonding in elements and compounds. Calculations for chemical reactions involving chemical formulae, reacting masses and volumes, and concentrations introduce students to the fundamentals of stoichiometry.

2 The Particulate Nature of Matter

Content

2.1 Kinetic particle theory

2.2 Atomic structure

2.3 Structure and properties of materials

2.4 Ionic bonding

2.5 Covalent bonding

2.6 Metallic bonding

Learning Outcomes

Candidates should be able to:

2.1 Kinetic particle theory

(a) describe the solid, liquid and gaseous states of matter and explain their interconversion in terms of the kinetic particle theory and of the energy changes involved

(b) describe and explain evidence for the movement of particles in liquids and gases (the treatment of Brownian motion is **not** required)

(c) explain everyday effects of diffusion in terms of particles, e.g. the spread of perfumes and cooking aromas; tea and coffee grains in water

(d) state qualitatively the effect of molecular mass on the rate of diffusion and explain the dependence of rate of diffusion on temperature