Science and Mathematics Education Centre

Effectiveness of Student Response Systems in Terms of Learning Environment, Attitudes and Achievement

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

Signature: ______________________________

Stephen T. Cohn

Date: __December 2011_________

Abstract

Most past research on the effectiveness of Student Response Systems (SRS) has focused on higher levels of education and neglected consideration of the learning environment. Therefore, this study is unique in its focus on Grade 7 and Grade 8 students and on the effect of using SRS on students' perceptions of the learning environment, as well as on the student outcomes of attitudes and achievement. This study also validated a new questionnaire, the How Do You Feel About This Class? (HDYFATC), which incorporates a new learning environment scale (Comfort) developed by the researcher. As schools incorporate technology such as SRS into the classroom, it is important to evaluate its effectiveness in terms of students' perceptions of the learning environment, attitudes, and achievement.

Student perceptions of the learning environment and their attitudes were assessed with the HDYFATC, which combines four learning environment scales (Involvement, Task Orientation, Equity, and Cooperation) from the What Is Happening In this Class? (WIHIC) questionnaire with one created by the researcher (Comfort) to assess how comfortable students are in their science class, and an attitude scale (Enjoyment) from the Test of Science Related Attitudes (TOSRA). Students' achievement was assessed using the average of their examination scores for the duration of the study.

The HDYFATC was administered to a sample of 1097 Grade 7 and Grade 8 students from 47 classes in three schools in New York State. Data analyses supported the HDYFATC's factorial validity, internal consistency reliability, and ability to differentiate between the perceptions of students in different classrooms. All items had a factor loading of at least 0.40 on their *a priori* scale and less than 0.40 on all other scales. The total variance was 76.13%, with the largest contribution from the Enjoyment scale. Eigenvalues ranged from 1.29 to 25.62. When the individual was used as the unit of analysis, the internal consistency reliability for different scales of the HDYFATC ranged from 0.94 to 0.95. ANOVA revealed significant differences between students' perceptions in different classes for each learning environment scale, with eta^2 values ranging from 0.50 to 0.60 for different scales.

To determine the effectiveness of SRS in terms of learning environment, attitudes, and achievement, data obtained from the HDYFATC and achievement scores were subjected to a MANOVA. The dependent variables were the five learning environment scales and two student outcome scales, while use or non-use of SRS was the independent variable. Because the multivariate test using Wilks' lambda criterion yielded a statistically significant result overall for the whole set of seven dependent variables, the univariate ANOVA results were interpreted separately for each individual dependent variable. The *F* value for between-group differences was statistically significant for every scale. Very large effect sizes ranged from 1.96 to 2.46 standard deviations for the learning environment scales and were 2.19 and 1.17 standard deviations for attitudes and achievement. For every scale, the SRS group had higher scores than the comparison group.

A two-way MANOVA was used to determine if the use of SRS was differentially effective for males and females. The independent variables were the use/non-use of SRS and gender, and the dependent variables were the seven learning environment and student outcome scales. Although both males and females benefited from the use of SRS, Task Orientation was the only scale for which a statistically significant interaction emerged. However, the degree of differential effectiveness found for males and females when using SRS was small and of very little educational importance. Females appeared to benefit slightly more than males from the use of SRS.

Simple correlation and multiple regression analyses were used to investigate the relationships between students' perceptions of the learning environment and the student outcomes of attitudes and achievement. All five learning environment scales correlated positively and significantly with both student attitudes and achievement. The multiple correlation of the five learning environment scales with student attitudes and achievement was, respectively, 0.79 and 0.45. Involvement, Task Orientation, and Comfort were statistically significant independent predictors of student attitudes, while Involvement, Equity, and Comfort were statistically significant independent predictors of achievement.

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I would like to thank the teachers who volunteered to participate in my study. I know it is difficult to be asked suddenly to change your method of teaching but you were up to the task. You have given up much of your time, between learning how to use this new equipment and having to make extra plans for the same course to accommodate this study. To use Student Response Systems, it takes hours of extra work to prepare, which at times is compounded with frustration when a technical glitch its encountered after so much hard work.

The administrators at the schools in which my study was conducted must also be recognized. Your permission to carry out this study was vital to its success. Without somewhere to conduct a study, it could never have taken place. As you were also open to the idea of your teachers trying something new, thank you.

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Words alone cannot begin to express the appreciation that I have for those mentioned in these two pages, so please take this as just a small gesture of my thanks.

Abbreviations

Below is a list of abbreviations that are used in this thesis:

CES	Classroom Environment Scale
CLES	Constructivist Learning Environment Survey
COLES	Constructivist-Oriented Learning Environment Survey
CUCEI	College and University Classroom Environment Inventory
HDYFATC	How Do You Feel About This Class? Questionnaire
ICE	Inventory of Classroom Environments
ICEQ	Individualized Learning Environment Questionnaire
LEI	Learning Environment Inventory
MCI	My Class Inventory
QTI	Questionnaire on Teacher Interaction
SAI	Scientific Attitude Inventory
SLAP	Survey of Laboratory Practices
SLEI	Science Laboratory Environment Inventory
SRS	Student Response Systems
TOMRA	Test of Mathematics Related Attitudes
TOSRA	Test of Science-Related Attitudes
TROFLEI	Technology-Rich Outcomes-Focused Learning Environment Inventory
WIHIC	What Is Happening In this Class? questionnaire

Table of Contents

Declaration ii
Abstract iii
Acknowledgements v
Abbreviations vii
List of Tables xiii
List of Figures xiii
Chapter 1 1
Introduction 1
1.1 Introduction 1
1.2 Rationale for the Study 1
1.3 Research Questions 3
1.4 Theoretical Framework 4
1.5 Research Methods 7
1.6 Significance of the Study 7
1.7 Context of the Study 8
1.8 Overview of Thesis 9
Chapter 2 11
Literature Review 11
2.1 Introduction 11
2.2 Learning Environments 12
2.2.1 Background 13
2.2.2 Instruments for Assessing Learning Environments 14
2.2.2.1 Learning Environment Inventory (LEI) 14
2.2.2.2 Classroom Environment Scale (CES) 16
2.2.2.3 My Class Inventory (MCI) 16
2.2.2.4 Questionnaire on Teacher Interaction (QTI) 17
2.2.2.5 Science Laboratory Environment Inventory (SLEI) 18
2.2.2.6 Constructivist Learning Environments Survey (CLES) 19
2.2.2.7 What Is Happening In this Class? (WIHIC) 20

2.2.2.8 *Technology-Rich Outcomes-Focused Learning Environment Inventory (TROFLEI)*............................ 20

2.2.2.9 *Constructivist-Oriented Learning Environment Survey (COLES)*..21

2.2.3 What Is Happening In this Class? (WIHIC) 22

2.2.3.1 Background to WIHIC.. 22

2.2.3.2 Validity of WIHIC...23

2.2.3.3 Shortcomings of WIHIC and Future Research 25

2.2.4 Research Involving Classroom Environment Instruments..................26

2.2.4.1 Associations between Student Outcomes and Environment.. 26

2.2.4.2 Differences between Student and Teacher Perceptions of Actual and Preferred Environment.............................. 29

2.2.4.3 Evaluation of Educational Innovations.......................... 29

2.2.4.4 Determinants of Classroom Environment.......................32

2.2.4.5 Use of Qualitative Research Methods............................32

2.2.4.6 Cross-National Studies...34

2.2.4.7 Teacher Education...36

2.2.4.8 School Psychology...36

2.2.4.9 Teachers' Attempts to Improve Classroom Environments..... 37

2.2.4.10 Transition from Primary to High School......................... 39

2.3 Student Attitudes 40

2.3.1 Assessment of Student Attitudes...41

2.3.2 Test of Science Related Attitudes (TOSRA) 42

2.3.2.1 Background to TOSRA..42

2.3.2.2 Validity of TOSRA.. 43

2.3.2.3 Shortcomings of TOSRA and Future Research................. 45

2.4 Gender Differences in Science Education...46

2.4.1 Past Studies of Gender Differences in Science Education..................46

2.4.2 Addressing Gender Differences 48

2.5 Student Response Systems 51

2.5.1 What are Student Response Systems?..52

2.5.2 Who Uses Student Response Systems? 52

2.5.3 Why Use Student Response Systems? 53

2.5.4 Past Research on Effectiveness of Student Response Systems...........55

2.5.5 Problems with Student Response Systems 58
2.5.6 Response Systems in the Future 59
2.6 Summary 60
Chapter 3 65
Research Methods 65
3.1 Introduction 65
3.2 Research Questions 65
3.3 Instrument Used to Collect Data 67
3.3.1 What Is Happening In this Class? (WIHIC) Questionnaire 67
3.3.1.1 What Is It? 67
3.3.1.2 Why Use It? 68
3.3.1.3 How To Use It 69
3.3.2 Comfort 69
3.3.3 Test of Science Related Attitudes (TOSRA) 70
3.3.3.1 What Is It? 70
3.3.3.2 Why Use It? 70
3.3.3.3 How To Use It 72
3.4 Data Collection 72
3.4.1 How Do You Feel About This Class? (HDYFATC) Questionnaire 73
3.4.2 Achievement 73
3.5 Sample 73
3.6 Administration of Questionnaire 74
3.7 Data Entry 76
3.7.1 Typographical Issues 76
3.7.2 Student Errors 77
3.8 Data Analysis 77
3.8.1 Research Question 1: Validity and Reliability of HDYFATC Scales 78
3.8.2 Research Question 2: Effectiveness of Student Response Systems 78
3.8.3 Research Question 3: Differential Effectiveness of Student Response Systems Among Different Genders 79
3.8.4 Research Question 4: Associations between Learning Environment, Attitudes, and Achievement 79
3.9 Summary 80

Chapter 4 82
Data Analyses and Results 82
4.1 Introduction 82
4.2 Validity and Reliability of the HDYFATC Questionnaire 83
4.2.1 Factor Structure of HDYFATC 83
4.2.2 Internal Consistency Reliability of HDYFATC 84
4.2.3 Ability of the HDYFATC to Differentiate Between Classrooms 84
4.2.4 Consistency of My Study's Results for HDYFATC with Past Research with WIHIC 84
4.3 Effectiveness of Student Response Systems 90
4.3.1 Effectiveness of Student Response Systems in Terms of Learning Environment 91
4.3.2 Effectiveness of Student Response Systems in Terms of Student Outcomes (Attitudes and Achievement) 92
4.4 Differential Effectiveness of Using Student Response Systems for Different Genders in Terms of Learning Environment, Attitudes, and Achievement 93
4.5 Associations between Learning Environment and Attitudes and Achievement 96
4.5.1 Associations between Learning Environment and Attitudes 97
4.5.2 Associations between Learning Environment and Achievement 97
4.5.3 Consistency of My Results with Past Studies 98
4.6 Summary 98
Chapter 5 102
Discussion 102
5.1 Introduction 102
5.2 Summary of Chapters 1–3 102
5.3 Summary of Results 105
5.3.1 Research Question 1 105
5.3.2 Research Question 2 107
5.3.3 Research Question 3 109
5.3.4 Research Question 4 110
5.4 Significance and Implications 111
5.5 Limitations 112
5.6 Recommendations for Further Research 113

5.7 Conclusion ... 115

References ... 117

Appendices ... 137

Appendix A: How Do You Feel About This Class? Questionnaire Revised ... 138

Appendix B: Participant Information Sheet ... 141

Appendix C: Consent Form ... 142

Appendix D: Letter to Teacher Participants ... 143

Appendix E: How Do You Feel About This Class? Questionnaire ... 144

Appendix F: Factor Analysis Results for Learning Environment and Attitude Scales for Previous Study ... 147

Appendix G: Internal Consistency Reliability (Cronbach Alpha Coefficient), Discriminate Validity (Mean Correlation with Other Scales), and Ability to Differentiate Between Classrooms (ANOVA Results) for Learning Environment and Attitude Scales for Previous Study ... 148

List of Tables

Table 2.1 Scales from Nine Learning Environment Instruments Classified According to Moos' Scheme 15

Table 2.2 TOSRA Scales and their Classification According to Klopfer's Scheme 43

Table 3.1 Size of Student Sample by Teacher, Student, Gender, and Instructional Method 75

Table 3.2 A Comparison of Ethnic, Socioeconomic, and Language Factors for the Three Schools 75

Table 4.1 Factor Analysis Results for the How Do You Feel About This Class? Questionnaire 85

Table 4.2 Internal Consistency (Cronbach Alpha Reliability) and Ability to Differentiate between Classrooms (ANOVA Results) for Learning Environment and Enjoyment Scales for Two Units of Analysis 86

Table 4.3 Average Item Mean, Average Item Standard Deviation and Differences Between SRS and Control Groups (*F* and Effect Size) in Students' Perceptions of Learning Environment, Enjoyment and Achievement 91

Table 4.4 Item Mean and Item Standard Deviation for Two Instructional Groups and Two Genders and Instruction-by-Gender Interaction (Two-way ANOVA) for each Learning Environment and Attitude Scale 94

Table 4.5 Associations between Learning Environment Scales and Student Outcomes (Enjoyment and Achievement) Using Simple Correlation and Multiple Regression Analyses 97

List of Figures

Figure 4.1 Comparison of SRS and Control Groups in Terms of Learning Environment and Attitudes and Achievement 93

Figure 4.2 Task Orientation Item Means for Male and Females Who Did Use SRS and Who Did Not Use SRS 95

Chapter 1

Introduction

1.1 Introduction

A current trend in education involves using Student Response Systems (SRS) to track student responses during class activities. New technology, such as SRS, requires funds to procure, implement, and maintain. Before this money is spent, it is important to ascertain the effectiveness of such technology in terms of fostering student outcomes as well as creating a positive learning environment.

Teachers are always striving to achieve the most effective educational methods possible. To achieve this, they often reflect on their lessons to see what did work, what did not work, and what could have been different. Another aspect of these reflections is consideration of what alternative materials could have been used to make the lesson more effective. Often the materials are technology related. Also, teachers often struggle to effectively assess student understanding and how to engage each and every student. Because there are students who never participate, it is hard to determine if the student is understanding the material or not. SRS allow teachers to answer some of these questions that arise during their reflections.

This initial chapter explains the purpose and rationale for this research, including its specific research questions and significance. Also included are a brief synopsis of the theoretical background, research methods employed, and the context for the study. Finally, an overview is provided of each of the other chapters in this thesis.

1.2 Rationale for the Study

Much of the research on Student Response Systems (SRS) has concentrated on its effects at the university level, and has been undertaken using informal questionnaires and interviews. However, few formal in-depth evaluation studies have been conducted at the middle-school level. Studies have shown a relationship between the use of SRS and the learning environment, attitudes, and achievement at higher education levels (Duncan, 2008; Wood, 2004), which are discussed in more detail in Chapter 2.

Not only is research lacking in these areas, but also more research needs to be conducted into gender[1] differences in students' responses to technology. Obtaining general information about students as a whole is valuable, but classifying the students and determining specific evaluation information more relevant to these specific groups can be more beneficial by allowing teachers and administrators specific avenues for professional development and instructional methods.

This lack of research could be detrimental to science education around the world. If more research results support this technology in terms of benefits for students, more institutions could confidently invest in SRS and use it more frequently. This could lead to students having a more positive view of their learning environment, having better attitudes towards science classes, and feeling more comfortable in class. In turn, this can engage the students more and promote student achievement.

My research adds to the fields of learning environments and attitudes by providing a new questionnaire, How Do You Feel About This Class? (HDYFATC) which measures students' perceptions of their learning environment, their attitudes, and their comfort, which is a new scale created by the researcher. This study is also significant because it examined connections between students' views of their learning environment in their science classes, their attitudes towards these classes, how comfortable they feel there, and their achievement levels in these science classes. This study could help to fill gaps in research knowledge about SRS and provide valuable and useful information that can be used to modify teaching methods, which could have a positive impact on the students.

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[1] While 'sex' refers to the biological and physical characteristics that makes one a male or female, and 'gender' incorporates the behavioral, social and cultural implications of being male or female (Torgrimson & Minson, 2005), the term 'gender' has been chosen for this study because the way in which students in the sample responded to the questionnaire could have been influenced by the culture and society in which they live based on being male or female.

1.3 Research Questions

This research was guided by the research problem:

> Is introducing new methods of questioning in the science classroom through technology beneficial in terms of learning environment, student attitudes, and student achievement?

Based on this research problem, four main questions were investigated. To answer the following research questions, the How Do You Feel About This Class? (HDYFATC) questionnaire was administered to 1097 Grade 7 and Grade 8 students in 47 classes in three schools in New York.

To examine whether the HDYFATC questionnaire was a valid and reliable measure of students' perceptions of their classroom learning environment and their attitudes to science, the first research question was delineated:

Research Question 1:

> Is the How Do You Feel About This Class? (HDYFATC)
> questionnaire valid and reliable when used with
> Grade 7 and Grade 8 science students in New York?

To examine the effectiveness of Student Response Systems in terms of students' views of their learning environment, their attitudes, and their achievement, the second research question was delineated:

Research Question 2:

> Is the use of Student Response Systems
> effective in terms of:
> (a) the learning environment?
> (b) student attitudes?
> (c) student achievement?

To investigate the differential effectiveness of Student Response Systems among different genders, the third research question was delineated:

Research Question 3:

> Is the use of Student Response Systems
> differentially effective for males and females in terms of:
>
> (a) the learning environment?
>
> (b) student attitudes?
>
> (c) student achievement?

To examine whether a relationship exists between students' perceptions of the classroom learning environment and student outcomes, the fourth research question was delineated:

Research Question 4:

> Are there associations between the learning
> environment and:
>
> (a) student attitudes?
>
> (b) student achievement?

1.4 Theoretical Framework

The current study focused on the effect that the use/non-use of student response systems (SRS), commonly referred to as Personal Response systems and various other names, has on students' perceptions of their learning environment, their attitudes, and their achievement. SRS consist of numerous parts, including a transmitter, often referred to as a 'clicker', which resembles a small television remote control, which students use to answer questions (Draper & Brown, 2004). To respond to questions, students aim this clicker at a sensor, which is connected to a computer. This computer has a program running that tabulates results and projects them onto a screen for all to see.

Currently, this technology is mostly used at the college level. By 2005, over 950 colleges had purchased these systems from just two manufacturers (Gilbert, 2005). Because of this, most research on the effectiveness of SRS has concentrated on the collegiate level and has revealed many positive outcomes associated with the use of SRS, as well as some areas of weakness.

Teachers in elementary, middle, and high schools are beginning to integrate this technology into their classrooms. Because of tight budgets, it is often beneficial, if not required, to have evidence that purchasing new equipment such as SRS has a positive impact on students. Because technology is changing rapidly and is expensive for schools, ascertaining its effectiveness is important.

This study both contributed to and drew upon the field of learning environments. It was noted by Lewin (1936) that the interactions between the surrounding environment and an individual's personality determine each individual's behaviors in a given situation. Murray (1938) built upon Lewin's theory when he proposed a needs-press model in which the needs of both the individual and the press of a given situation or environment both can affect the outcome of behavior. A strong theoretical foundation for the field of learning environments was built with these two models.

The needs-press model distinguishes between *alpha press,* for which an environment is assessed by an external observer, and *beta press,* for which an environment is assessed by a participant. Stern, Stein, and Bloom (1956) expanded upon this distinction by noting that participants might have perceptions that agree with a group consensus (*consensual beta press*) while also holding their own personal perceptions that might differ from those of the group (*private beta press*).

Perceptions of the learning environment have been assessed through the use of both qualitative and quantitative methods. Qualitative methods primarily involve interviews. Quantitative methods typically involve questionnaires and other data-gathering instruments. During the growth of the field of learning environments research, many instruments have been developed, beginning historically with the Learning Environment Inventory (LEI) (Walberg & Anderson, 1968) and Classroom Environment Scale (CES) (Moos & Trickett, 1974).

As the number of learning environment instruments has grown, they have also been diversified for uses at various grade levels, including the My Class Inventory for primary-school students (Fisher & Fraser, 1981), the Individualized Classroom Environment Questionnaire for secondary students (Rentoul & Fraser, 1979), and the College and University Classroom Environment Inventory for higher education students (Fraser & Treagust, 1986) were created. Certain learning environment instruments were also created to be used in specific situations, such as the Science Laboratory Environment Inventory (Fraser, Giddings, & McRobbie, 1992) and the Constructivist Learning Environment Survey (Taylor, Fraser, & Fisher, 1997). Literature related to these questionnaires is reviewed in detail in Section 2.2.2.

The What Is Happening In this Class? (WIHIC) questionnaire (Fraser, Fisher, & McRobbie, 1996) is unique in that it assesses numerous aspects of the learning environment that include interactions between students, interactions between the teacher and the students, and the importance of achieving goals within the learning environment. The How Do You Feel About This Class? (HDYFATC) questionnaire contains five of the seven learning environment scales (Involvement, Student Cohesiveness, Task Orientation, Cooperation, and Equity) from the WIHIC, while omitting Teacher Support and Investigation.

While my study focused primarily on the field of learning environments, it also involved student attitudes. Attitudes are described as individually-attributed beliefs, emotions and behavioural tendencies that someone has towards specific abstract or concrete objects (Baron & Byrne, 1977). Attitudes are one of the main determinants of behavior (Tavsancil, 2006). According to Allport (1956), the first study of attitudes was conducted by Thurstone (1929).

Like learning environments, attitudes typically are assessed through both qualitative and quantitative methods. Qualitative information is often gathered through interviews, whereas quantitative data typically are obtained through instruments. Numerous questionnaires have been developed to be used at different levels of education to assess the students' attitudes. One instrument, the Test of Science Related Attitudes (TOSRA), was created by Fraser (1978b) after he noted three major shortcomings with previous instruments (low reliability, a lack of economy of items, and the combination of distinct attitude concepts into a single scale which creates a mixture of variables).

The present study was located in the field of learning environments because it involved differences between students following different methods of responding to questions in the classroom (use/non-use of electronic student response systems) in terms of classroom environment and outcomes. Through the use of scales mainly from the What Is Happening In this Class? (WIHIC) questionnaire, it was possible to compare students who were experiencing the two different ways of responding to classroom questions. In Chapter 2, literature is reviewed concerning student attitudes (Section 2.3) and the WIHIC (Section 2.2.3).

1.5 Research Methods

To answer my four research questions, 10 teachers used SRS in their science classes for the first four months of the school year. The beginning of the school year was specifically chosen so that the students had a limited pre-conception in terms of the classroom learning environment or their attitudes towards the class. To minimize the teacher as a variable in the study, each teacher used SRS in half of his/her classes (the study group) and not in the other half (the control group).

After the study period, the students responded to the How Do You Feel About This Class? (HDYFATC) questionnaire which combines four learning environment scales (Involvement, Task Orientation, Cooperation, and Equity) from the What is Happening In this Class? (WIHIC) with one new learning environment scale (Comfort) created by the researcher and an attitude scale (Enjoyment) from the Test of Science Related Attitudes (TOSRA). Each scale contains 8 items.

To assess achievement, students in both the control and experimental groups took their teachers' normal quizzes and examinations. The use of the same method of assessing achievement allowed for consistency. At the end of the study, an average score was determined based on each quiz and examination grade. These averages were then divided by 20 for consistency with the range of scores possible for HDYFATC scales.

The quantitative data obtained from the HDYFATC and achievement measures were subjected to numerous methods of analysis to answer the four research questions stated above. Chapter 3 provides a more detailed description of the methods used in this study.

1.6 Significance of the Study

This study is significant for numerous reasons. First, there is no existing questionnaire that measures all three components that are important in this study:

learning environment, comfort and attitudes. This study involved developing and validating such a questionnaire with middle-school students in New York.

Schools are consistently trying to maintain the latest technology. Because this is very expensive, school districts only want to invest in the most effective tools possible. By identifying how effective SRS are and how students feel about them, school districts can then better decide if they feel that investing in these response systems is warranted.

This study investigated the differential effectiveness of SRS for males and females in terms of how students perceive their learning environment, their attitudes towards science class, and their achievement in science class. The results of this study can help teachers in their attempts at promoting more gender-fair classrooms.

The sample for this study was selected to be representative of Grade 7 and Grade 8 students in New York, which is noteworthy because most past studies of the effectiveness of SRS were conducted at the university level.

1.7 Context of the Study

Advances in technology potentially have an impact on education. Students have access to more technology in their personal lives. To keep students engaged in school, incorporating technology is potentially beneficial. Because this technology is often expensive, school districts want to only invest in products which they know have a definite positive impact on students. To see how technology affects students, some teachers refer to past studies of its effectiveness in terms of students' perceptions of their learning environments, students' attitudes towards their classes, and student achievement in their classes.

SRS are just one example such technology. Many students have seen these products on television game shows. This study concentrated on the impact of this specific technology on students in their classes. When schools are contemplating buying SRS, they could refer to my research findings in order to help them to gauge the likely impact when they are implemented in their classes.

1.8 Overview of Thesis

The background, methods, and findings of this study are presented in five chapters. Chapter 1 introduced the background (Section 1.1), rationale (Section 1.2), research questions (Section 1.3), theoretical framework (Section 1.4), basic research methods (Section 1.5), significance of the study (Section 1.6), educational context (Section 1.7), and an overview of the thesis (Section 1.8).

Chapter 2 provides a review of literature that is related to this study. Section 2.2 reviews the field of learning environments, including background information, past research, and learning environments instruments. The field of student attitudes is reviewed in Section 2.3. Section 2.4 is devoted to gender differences, including past research on gender differences in science education and ways to address gender differences to achieve a more equal opportunity for both males and females. Literature about Student Response Systems (SRS) is reviewed in Section 2.5, including what they are, who uses them, why they are used, past research on the effectiveness of SRS, problems with them, and the future potential and uses of these response systems.

Chapter 3 provides information about the research methods and sample in this study. The research questions that drove the study are restated in Section 3.2. Information about the questionnaire that was used (Section 3.3), methods of data collection (Section 3.4), the sample of students (Section 3.5), administration of the questionnaire (Section 3.6), data entry (Section 3.7), and the methods of analyzing data (Section 3.8) are all contained in Chapter 3.

Chapter 4 contains a detailed description of the data analyses and results related to the four research questions. Results pertaining to the first research question, dealing with the validity and reliability of the How Do You Feel About This Class? questionnaire, are reported in Section 4.2. The second research question, dealing with the effectiveness of SRS in terms of the learning environment, attitudes, and achievement, is the focus of Section 4.3. Analyses and results for the third research question, concerning the differential effectiveness of SRS for males and females, is considered in Section 4.4. The fourth research question, concerning associations between the learning environment and the student outcomes of attitudes and achievement, is the focus of Section 4.5.

Chapter 5 contains an in-depth discussion about the results of the study and their educational implications. Also provided are a summary of the thesis (literature review and methods) (Section 5.2), a summary of the results (Section 5.3), the significance and implications of this study (Section 5.4) and limitations (Section 5.5) and several recommendations for future research (Section 5.6). Finally, the thesis is concluded in Section 5.7.

The appendices at the end of the thesis contain numerous documents pertinent to this study. The How Do You Feel About This Class? (HDYFATC) questionnaire used in this study can be found in Appendix A along with directions for its administration. The information sheet that was provided to the students, teachers, and school administrators to provide relevant information about the study can be found in Appendix B. The consent form that was signed by parents and students is located in Appendix C. Appendix D provides the letter that was sent to the teachers who participated in the study. Appendix E provides the first version of the HDYFATC that was used in a pilot study that previously was undertaken as part of my Masters degree and then modified for the present study. The previous analyses of data from the first version of the HDYFATC questionnaire, used to determine its reliability and validity and to guide its modifications, can be found in Appendix F (factor analysis), whereas Appendix G contains ANOVA results for class membership differences.

Chapter 2

Literature Review

2.1 Introduction

As with all good research, one must first gather background information. This chapter provides an in-depth review of literature on many topics that are pertinent to this study. This review of literature begins with the first focus of the study, the field of learning environments (Section 2.2), in which extensive research has been conducted. This section encompasses information about instruments used in this field (Section 2.2.2) and about numerous past studies involving the use of classroom environment instruments (Section 2.2.4). For easy reference, Table 2.1 outlines selected learning environment instruments, the year created, their authors, at what level they are used, how many items per scale, and the classification of scales according to Moos' (1974) scheme.

Because this study used a questionnaire containing numerous scales from the What Is Happening In this Class? (WIHIC) questionnaire (Fraser, Fisher, & McRobbie, 1996), an extensive review of literature related to the WIHIC is provided in this chapter (Section 2.2.3). This review of literature on the WIHIC includes studies that have been conducted to validate this questionnaire (Section 2.2.3.2). As with all questionnaires, there are some problems as well as more future research that is needed. Section 2.2.3.3 explains these issues.

Much research has also been conducted in the field of student attitudes, which is another focus of this study. Section 2.3 reviews literature from this field, and includes a brief history of research on attitudes as well as instruments used to assess them (Section 2.3.1).

Because this study incorporated a scale from the Test of Science Related Attitudes (TOSRA) (Fraser, 1981), this chapter also describes the history of this questionnaire (Section 2.3.2). This review of literature related to the TOSRA includes a detailed consideration of studies that have been conducted to validate the TOSRA (Section

2.3.2.1), as well as problems and future research that could be conducted with this attitude instrument (Section 2.3.2.2).

My study also explored the differential effectiveness of SRS for males and females in the science classroom. To understand results obtained through this research, it is important to first have an understanding of this topic (Section 2.4). This literature review encompasses past studies on gender inequities (Section 2.4.1), as well as ways to minimize gender differences in the classroom (Section 2.4.2).

Finally, another key aspect of this study was the use of Student Response Systems (SRS), previously introduced in the Theoretical Framework (Section 1.4). This chapter not only details what SRS are (Section 2.5.1), but it also reviews literature on who the primary users of this technology are (Section 2.5.2), the rationale for using SRS (Section 2.5.3), past research on the effectiveness of SRS (Section 2.5.4), problems with SRS (Section 2.5.5) and the future potential of SRS (Section 2.5.6).

The research that has already been conducted on the effectiveness of the Student Response Systems (Section 2.5.4) has been focused mostly on learning environments, with little emphasis on attitudes and achievement. No major past research has focused on either the effect that SRS have on student attitudes or the differential effectiveness of SRS for males and females.

Through this extensive literature review, a deeper understanding of the areas involved in my research can be achieved. Areas with a lack of consensus amongst past researchers are identified. Through recognizing these areas, my research can illuminate past discrepancies. Not only are these problem areas identified, but commonalities among past research findings are delineated as well. This built a strong foundation for my research.

2.2 Learning Environments

One of the main foci of this study was the effectiveness of the use of SRS in terms of students' views of their learning environment. Because of this, a detailed literature review is provided of this field.

2.2.1 Background

Much progress has been made since 1968 when Herbert Walberg and Rudolf Moos began their semi-independent research on classroom climates (Fraser, 1998b). Harvard Project Physics involved a set of research and evaluation activities that was conducted by Walberg, which led to the creation of the Learning Environment Inventory (LEI) (Walberg & Anderson, 1968). During this time, Moos developed the first scales that measured social climates which were used in psychiatric hospitals and correctional institutions (Moos, 1974, 1979). This work by Moos led to the creation of the Classroom Environment Scale (CES) (Moos, 1979; Moos & Trickett, 1974).

The ideas of Lewin (1936) and Murray (1938) and their followers have often underpinned research by Moos, Walberg, and others. In 1936, Lewin realized the importance of the environment as well as its interaction with individuals. Even with such an abundance of work being focused on learning environments, Fraser (2001) explains how many teachers often speak about classroom climate, but very seldom is it effectively evaluated.

The field of learning environments is continuously growing. More researchers are gaining an interest in this field and contribute many detailed studies and new research each year. Detailed literature reviews (Fraser, 2007, in press) clearly show the growth of the field of learning environments. Not only has the work on learning environments led to literature reviews, but it has also led the American Educational Research Association to create a Special Interest Group (SIG) on Learning Environments. This work has also spawned significant books on learning environments research (Aldridge & Fraser, 2008; Fisher & Khine, 2006; Fraser, 1986; Fraser & Walberg, 1991; Goh & Khine, 2002; Khine & Fisher, 2003).

Fraser (1998b, p. 527) states that "although research and evaluation in science education have relied heavily on the assessment of academic achievement and other valued learning outcomes, these measures cannot give a complete picture of the educational process". That is, too often we rely solely on student performance on tests to determine what is happening in a classroom and to evaluate teacher and student performance. Fraser (1998b, p. 528) also claims that "students are at a good vantage point to make judgments about classrooms because they have encountered many different learning environments and have enough time in a class to form accurate impressions. Also, even if teachers are inconsistent in their day-to-day behavior, they usually project a consistent image of the long-standing attributes of classroom environment."

2.2.2 Instruments for Assessing Learning Environments

Throughout the years, as research has shown the importance of effective tools for measuring classroom climate, numerous instruments have been created to do just that. Many of these instruments measure specific scales based on Moos' (1974) scheme for classifying the dimensions of human environments (Fraser, 1998b). Moos' scheme is broken down primarily into three distinct areas: relationship dimensions – identifies the nature and intensity of personal relationships within the environment and assesses the extent to which people are involved in the environment and support and help each other; personal development dimensions – assesses the basic directions along which personal growth and self-enhancement tend to occur; and system maintenance and system change dimensions – involves the extent to which the environment is orderly, clear in expectations, maintains control and is responsive to change. These instruments are used worldwide and much research is still being conducted to validate them in different languages.

Table 2.1 outlines some of the frequently-used learning environment instruments. It not only gives the name of the instrument, but it also identifies what level it is best used for, the authors, the date when it was developed, and the number of items per scale. It also classifies each scale according to Moos' scheme: relationship dimensions, personal development dimensions, and system maintenance and change dimensions.

2.2.2.1 Learning Environment Inventory (LEI)

The Learning Environment Inventory (LEI) was first developed and validated based on the research on Harvard Project Physics (Walberg & Anderson, 1968). This historically-important questionnaire contains seven statements on 15 different scales (for a total of 105 items). The respondents state whether they agree or disagree with the statement using the responses of Strongly Agree, Agree, Disagree, and Strongly Disagree. To determine the consistency of the students' responses, some items are

Table 2.1 Scales from Nine Learning Environment Instruments Classified According to Moos' Scheme

Instrument	Level	Date Developed & Authors	Items per Scale	Scales Classified According to Moos' Scheme: Relationship Dimensions	Personal Development Dimensions	System Maintenance and Change Dimensions
Learning Environment Inventory (LEI)	Secondary	1968 Walberg & Anderson	7	Cohesiveness Friction Favouritism Cliqueness Satisfaction Apathy	Speed Difficulty Competitiveness	Diversity Formality Material environment Goal direction Disorganization Democracy
Classroom Environment Scale (CES)	Secondary	1974 Moos Trickett	10	Involvement Affiliation Teacher support	Task orientation Competition	Order and organization Rule clarity Teacher control Innovation
My Class Inventory (MCI)	Elementary	1981 Fisher & Fraser	6–9	Cohesiveness Friction Satisfaction	Difficulty Competitiveness	
Questionnaire on Teacher Interaction (QTI)	Primary/ Secondary	1985 Wubbels, Creton, & Hoomayers	8–10	Helpful/friendly Understanding Leadership Student responsibility and freedom Dissatisfied Admonishing Uncertain Strict		
Science Laboratory Environment Instrument (SLEI)	Upper Secondary/ Higher education	1995 Fraser, Giddings & McRobbie	7	Student cohesiveness	Open-endedness Integration	Rule clarity Material environment
Constructivist Learning Environment Survey (CLES)	Secondary	1995 Taylor, Dawson & Fraser	7	Personal relevance Uncertainty	Critical voice Shared control	Student negotiation
What Is Happening In this Class? (WIHIC)	Secondary	1996 Fraser, McRobbie & Fisher	8	Student cohesiveness Teacher support Involvement	Investigation Task orientation Cooperation	Equity
Technology-Rich Outcomes-Focused Learning Environment Inventory (TROFLEI)	Upper Secondary	2004 Aldridge, Dorman & Fraser	8	Student cohesiveness Teacher support Involvement	Investigation Task orientation Cooperation	Equity Differentiation Computer usage Young ethos
Constructivist-Oriented Learning Environment Survey (COLES)	Upper Secondary	In press Aldridge, Fraser, Bell & Dorman	8	Student cohesiveness Teacher support Involvement Personal relevance	Task orientation Cooperation	Equity Formative assessment Assessment criteria Differentiation Young ethos

reversed (Fraser, Anderson, & Walberg, 1982; Walberg & Anderson, 1968). This questionnaire is best used at the secondary education level.

2.2.2.2 Classroom Environment Scale (CES)

After much work in different environments, including hospitals, prisons, and schools, Rudolf Moos of Stanford University created the Classroom Environment Scale (CES) (Moos, 1974). The published version of the questionnaire has 10 items in each of the nine different scales of Involvement, Affiliation, Teacher Support, Task Orientation, Competition, Order and Organization, Rule Clarity, Teacher Control, and Innovation. The CES has true–false responses and a transparent scoring-and-answer sheet (Fisher & Fraser, 1983b; Moos, 1979; Moos & Trickett, 1974, 1987). This instrument is best used at the secondary level of education.

2.2.2.3 My Class Inventory (MCI)

The My Class Inventory (MCI) is a simplified version of the LEI to be used among children ages 8–12 years old (Fisher & Fraser, 1981). The MCI has between six and nine items in the following scales: Cohesiveness, Friction, Satisfaction, Difficulty, and Competitiveness. This adds up to a total of 38 items. The respondent reads simple statements and states either ‘yes’ or ‘no’. These answers are recorded directly on the survey (Fisher & Fraser, 1981; Fraser et al., 1982; Fraser & O'Brien, 1985). Another version of the MCI, used successfully by Goh, Young and Fraser (1995), includes a three-point response scale – Seldom, Sometimes, and Most of the Time – and includes a Task Orientation scale.

The MCI has also been validated in a modified form that assesses cohesiveness, difficulty and competition. This study was conducted in Brunei Darussalam in 15 government secondary school with a sample of 1565 students from 81 classes. The purpose of this study was to investigate associations between the classroom learning environment of lower-secondary mathematics classes and students’ satisfaction with learning mathematics (Majeed, Fraser, & Aldridge, 2002). As previously noted (Section 2.2.2.3), a short form of the MCI, consisting of 18 items from four scales (cohesion, competitiveness, friction, and satisfaction) has also been validated for use with elementary-age students (Sink & Spencer, 2005). This short form was used in a lower- to middle-class school district in urban Washington state.

The factorial validity and reliability of the MCI were replicated when used with a sample of 588 Grade 3 to Grade 5 students in Texas (Scott Houston, Fraser, & Ledbetter, 2008). This study evaluated the effectiveness of instruction using a textbook, science kits, or a combination of both. It was found that using science kits was associated with a more positive learning environment in terms of student satisfaction and cohesiveness. In classrooms with greater cohesiveness and less friction and competition, higher student satisfaction was present. Qualitative data were also collected in conjunction with the quantitative data from the MCI. Both data sets generally supported each other.

2.2.2.4 Questionnaire on Teacher Interaction (QTI)

Research on the Questionnaire on Teacher Interactions (QTI) began in the Netherlands and aimed at measuring teacher-student interactions in the classroom (Wubbels, Creton, & Hoomayers, 1985). The QTI was adapted from work by Leary (1957) on interpersonal teacher behavior. Unique to the QTI is its theoretical basis which draws upon a systems perspective on communication processes (Watzlawick, Beavin, & Jackson, 1967) and a theoretical model of proximity (Cooperation – Opposition) and influence (Dominance – Submission) which acknowledges that behaviours from the students might affect the teacher's interactions with them. Similarly, the teacher's interactions might affect the students' behaviours. These two ideas suggest a symbiotic relationship. The original version of the QTI consisted of 77 items divided between 8 scales. A short version also contains 8 scales, but each scale contains only 6 items each, for a total of 48 items. Responses to the QTI are on a five-point frequency scale ranging from Never (0) to Always (4) (Wubbels & Levy, 1991, 1993).

The QTI has been used in research in the USA (Wubbels & Levy, 1993) and Australia (Fisher, Henderson, & Fraser, 1995). In Singapore, the QTI has been cross-validated for use in a different country with a sample of 1512 primary mathematics students in 39 classes in 13 schools (Goh & Fraser, 1996, 1998, 2000). This study also found the QTI to be useful in several research applications. Further validation of the QTI for use in Singapore was undertaken with a sample of 497 gifted and non-gifted chemistry students (Quek, Wong, & Fraser, 2005) and 20 secondary science classes (Fisher, Goh, Wong, & Rickards, 1997).

The QTI has also been translated into Standard Malay and cross-validated with 3104 primary school students from 136 classes in Brunei Darussalam (Scott & Fisher, 2004). Also, in Brunei Darussalam, an English version of the QTI was cross-validated for secondary schools for samples of 1188 science students (Khine & Fisher, 2002) and 644 chemistry students (Riah & Fraser, 1998). A Korean-language version of the QTI has been validated in Korea among 543 Grade 8 students in 12 schools (Kim, Fisher, & Fraser, 2000). Also in Korea, Lee, Fraser, and Fisher (2003) cross-validated the QTI with a sample of 440 Grade 10 and Grade 11 science students. The QTI has also been translated into the Indonesian language and used in Indonesia and cross-validated with a sample of 422 university students in 12 research methods classes (Fraser, Aldridge, & Soerjaningsih, 2010).

2.2.2.5 Science Laboratory Environment Inventory (SLEI)

Because of the uniqueness of science laboratory classes, a questionnaire was developed specifically to assess this type of environment (Fraser, Giddings, & McRobbie, 1995; Fraser & McRobbie, 1995). The Science Laboratory Environment Inventory (SLEI) has seven items in each of its five scales: Student Cohesiveness, Open-Endedness, Integration, Rule Clarity, and Material Environment. The frequency of responses to the items are: Almost Never, Seldom, Sometimes, Often, and Very Often. The SLEI has a Open-Endedness scale because of the importance of open-ended laboratory activities. This questionnaire was field tested and validated simultaneously with students in the USA, Canada, England, Israel, Australia, and Nigeria (Fraser & McRobbie, 1995). The SLEI is best used for upper secondary and higher education students.

The SLEI was used in a study with a sample of 761 high-school biology students in 25 classes in Florida involving an evaluation of the use of anthropometric activities in terms of student outcomes and classroom environment (Lightburn & Fraser, 2007). This study, conducted at a suburban public high school in the southern United States, used principal components factor analysis with varimax rotation to confirm the validity of the questionnaire for use with this sample. Only a small number of items needed to be removed because their factor loading below 0.40 with their own scale or higher than 0.40 with any other scales.

The SLEI was also used in Korea to investigate the learning environment of senior high school science laboratory classrooms. To accomplish this, the SLEI was translated into Korean and administered to 99 science-independent stream students, 195 science-oriented stream students, and 145 humanities stream students for a total sample of 439 students. Data analyses confirmed the validity, reliability, and ability to differentiate between the perceptions of students in different classrooms of this new Korean language version of the SLEI (Fraser & Lee, 2009).

The validity of the English version of the SLEI was also confirmed through a study in Singapore (Wong & Fraser, 1995, 1996). This study involved 1592 Grade 10 chemistry students from 56 classes in 28 schools. Also, Quek et al. (2005) cross-validated the English version of the SLEI in Singapore in a study involving 497 gifted and non-gifted chemistry students. The English version of the SLEI was also cross-validated in Brunei Darussalem with a sample of 644 Grade 10 chemistry students (Riah & Fraser, 1998).

2.2.2.6 Constructivist Learning Environments Survey (CLES)

The Constructivist Learning Environments Survey (CLES) (Taylor, Fraser, & Fisher, 1997) was created to assess the extent to which a classroom's environment is consistent with a constructivist epistemology, which assumes that meaningful learning is a cognitive process which requires students to relate their knowledge to the world around them. The CLES assesses Personal Relevance, Uncertainty Critical Voice, Shared Control, and Student Negotiation through its 36 items. The five frequency responses range from Almost Never to Almost Always. With the knowledge gained through the use of this questionnaire, teachers can reflect on their epistemological assumptions and revise their teaching practices. The CLES is best used with secondary students.

The CLES was used in South Africa to help teachers to become more reflective during their daily mathematics classroom teaching (Aldridge, Fraser, & Sebela, 2004). A modified English version of the CLES was administered to 1,864 Grade 4 to 9 students in 43 classes with 18 teachers from 6 schools. Data analysis revealed that the CLES was valid for use in South Africa, although originally it was designed and used in a Western context. The only few items that were discarded during factor analysis were ones with negative wording.

The CLES has also been translated into Chinese for use in Taiwan. In this cross-national study, 1081 science students in 50 Australian classes were given the original English version of the CLES, while the new Chinese version was administered to 50 classes in Taiwan involving 1879 science students. Similar scale reliabilities and a similar five-factor structure emerged in both countries (Aldridge, Fraser, Taylor, & Chen, 2000).

A comparative student version of the CLES (CLES–CS) was developed for evaluating the impact of an innovative teacher development program in school classrooms (Nix, Fraser, & Ledbetter, 2005). This study, involving a sample of 1079 students in 29 classes in north Texas, showed that all but four items had a factor loading of at least 0.40 on their *a priori* scale and no other scale. These four problematic items consisted of a question that was negatively worded, a question that was reverse-scored, and questions that were ambiguously interpreted.

The CLES has been modified and translated into Spanish. This modified Spanish version and the English version were administered to 739 Grade K–3 science students in Miami. Analyses supported the validity of both versions when used with young children (Peiro & Fraser, 2009).

2.2.2.7 What Is Happening In this Class? (WIHIC)

The What Is Happening In this Class? (WIHIC) questionnaire combines scales from previous instruments and combines them with some new scales (Fraser et al., 1996). The WIHIC has both a Class form – to assess students' perceptions of the class as a whole – and a personal form – to assess a student's personal perceptions of his/her role in the classroom. Because the WIHIC was the main instruments used in my study, it is discussed in considerable detail in Section 2.2.3.

2.2.2.8 Technology-Rich Outcomes-Focused Learning Environment Inventory (TROFLEI)

The Technology-Rich Outcomes-Focused Learning Environment Inventory (TROFLEI) was designed as a way to collect formative and summative information about a new school. This innovative post-secondary school emphasized an outcomes focus and use of ICT in program delivery. This questionnaire incorporates all seven scales of the What Is Happening In this Class? (WIHIC) (see Section 2.2.3 and

Section 3.3.1 for more information on the WIHIC). In addition to these seven WIHIC scales, the Differentiation scale from the Individualized Classroom Environment Questionnaire (ICEQ) was used to assess the extent to which teachers cater for students differently according to their abilities, rates of learning, and interests. A Computer Usage scale measures the extent to which students use computers as a tool to communicate with other students and to access information. Finally, Young Ethos assesses the extent to which teachers treat students as young adults, including giving them appropriate responsibility (Aldridge, Dorman, & Fraser, 2004; Aldridge & Fraser, 2008).

The 80-item TROFLEI has eight items in each of 8 scales. Students respond using a five-point frequency scale (Almost Never, Seldom, Sometimes, Often and Almost Always). The TROFLEI is innovative in that it employs a side-by-side response format which enables students to provide their perceptions separately actual and preferred classroom environment.

Aldridge, Fraser and Dorman have conducted extensive research in Western Australia and Tasmania into the validity and reliability of the TROFLEI. These studies involved the following samples: 2317 students from 166 Grade 11 and Grade 12 classes (Aldridge & Fraser, 2008; 2011), 1249 students (772 from Western Australia and 477 from Tasmania) (Aldridge, Dorman et al., 2004), 4146 Grade 8–13 students (Dorman & Fraser, 2009), 2317 students (Aldridge & Fraser, 2008), 4146 students (Dorman, Aldridge, & Fraser, 2006), and 1035 Grade 11 and Grade 12 students from 80 classes (Aldridge, Fraser, & Fisher, 2003).

2.2.2.9 Constructivist-Oriented Learning Environment Survey (COLES)

The Constructivist-Oriented Learning Environment Survey (COLES) is a new learning environment questionnaire designed to provide feedback as a basis for reflection in teacher action research. The COLES incorporates six scales (Student Cohesiveness, Teacher Support, Involvement, Task Orientation, Cooperation and Equity) from the What Is Happening In this Class? (WIHIC), two scales (Differentiation and Young Adult Ethos) from the Technology-Rich Outcomes-Focused Learning Environment Inventory (TROFLEI), one scale (Personal Relevance) from the Constructivist Learning Environment Survey (CLES) and two new scales related to assessment (Formative Assessment and Assessment Criteria).

The Formative Assessment measures the extent to which students feel that the assessment tasks given to them make a positive contribution to their learning, while the Assessment Criteria scale measures the extent to which assessment criteria are explicit so that the basis for judgments is clear and public (Aldridge, Fraser, Bell, & Dorman, in press).

The validity and reliability of this new questionnaire were confirmed in Western Australia with a sample of 2043 Grade 11 and 12 students from 147 classes in 9 schools. In this study, the Rasch model was used to convert data collected using a frequency response scale into interval data suitable for parametric analyses. Analysis of raw scores and Rasch scores revealed that differences between the validity results (reliability, discriminate validity, and ability to differentiate between classrooms) were negligible (Aldridge, Fraser, Bell, & Dorman, in press).

2.2.3 What Is Happening In this Class? (WIHIC)

Because the main instrument used to obtain quantitative data in my study included numerous scales from the What Is Happening In this Class? (WIHIC) questionnaire, this section reviews in detail how the WIHIC was created, how it was validated, past studies that used it, and its limitations.

2.2.3.1 Background to WIHIC

The WIHIC questionnaire builds on other previous instruments that were used to measure learning environments, but also incorporates additional scales to assess contemporary concerns such as equity and constructivism. The other factor that sets the WIHIC apart is the fact that there are two different forms, one for the student to fill out as an individual and the other for the student to fill out based on the class as a whole (Fraser et al., 1996). The first version of the WIHIC consisted of 90 items, but it was evolved to its current form through extensive analysis of responses from 355 junior high school science students as well as detailed interviews (Fraser et al., 1996). From this, 54 items in seven different scales were found to be valid and reliable. More items, to make a total of 80, were added and field tested to form the final version of the WIHIC. This final version was field tested in Australia with 50 classes containing a total of 1,081 students. It was also translated into Chinese and used in Taiwan with 50 classes containing a total of 1879 students (Aldridge &

Fraser, 2000; Aldridge, Fraser, & Huang, 1999). These analyses led to a reduction of the WIHIC to 56 items in seven scales with 8 items per scale. Subsequently, the WIHIC has been successfully cross-validated and used in many other locations as described below.

2.2.3.2 Validity of WIHIC

One reason why the WIHIC has been so widely used is that it has been proven to be valid and reliable so many times, in different countries, and by different researchers. Jeffrey Dorman (2003) used confirmatory factor analysis (CFA) to validate this questionnaire with a sample of 3980 high school students in Canadian, British, and Australian Grade 8, 10, and 12 mathematics classes. Dorman (2003) explains that this was unique in that not many studies have reported the use of the CFA to support the structural characteristics of instruments. Dorman found that all scales had good internal consistency with coefficient alphas ranging from 0.76 to 0.85. Dorman also found that some scales do overlap, but not to an extent that it would violate the psychometric structure of the instrument. Another major finding in this study was that the scales differentiated significantly between grade levels that were represented in this study. The study conducted by Dorman attests to the wide international applicability of this instrument to accurately measure classroom environment.

The WIHIC has been cross-validated with the following samples:

- A sample of 665 middle-school students in California from 11 different schools supported the validity and usefulness of the WIHIC for this population (den Brok, Fisher, Rickards, & Bull, 2006).

- MacLeod and Fraser (2010) simultaneously administered English and Arabic versions of the WIHIC to 763 college students in 82 classes. Data analysis confirmed sound validity and internal consistency in both the actual and preferred forms for both languages. Afari, Aldridge, Fraser, and Khine (in press) also verified the validity of an Arabic version of the WIHIC in the United Arab Emirates with 352 college students in 33 classes.

- A modified version of the WIHIC was used to investigate Turkish high school students' perceptions of their learning environment in their biology classrooms. One study involved a sample of 399 Grade 9 and Grade 10 students (Cakiroglu, Telli, & Cakiroglu, 2003). Another study involved a sample of 1474 students (Cakiroglu, den Brok, Tekkaya, & Telli, 2009).

- The WIHIC was modified for young students and their parents and then administered to 520 Grade 4 and Grade 5 students and 120 parents in South Florida (Allen & Fraser, 2007).

- 1040 senior high-school students in 81 schools in Australia and Canada were involved in a study that used the WIHIC to assess students' perceptions of their learning environments. This study confirmed the validity and reliability of the WIHIC for use in Canada (Zandvliet & Fraser, 2004, 2005).

- 525 female students from 27 classes at a large urban university in the United States responded to the WIHIC as part of an evaluation of the effectiveness of an innovative course aimed at improving elementary teachers' perceptions towards laboratory-based learning environments. The sample's age range was 20–52 years with an average age of 24 years and a median age of 23 years (Martin-Dunlop & Fraser, 2007).

- In California, Ogbuehi and Fraser (2007) administered a modified version of the WIHIC to middle-school mathematics students. Analysis of data from a sample of 661 students from 22 classrooms in four inner city schools supported the factor structure, internal consistency reliability, and discriminant validity of the WIHIC.

- Wolf and Fraser (2008) administered the WIHIC to 1434 middle-school students in 71 classes in New York and confirmed its reliability and validity when used with this population.

- In Singapore, two studies have been conducted to cross-validate the WIHIC. Both the preferred and actual forms were found to have a strong validity and reliability for a sample of 2310 students in 75 senior high school mathematics and geography classes (Chionh & Fraser, 2009). Also, data from 250 adults in 23 computer courses in four Singaporean computing schools helped to support the WIHIC's validity (Khoo & Fraser, 2008).

- Sound factorial validity for the WIHIC was found in a study conducted in southeastern U.S. among 573 elementary school students in Grades 3–5 (Pickett & Fraser, 2009).
- A sample of 543 Grade 8 students from 12 different schools was used in validating the WIHIC in the Korean language (Kim et al., 2000).
- The WIHIC has also been translated into the Indonesian language and used with students in computing-related courses at the university level. This version of the WIHIC was cross-validated with a sample of 2498 university students in 50 computing classes (Margianti, Fraser, & Aldridge, 2001).
- A modified version of the WIHIC was cross-validated simultaneously in Indonesia and Australia with a sample of 1161 secondary students (594 students from 18 classes in Indonesia and 567 students from 18 classes in Australia) (Fraser, Aldridge, & Adolphe, 2010).
- Dorman (2008) verified the validity of the WIHIC in Australia with a sample of 978 secondary school students.
- The English and Spanish versions of the WIHIC have been validated in Florida with 78 parents and 172 kindergarten science students (Robinson & Fraser, in press) and 924 students in 38 Grade 8 and Grade 10 science classes (Helding & Fraser, in press).

2.2.3.3 Shortcomings of WIHIC and Future Research

As with all instruments, the WIHIC has its limitations. The first limitation is the language. The WIHIC has been validated in numerous languages including Chinese, Korean, Indonesian, Spanish, and Arabic. In order to use this questionnaire in more countries, much work must be done to translate and validate it in other languages. Another limitation is that the WIHIC might not be equally reliable for the wide variety of classrooms that occur naturally in different countries with different cultures, as well as those with a greater emphasis on technology and web-based learning. What might be valued and tested in one type of classroom might not be of importance to others.

Even with these translations, another problem that is shared with most other questionnaires is readability. The subjects in a study cannot accurately answer questionnaires if they cannot understand the wording. The wording must be clear so that it is understood in the same way by all who complete it. Failure to do this can result in inaccurate results.

More research should be undertaken in order to reduce or eliminate the shortcomings and limitations of the WIHIC. First, the questionnaire should be translated into more languages and cross-validated. This will enable the WIHIC to be a more widely used and practical in more classrooms throughout the world. In addition to this, research needs to be undertaken into the applicability of the WIHIC in cultures with different values and unique school settings, such as in Asian countries. Also, a new questionnaire, or version of the existing ones, needs to be created in order to take into account the learning environments that have a greater emphasis on technology and the use of the Internet. Some researchers are looking into modifying the widely-used paper-and-pencil instruments into computer and online formats (Fraser, 2002).

2.2.4 Research Involving Classroom Environment Instruments

To effectively show the various applications of classroom environment instruments, this section considers 10 types of past research which focused on (1) associations between student outcomes and environment, (2) differences between student and teacher perceptions of actual and preferred environment, (3) evaluation of educational innovations, (4) determinants of classroom environment, (5) use of qualitative research methods, (6) cross-national studies, (7) teacher education, (8) school psychology, (9) teachers' attempts to improve classroom environments and (10) transition from primary to high school.

2.2.4.1 Associations between Student Outcomes and Environment

In past classroom environment research, the strongest tradition has involved investigating the associations between the students' cognitive and affective learning outcomes and their perception of psychosocial characteristics of their classrooms (Fraser & Fisher, 1982; Haertel, Walberg, & Haertel, 1981; McRobbie & Fraser, 1993). A compilation of 40 past studies shows that the relationships between outcome measures and the way in which students perceive their classroom environment has been replicated for a variety of cognitive and affective outcome measures, a variety of classroom environment instruments and a variety of samples that include numerous countries and grade levels (Fraser, 1994, 2002).

In Asia, many studies have revealed associations between students' outcomes and how they perceive their classroom environment. These studies have involved numerous learning environment instruments, student outcomes, grade levels and school subjects. Not only were English versions of these instruments used, but some were also translated into various Asian languages:

- Through the use of several different instruments, relationships have been established between numerous student outcomes and students' perceptions of their classroom environment in Singapore. Links have been established in Singapore between students' attitudes and scores on the Science Laboratory Environment Inventory (SLEI) for a sample of 1592 chemistry students in 56 different Grade 10 classes (Wong & Fraser, 1996). Another study used the My Class Inventory (MCI) and the Questionnaire on Teacher Interaction (QTI) with 1512 primary mathematics students in 39 classes to establish a relationship between the classroom environment and mathematics achievement and attitudes (Goh & Fraser, 1998, 2000). A comprehensive study established relationships between What Is Happening In this Class? (WIHIC) questionnaire scales and examination results, attitudes and self-esteem with 2310 geography and mathematics students in 75 classes (Chionh & Fraser, 2009). Using the SLEI and QTI, a relationship was established with student attitudes for a sample of 497 gifted and non-gifted chemistry students at the secondary level (Quek et al., 2005). A link has been established between student satisfaction and dimensions of the WIHIC with a sample of 250 adults attending 23 computing classes (Khoo & Fraser, 2008). Associations have been found between classroom environment, achievement, and attitudes among a sample of 671 high school geography students in 24 classes in Singapore through the use of a learning environment instrument suited for computer-assisted instruction classrooms (Teh & Fraser, 1995). The SLEI was used in both Singapore and Papua New Guinea in investigating relationships between attitudes and classroom environment (Waldrip & Wong, 1996).

- Outcome-environment relationships have been found in Taiwan for student satisfaction and a Chinese-language version of both the WIHIC and Constructivist Learning Environment Survey (CLES). This study involved a sample of 1879 students in 50 science classes (Aldridge & Fraser, 2000; Aldridge et al., 1999; Aldridge et al., 2000).

- In Korea, outcome-environment associations have been reported for numerous groups. First, students' attitudes to science and a Korean-language version of the SLEI, CLES, and QTI with a sample of 440 students in 13 Grade 10 and Grade 11 science classes (Fraser & Lee, 2009; S. S. U. Lee et al., 2003). Similar associations have been noted between student attitudes and a Korean-language version of the CLES for a sample of 1083 students in 24 science classes (Kim, Fisher, & Fraser, 1999). Finally, a study involving a sample of 543 students in 12 schools responding to the QTI and WIHIC revealed outcome-environment associations (Kim et al., 2000).

- Associations have been reported in Indonesia between the outcomes of achievement and attitudes and students' perceptions on an Indonesian-language version of the WIHIC. This was completed through a study of 50 university classes containing 2498 students (Margianti et al., 2001). Also, Indonesian-language versions of the WIHIC and QTI have been used with 422 university students in 12 classes to establish links with student outcomes including course achievement, leisure interest in computers, and attitude towards the internet (Fraser, Aldridge, & Soerjaningsih, 2010). Fraser, Aldridge and Adolphe (2010) also used a modified version of the WIHIC in Australia and Indonesia simultaneously.

- In Brunei Darussalam, outcome-environment associations have been established among different groups. First, a study involving a sample of 1565 Form 2 mathematics students in 81 classes revealed a relationship with satisfaction and scales of the MCI (Majeed et al., 2002). Second, associations between science attitudes and scales of both the WIHIC and QTI have been established with a sample of 1188 Form 5 mathematics students in 54 classes (Khine, 2001; Khine & Fisher, 2001, 2002). Next, achievement and attitudes have been found to be related to scales of the WIHIC, QTI and

SLEI for a sample of 644 students in 35 chemistry classes from 23 government secondary schools (Riah & Fraser, 1998). Finally, enjoyment of science lessons was found to be related to scales of a primary school version of the QTI that had been translated into Standard Malay and used with 3104 students in 136 classes in 23 private schools (Scott & Fisher, 2004).

- In Jammu, India, Koul and Fisher (2005) studied associations between students' cultural background and their perceptions of their teacher's interpersonal behavior and classroom learning environment. This research was conducted with a sample of 1021 students from 31 classes in seven co-educational private schools. These students completed a survey that included the WIHIC, QTI, and a question relating to cultural background. It was found that the Kashmiri group of students had more positive perceptions of their classroom environments and teacher interactions relative to students of other cultural groups identified in this study.

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

A study of the differences between students and teachers in their perception of the same classroom environment and between actual and preferred environments (Fisher & Fraser, 1983a) revealed that students preferred a more positive environment than was present for all five environmental dimensions assessed. For four of the dimensions, teachers perceived a more positive classroom environment than the students in those classes. This research has been replicated using the WIHIC and QTI among samples of Singaporean high school students (Chionh & Fraser, 2009; Wong & Fraser, 1996) and using the WIHIC among 2498 university students in Indonesia (Margianti et al., 2001).

2.2.4.3 Evaluation of Educational Innovations

An evaluation of the Australian Science Education Project (ASEP) revealed that ASEP students perceived their classrooms as being more individualized and satisfying and also having a better material classroom than those of a control group (Fraser, 1979). Even with the potential value of using learning environment dimensions in the evaluation of educational innovations, not many studies have been carried out on this in Asia (Fraser, 2002). In Singapore, Teh used a classroom environment instrument that he developed, the Geography Classroom Environment Inventory, as a source of dependent variables in evaluating computer-assisted learning (Fraser & Teh, 1994; Teh & Fraser, 1994). A group of students using micro-PROLOG-based computer-assisted learning had much higher scores for achievement (3.5 standard deviations), attitudes (1.4 standard deviations) and classroom environment (1.0–1.9 standard deviations) compared with a control group. The WIHIC was also used in Singapore in evaluating adult computer application courses with a sample of 250 students in 23 classes (Khoo & Fraser, 2008). In this study, students perceived their computing classes as being fairly high in equity, teacher support, task orientation, and involvement. Also students of different genders and ages varied in their perceptions of how effective the course was.

A comparative student version of the CLES (CLES–CS) was developed to evaluate the impact of an innovative teacher development program on teachers' behavior in their school classrooms. The CLES–CS was administered to 1079 students in 59 classes in north Texas. Data analyses revealed that this version of the CLES was valid, reliable, and able to distinguish between different classes of students. Students of teachers who attended special Integrated Science Learning (ISL) training perceived higher levels of Personal Relevance and Uncertainty of Science in their classrooms compared with their perceptions of non-science teachers in the same school (Nix et al., 2005).

Evidence of a positive influence of using anthropometric activities on students' attitudes and classroom learning environment has been reported in a study conducted with a sample of 761 high-school biology students in Florida. Student achievement and attitudes also were assessed. Students' perceptions of learning environment were assessed with the SLEI (Lightburn & Fraser, 2007).

A study of the effects of inquiry-based teaching on students' perceptions of the classroom learning environment, attitudes, and achievement among middle-school physical science students was reported by Wolf and Fraser (2008). To accomplish this, the researcher combined the WIHIC and a modified form of the TOSRA to create his own questionnaire referred to as the Survey of Laboratory Practices (SLAP). This questionnaire was administered to the sample and analyzed in addition to qualitative data that was collected through interviews. For a sample of 1434 students in 71 non-inquiry based classes and 165 students in 8 inquiry-based classes, inquiry promoted more student cohesiveness and was differentially effective based on gender (Wolf & Fraser, 2008).

Research involving 22 middle-school mathematics classrooms in four inner-city schools in California containing 661 students focused on the effectiveness of using innovative teaching strategies for enhancing the classroom environment and students' attitudes and conceptual development. Through the use of the WIHIC, CLES, and Test of Mathematics Related Attitudes (TOMRA), it was found that these questionnaires were valid, reliable, and able to distinguish between different classes when used with middle-school mathematics students in California. It was also concluded that these innovative teaching methods were effective in terms of learning environment, attitudes, and mathematics concept development (Ogbuehi & Fraser, 2007).

A study was undertaken into the effectiveness of an innovative science course for prospective elementary teachers (Martin-Dunlop & Fraser, 2007). The goals of this course are to improve the students' perceptions of laboratory learning environment and attitudes towards science through the use of guided open-ended approaches to investigations and through instructors using cooperative learning groups to create an environment of support. The sample of 525 female students from 27 classes in a large urban university was given a questionnaire at the beginning of the course to measure ideas and attitudes based on previous science laboratory courses. When students were then given the same questionnaire at the conclusion of the course, a significant improvement on all seven scales was found. The largest improvements were in the areas of Open-Endedness and Material Environment (Martin-Dunlop & Fraser, 2007).

Afari and colleagues (in press) used an Arabic translation of the WIHIC to determine how the use of mathematics games affected the learning environment. This study involved 352 college students from 33 classes in the United Arab Emirates. The use of games was found to promote a positive classroom environment.

2.2.4.4 Determinants of Classroom Environment

Classroom environment dimensions have been used as dependent variables in investigating the effect of such factors as class size, grade level, teacher personality, subject, and type of school on classroom environment (Fraser, 1994). In Japan, differences between the classroom environment perceptions of normal students and at-risk students were studied (Hirata & Sako, 1998). In Singapore, interesting differences in classroom environment perceptions have been identified when comparing gifted and non-gifted students (Quek et al., 2005). Differences in students' classroom environment perceptions were found to depend on whether the teacher was Asian or Western in a study in Brunei (Khine & Fisher, 2001, 2002). The SLEI, CLES and QTI were used in Korea in an investigation of differences between science-oriented and humanities-oriented streams in terms of student-perceived learning environment (Fraser & Lee, 2009; S. S. U. Lee et al., 2003). Also in Korea, the CLES was used in comparing the levels of perceived constructivism in Grade 10 and Grade 11 (Kim et al., 1999). Differences in classroom environment were found in Indonesia for university students in statistics and linear algebra classes (Margianti et al., 2001). Similar differences have been observed between computer science and management classes (Fraser, Aldridge, & Soerjaningsih, 2010).

Many of the studies of determinants of classroom environments have been conducted in Asia and have focused on gender. From these studies, it has been noted that females and males vary in how they perceive their classroom environments. Females tend to have a more favorable view of classroom environment (Fraser, 2002). The countries in which these studies of gender difference have been conducted include, but are not limited to, Brunei (Khine & Fisher, 2001, 2002; Riah & Fraser, 1998), Korea (Kim et al., 2000), Singapore (Chionh & Fraser, 2009; Goh & Fraser, 1998; Khoo & Fraser, 2008; Quek et al., 2005; Wong & Fraser, 1996) and Indonesia (Margianti et al., 2001).

2.2.4.5 Use of Qualitative Research Methods

Much progress has been made in incorporating both qualitative and quantitative research methods in the same study of learning environments (Fraser & Tobin, 1991; Tobin & Fraser, 1998). Fraser (1999) incorporated a teacher-researcher perspective as well as the perspective of six university-based researchers in a multilevel study of learning environments. This interpretive study was conducted in a Grade 10 teacher's classroom at a school which provided a challenging learning environment because of many students were from working class backgrounds, some of whom had English as a second language and others of whom were experiencing problems at home. Several researchers visited the class each time it met for a period of five weeks. Student diaries, as well as interviews with the teacher-researcher, students, school administrators and parents, were used in conjunction with a video camera to record information for analysis at a later time. The researchers wrote notes during or soon after each classroom observation and they all met three times a week to discuss the progress of the study. This qualitative data were complemented with quantitative data obtained through a classroom environment questionnaire.

Quantitative methods seem to have dominated Asian research into learning environments. In some notable studies, qualitative methods, such as interviews of small groups of students, were used to check the suitability of a learning environment questionnaire and modifying it before using it in a large-scale study (Fraser, Aldridge, & Soerjaningsih, 2010; Khine, 2001; Margianti et al., 2001). Khoo and Fraser (2008) randomly selected 46 students for interviews to cross-check students' perceptions of their classroom environments in Singapore. A pilot study in Brunei was conducted in which students were interviewed concerning difficulties experienced in responding to classroom environment studies (Khine & Fisher, 2001, 2002).

A study in Singapore used interpretive and narrative methods to support the validity of a modified version of the CLES in English classes at the senior high school level. Both the qualitative and quantitative methods were used in conjunction with one another in investigating the extent to which the teaching of learning environment in English classes is consistent with critical constructivism (Wilks, 2000).

In a Korean study, a strong quantitative component involved in the administration of the SLEI, CLES and QTI to 439 students in 13 classes. Four of these classes were from the humanities stream, four from the science-oriented stream and five classes were from the science-independent stream (Fraser & Lee, 2009; S. S. U. Lee et al., 2003). Two or three students were selected from each class in the humanities stream and science-oriented stream to participate in face-to-face interviews. Because of practical constraints, interviews were conducted via e-mail with students in the science-oriented stream. The face-to-face interviews were audio-taped, transcribed into Korean and translated into English. The students verified the accuracy of the transcriptions from their interviews to ensure that their voices had been heard accurately. One class from each stream was also selected to be observed, which allowed the observer to record salient events occurring in the classroom. Also, photographs were taken and field notes were created and translated into English in order to transfer the images into English.

The interviews and observations supported the findings from using the learning environment surveys. Interviews with the students contributed to clarifying their replies to the questionnaire. Also, interviews with the teachers helped with drawing conclusions by providing information about the practical situation in classrooms and schools (S. S. U. Lee et al., 2003).

In an interpretive study of the nature of classroom environments in Taiwan and Australia, Aldridge, Fraser, and Huang (1999) used multiple research methods from different paradigms. To supplement quantitative data, qualitative data were obtained through classroom observations, interviews with students and teachers, and narrative stories written by the researchers. These narrative stories were used to portray archetypes of science classrooms in each country. Stories represented a way of knowing and thinking (Carter, 1993; Casey, 1995) with the use of the researcher's images, understandings, and interpretations of the learning environments. The stories, along with their interpretations and subsequent commentaries, provided a second layer or representation (Geelan, 1997). In investigating the learning environment in these two countries, researchers concentrated on three main themes: pressures experienced by teachers; respect for teachers; and questioning techniques.

2.2.4.6 Cross-National Studies

Obtaining data from multiple countries can offer insight into variation in variables of interest, such as teaching methods and student attitudes. Also, because normal practices in some countries might be considered strange in others, a cross-national study can make some of these practices more obvious (Fraser, 1997). The WIHIC and CLES were administered to 1879 students in 50 junior high school science classes in Taiwan and to 1081 students in 50 classes in Australia (Aldridge et al., 1999; Aldridge et al., 2000; She & Fisher, 2000). The English version of these questionnaires was translated into Chinese, and retranslated back into English by independent members of the study (Aldridge et al., 2000).

Interviews with students and teachers were conducted, as well as classroom observations, to gather qualitative data. Data from the questionnaires guided the researchers in determining which students and teachers to interview, as well as which classrooms to observe. This was done in an attempt to determine the reasons for differences between the countries in the means on the two questionnaires. The researchers also wanted to determine if the questions were interpreted consistently in the two countries. Differences in responses to the questionnaires between the countries arose because of cultural differences, which suggested the need for caution when interpreting differences in responses to classroom environment questionnaires in different countries (Aldridge et al., 1999; Aldridge et al., 2000).

In another study, the QTI was administered to 20 science classes from 10 schools in each of Australia and Singapore (Fisher et al., 1997). Because of differences in cultural backgrounds of the two countries, it was not surprising to find that, in Australia, students perceived their teachers as giving more responsibility and freedom to the students whereas, in Singapore, students perceived the teacher as being more strict (Fraser, 2002).

Fraser et al. (2010) used a modified version of the WIHIC in Australia and Indonesia simultaneously in a study aimed at cross-validating the modified version, investigating differences between countries and genders in perceptions of the classroom environment, and investigating associations between students' attitudes to science and their perceptions of classroom environment. 594 students from 18 classes in Indonesia and 567 students from 18 classes in Australia (a total sample of 1161 students) confirmed the validity of this version of the WIHIC through principal components factor analysis with varimax rotation. Some differences between countries and genders in students' perceptions of their classroom environment were found through a two-way MANOVA. Generally, positive associations between the classroom environment and student attitudes to science in both countries were also found through multiple regression and simple correlation analyses (Fraser, Aldridge, & Adolphe, 2010).

2.2.4.7 Teacher Education

Fraser (1993) reported some case studies of how classroom and school environment ideas have been used within preservice and inservice teacher education to (1) sensitize teachers to subtle but important aspects of classroom life, (2) show how assessment of classroom environment can be used to facilitate practical improvements in classrooms, (3) provide a valuable source of feedback about teaching performance for the formative and summative evaluation of student teaching and (4) illustrate the usefulness of including classroom environment assessments as part of a teacher's overall evaluation and monitoring activities. Information on student perceptions of the classroom learning environment during preservice teachers' field experience adds useful information to the data collected by university supervisors, school-based cooperating teachers and student teacher self-evaluation (Duschl & Waxman, 1991).

A study in Western Australia used both the preferred and actual forms of the COLES. The information obtained from this questionnaire, in addition to reflective journals, written feedback, forum discussions, and teacher interviews, were used in attempts at improving classroom environments. A pretest was given prior to beginning the research. Six weeks after implementing classroom strategies aimed at reducing actual-preferred discrepancies, the COLES was then administered again. The sample for this study consisted of 2043 Grade 11 and Grade 12 students from 147 classes in 9 schools. Data analysis verified the validity and reliability of the COLES when used with this sample. A circular profile was used as a means of providing each teacher with a comparison of mean actual and preferred responses for his/her class (Aldridge, Fraser, Bell, & Dorman, in press).

2.2.4.8 School Psychology

Traditionally, school psychologists tend to focus mostly, and sometimes solely, on their roles in assessing and enhancing academic achievement and other valued learning outcomes (Fraser, 1998a). School psychologists and teachers can become sensitized to subtle but important aspects of classroom life through using learning environment instruments. They can use discrepancies between students' perceptions of actual and preferred environments as a basis to guide improvement in classrooms (Burden & Fraser, 1993).

Evaluation has become a key component of the school counseling profession (Erford, House, & Martin, 2003; Sink, 2005). It has been suggested that, without a data-driven and results-based orientation, school counseling will not thrive (Adelman & Taylor, 2002; Bemak, 2000; Brigman & Campbell, 2003; Carey & Dimmitt, 2004; House & Hayes, 2002; Hughes & James, 2001; Isaacs, 2003; Myrick, 2003). Effective school counselor programs should lead to improved school and classroom climates which, in turn, are likely to promote improved student academic performance (Bemak, 2000; Brown, 1999; Hernández & Seem, 2004; Lapan, 2001; Littrell & Peterson, 2001; Sink, 2005; Sutton & Fall, 1995). However, there is concern over the lack of psychometrically-sound instruments that measure climate in elementary school counseling programs. Because of this, Sink and Spencer (2005) conducted a study in 20 K–6 elementary schools in urban Washington State to verify the validity and reliability of the My Class Inventory Short Form (MCI–SF) for use with students in this age range. The sample consisted of 882 Grade 4 students, 1023 Grade 5 students and 912 students from Grade 6 for predominantly lower-class to middle-class families in the USA.

2.2.4.9 Teachers' Attempts to Improve Classroom Environments

Feedback on students' and teachers' perceptions of the classroom has been used in a five-step procedure as a basis for reflection of, discussion of, and systematic attempts to improve classroom environments (Fraser & Fisher, 1986). This work has been conducted at numerous levels, including the early childhood level (Fisher, Fraser, & Bassett, 1995), primary level (Aldridge, Fraser, & Ntuli, 2009; Fraser & Deer, 1983), secondary level (Aldridge, Fraser & Sebela, 2004; Thorp, Burden, & Fraser, 1994; Woods & Fraser, 1996) and higher education level (Yarrow & Millwater, 1995; Yarrow, Millwater, & Fraser, 1997). First, the preferred form of a classroom environment instrument is responded to by all students, who respond to the actual form a week later. Second, teachers are provided with feedback in the form of class means for both forms of the instruments. Third, the teacher assesses similarities and differences in average scores on the two forms to permit in-depth reflection and discussion about the results to determine if any attempt should be made to change the classroom environment and, if so, in which areas. Fourth, the teacher incorporates any changes considered to be needed in the classroom for a period of approximately two months. Fifth, the actual form of the learning environment instrument is re-administered to see if the intervention has been successful in creating a classroom environment that is closer to the students' preferred environment (Fraser & Fisher, 1986).

This approach was used with the Classroom Interaction Patterns Questionnaire in an attempt to improve the classroom environment of 16 teachers. This instrument assesses students' perception of teacher beahaviours such as Praise and Encouragement, Open Questioning, Lecture and Direction, Individual Work, Discipline and Management, and Group Work. Half of the teachers who received feedback attempted changes in their classroom, whereas the other half only administered the questionnaires. Those teachers who received feedback and acted on it were able to reduce the discrepancies between the actual and preferred perceptions of the classroom environment for most dimensions (Woods & Fraser, 1995).

Yarrow et al. (1997) conducted a study that introduced the field of learning environment to 117 preservice education teachers through being involved in action research aimed at improving their university education classes and their 117 primary school classes during student teaching practice. The MCI was used at the primary level and the College and University Classroom Environment Inventory (CUCEI) at the university level. Improvements were noticed at both the primary and university levels. The preservice teachers valued the opportunity to participate in action research aimed at improving classroom environments as well as the opportunity for the topic of learning environment to be included in their preservice program (Fraser, 1998a).

In attempts to help South African teachers become more reflective in their daily mathematics classroom teaching, a study was conducted that combined both quantitative and qualitative research methods. The Constructivist Learning Environment Survey (CLES) was administered to the 1864 Grade 4 to Grade 9 students in 43 classes of 18 teachers in 6 schools to assess their perceptions of the emphasis on constructivism in the classroom environment. After the data were analyzed, the teachers utilized the feedback information obtained. The teachers maintained daily journals as a way of reflecting on their teaching practices. After 12 weeks, the CLES was re-administered to the sample to see if there had been any changes (Aldridge, Fraser et al., 2004). A sizeable improvement in teachers' emphasis on all CLES dimensions in their classrooms was found.

Sinclair and Fraser (2002) used both perceived and preferred forms of the Elementary and Middle School Inventory of Classroom Environments (ICE) to assess upper primary and middle school (Grades 6–8) students' views of their learning environment. The sample consisted of students in the 43 classes of 10 middle-grade teachers in an urban North Texas school setting. The ICE assessed Cooperation, Teacher Empathy, Involvement and Task Orientation.

A primary-school version of the What Is Happening In this Class? (WIHIC–Primary) was used in a distance-education program to determine students' preferred and actual views of their learning environments. 31 teachers administered the WIHIC–Primary to their 1077 learners. Feedback from this questionnaire was used to modify teaching strategies during a 12-week intervention period. This was the first learning environment study conducted at the primary-school level in South Africa. Also, this study cross-validated an IsiZulu version of the WIHIC when used for the first time in South Africa. Overall, this study supported the success of teachers' use of a learning environment questionnaire in guiding improvements in their teaching (Aldridge et al., 2009).

2.2.4.10 Transition from Primary to High School

An investigation of the effects of transitioning from primary to high school in the USA has revealed a deterioration in the classroom environment when the students moved from generally smaller primary schools to larger, departmentally-organized lower secondary schools. This could be a result of less positive student relations with teachers and reduced student opportunities for decision making in the classroom (Midgley, Eccles, & Feldlaufer, 1991).

Another study, involving a sample of 1040 students from 47 feeder primary schools and 16 linked high schools in Australia, indicated that students perceived their high school classroom environments less favorably than their primary school classroom environments on some (but not all) dimensions of the QTI and MCI. It was also noted that this transition experience was different for boys and girls and for different school size pathways (Ferguson & Fraser, 1999).

2.3 Student Attitudes

Another focus of this study was changes in students' attitudes towards their science classes as criteria when evaluating the effectiveness of using SRS. Because of this, a review of literature on attitudes is provided below.

The term 'attitude' is described as a variety of ideas, such as an opinion or feeling about something, physical posturing, or assertiveness (*American Heritage® Dictionary of the English Language*, 2000). Baron and Byrne (1977) describe attitudes as individually attributed beliefs emotions and behavioral tendencies that someone has towards specific abstract or concrete objects. Attitudes are one of the main determinants of behavior (Tavsancil, 2006). Krech and Crutchfield (1980) explain that understanding attitudes allows knowledge of several related behaviors. Emotions, which are expressed through attitudes, affect what is being learnt. These emotions have a significant impact on learning (Caine & Caine, 1994; Lackney, 1998). Stodolsky, Salk and Blaessner (1991) explain that, even if information is forgotten, attitudes towards a subject often remain. Allport (1956) reports that the first study of attitudes was conducted by Thurstone (1929).

An attitude can be used to describe one's feeling about a wide range of situations. In my study, students' attitudes towards their science classes were researched. These attitudes in science can encompass students' enjoyment of a science class, enjoyment in manipulating equipment (such as in a laboratory setting), enjoyment of their pursuit of knowledge, and interest in pursuing a career in science (Wolf & Fraser, 2008). Students' attitudes towards their middle-school science classes can have a major impact on their choice of science courses in high school and college (Misiti, Shrigley, & Hanson, 1991).

Because, as previously noted, the term 'attitude' can take on many meanings, Klopfer (1971) classified various objectives in science. Klopfer (1976) categorized six distinct categories of conceptually-different attitudinal aims: Manifestation of favorable attitudes toward science and scientist, Acceptance of scientific enquiry as a way of thought, Adoption of scientific attitudes, Enjoyment of science learning experiences, Development of interest in science and science related activities, and Development of interest in pursuing a career in science (Klopfer, 1976). My study involved assessing attitudes that are primarily linked to Klopfer's categories of manifestation, adoption, and enjoyment.

2.3.1 Assessment of Student Attitudes

Perrodin (1966) was one researcher who assessed student attitudes. In his study, he assessed the attitudes of over 500 fourth, sixth, and eighth graders in the United States of America through the use of open-ended statements, which allowed students to input their own feedback. After his data were collected, he summarized the responses to obtain his conclusion. This qualitative method required a great amount of time to collect, transcribe, and analyze data.

To assess emotional and intellectual attitudes towards science among secondary school students, Moore and Sutman (1970) developed a quantitative instrument, the Scientific Attitude Inventory (SAI), which contains 60 items that range from the knowledge of laws and theories of science to feelings about being a scientist. After examining 30 studies that used the SAI, Munby (1983) questioned its validity. It was conceptualized by Baker (1985) that the SAI possessed two scales, positive and negative. Because of this, he calculated the total attitude score as the positive scale minus the negative scale. Other studies did not report such separations of scales or calculations (Munby, 1982). The SAI was revised by Moore and Foy (1997), who did not discuss any solutions to these difficulties, which leads to the continuation of doubts as to its reliability (Munby, 1997).

Because Fraser (1978b) noted three potential problems with several instruments used to assess attitudes towards science (low statistical reliability, a lack of economy of items, and the combination of distinct attitude concepts into a single scale which creates a mixture of variables), he developed the Test of Science Related Attitudes (TOSRA). The TOSRA builds on an earlier group of five attitude scales. These scales were extended and improved in four ways and two new scales were also added to create the final version of the TOSRA with seven scales consisting of ten items each (Fraser, 1981). Because I assessed student attitudes in my study using one scale from TOSRA, Section 2.3.2 and Section 3.3.3 provide more information about the development and use of TOSRA.

2.3.2 Test of Science Related Attitudes (TOSRA)

The instrument that was used to obtain quantitative data in this study also included a scale from the Test of Science Related Attitudes (TOSRA). Because of this, literature is reviewed below concerning how the TOSRA was created, how it was validated, and past studies that used it. It is also important to know the limitations of this instrument, which also are considered below.

2.3.2.1 Background to TOSRA

The Test of Science Related Attitudes (TOSRA) builds on an earlier battery of attitude scales that were contained in earlier versions of the following TOSRA scales: Social Implications of Science, Attitude to Scientific Inquiry, Adoption of Scientific Attitudes, Enjoyment of Science Lessons and Leisure Interest in Science. The development and validation of each of these five scales has been discussed at length prior to the new version of the TOSRA (Fraser, 1977c). Based on reactions from science teachers and experts in educational measurement about each previous item's clarity, readability, face validity and scale allocation, a new version of each scale was assembled. After the first version was tested on 165 Year 7 students in Melbourne, Australia, a second version was created based on evidence and results from data obtained from field testing of that first version. A sample of 1158 Year 7 students in Melbourne, Australia field tested the revised version of the TOSRA items, which showed satisfactorily high reliability (Fraser, 1981).

The first five attitude scales were extended and improved in four ways to create the TOSRA. Two new scales, Normality of Scientists and Career Interest in Science were added. The original battery of questions involved three sets of instructions and answering formats, whereas the new version had one consistent and uniform set of directions and answering format throughout. Also, unlike the first set of scales which had various numbers of items, the improved version was consistent with 10 items per scale, which facilitates ready comparison between performance on different scales. The final version of the TOSRA was obtained after modifying a pool of items based on reactions solicited from a group of science teachers and experts in educational measurement. Also, to finalize the TOSRA, a version containing 14 items per scale and the subsequent use of the item analysis techniques described by Fraser (1977a) reduced the number of items per scale to 10. The final version of the TOSRA was field tested with 1337 students from all four junior high school grade levels (Years 7–10) unlike the prior scales that were field tested with only Year 7 students (Fraser, 1981).

A noteworthy characteristic of the TOSRA is that it encompasses the categories delineated in Klopfer's (1976) classification that was discussed in Section 2.3. Fraser (1978a) believes that Klopfer's manifestation of favorable attitudes towards science and scientists is actually two subcategories with similar attitudes. Because of this, Fraser created two different scales for this classification, each addressing a subcategory. The Social Implications of Science was created because of its importance in measuring attitude towards the social benefits and problems that are associated with progress in science (Fraser, 1977a; Zoller & Watson, 1974). Because students tend to perceive scientists as eccentric and different from others, the Normality of Scientists scale was created (Fraser, 1977b; Mead & Metraux, 1957). The other scales of the TOSRA and their classification according to Klopfer's scale can be seen on Table 2.2.

Table 2.2 TOSRA Scales and their Classification According to Klopfer's Scheme

TOSRA Scale	Klopfer Classification
Social Implications of Science Normality of Scientists	Manifestation of favorable attitudes towards science and scientists
Attitude to Science Inquiry	Acceptance of scientific enquiry as a way of thought
Adoption of Scientific Attitudes	Adoption of scientific attitudes
Enjoyment of Science Lessons	Enjoyment of science learning experiences
Leisure Interest in Science	Development of interest in science and science related activities
Career Interest in Science	Development of interest in pursuing a career in science

2.3.2.2 Validity of TOSRA

The TOSRA was field tested with a total sample of 1337 students in 44 classes from 11 different schools (Fraser, 1981). Each of the 11 schools provided information for one class in each year of junior high school, Years 7, 8, 9 and 10. The sample size was 340 for Year 7 students, 335 for Year 8 students, 338 for Year 9 students and 324 for Year 10 students (Fraser, 1981). The total sample contained nearly the same number of boys and girls. Drawing only one class at each grade level from each school achieved the broadest spectrum of schools possible with the given sample size. Obtaining data from each grade level in each of the 11 participating schools permitted investigation of how students' attitudes towards science change during their junior high school years within a given school. The schools were carefully selected to cover a wide spectrum of socioeconomic and geographic areas and to be representative of the population of schools in the Sydney, Australia metropolitan area. Of these 11 schools, five were coeducational government high schools, two were single-sex government high schools (one boys and one girls), two independent Catholic schools (one boys and one girls) and two independent non-Catholic schools (one boys and one girls) (Fraser, 1981).

Since the initial validation of the TOSRA, numerous studies have taken place which confirmed its validity and reliability:

- First, a study of 712 Year 7–9 students in Sydney, Australia from 23 different classes, each with a different teacher, in eight different schools was conducted (Fraser & Butts, 1982).

- In four comprehensive state high schools in Brisbane, Australia, two samples of students were studied. One sample consisted of 567 Year 10 students and the other consisted of 273 Year 12 students (Lucas & Tulip, 1980).

- 1041 Year 8–10 students from 11 schools in the suburban areas of Perth, Western Australia were studied (Schibeci & McGaw, 1980).

- In Philadelphia, Pennsylvania in the United States, 546 Year 9 girls in two urban Catholic schools were studied (Fraser & Butts, 1982).

- In Singapore, 1592 final-year secondary school chemistry students from 56 classes in 28 randomly-selected coeducational government schools responded to TOSRA (Wong & Fraser, 1996).

- 1161 students (594 students from 18 classes in Indonesia and 567 students from 18 classes in Australia) in private coeducational schools (Fraser, Aldridge, & Adolphe, 2010).

All of the cross-validation data obtained through these studies compare favorably with the validation data reported previously. These data are not only important because they confirm the validity of the TOSRA for use with Australian students, but they also support the cross-cultural validity of the TOSRA for use in the United States (Fraser, 1981).

2.3.2.3 Shortcomings of TOSRA and Future Research

In order for the TOSRA to be more widely useful, further work needs to be undertaken. It would be desirable for TOSRA to be translated into numerous other languages and cross-validated. Differences in classrooms and cultures make it hard to determine what is valued when investigating student attitudes. For example, what is valued in one culture might not be valued in other countries.

Readability is another problem with questionnaires. With translations, some of the intended meaning can be lost. If students cannot accurately read and understand a questionnaire, then they cannot accurately answer the items. To prevent inaccurate results, the questionnaire must be written in a way that is interpreted in a consistent manner by all of the members of the sample.

Students might not respond to a questionnaire in an honest manner if they feel that their response could have an impact on their grades. They might chose to reflect opinions which are more positive or negative than they really are. Because of this, like most attitudes questionnaires, the TOSRA is not very useful for contributing towards students' grades (Fraser, 1981).

To eliminate or minimize the limitations of the TOSRA, more research must be conducted. The questionnaire should be translated into more languages and cross-validated in order to enable it to be widely used in classrooms around the world. Some of this research should include determining the effectiveness of the TOSRA in measuring student attitudes in countries with clearly unique and different school values.

To prevent students from answering inaccurately, it is important that the person administering the questionnaire follows the written directions and is sure to place strong emphasis on the fact that students' responses will have no impact on their grades.

2.4 Gender Differences in Science Education

My study investigated the differential effectiveness for males and females in terms of attitude, achievement, and perceptions of their learning environment when SRS are used. Therefore the section below provides a literature review on the topic of gender differences in science education.

According to the National Research Council, all students in the USA are entitled to equal opportunities to become scientifically literate, irrespective of their gender or racial background (NRC, 1997). Students' perceptions of science can begin to develop before the age of nine years old (Joyce & Farenga, 1999). Typically, there are few differences between males and females in their attitudes towards science in their elementary-school years (Alexakos & Antoine, 2003), but these differences are likely to become more apparent during the middle-school years (NCES, 2000).

2.4.1 Past Studies of Gender Differences in Science Education

Students of all ages engage in scientific practices outside the classroom, often without realizing it. Farenaga and Joyce (1997a) administered a modified version of the Science Experiences Survey (SES), originally developed by Mason and Kahle (1989), to assess students' participation in science at home. This modified version of the SES includes questions relating to life-, physical-, and general-science activities and materials. 427 students in Grades 4 to 6 (ages 9 to 13 years) responded to this survey. Males participated in a statistically significant greater number of science activities than females of the same age, especially physical science activities. No significant difference was found between males and females in terms of participation in life science activities. Males were found to be more likely to build models, seek action-oriented activities, and fix objects (Farenga & Joyce, 1997b), as well as to listen to science news and read science-oriented magazines and books. Outside of the classroom, females tended to focus on life science activities such as nurturing and caring for plants and animals. Females were also more likely to collect and catalogue shells and leaves, another life-science activity. This study shows that, at an early age, males and females both naturally undertake science-related activities.

Throughout secondary school, gender gaps in achievement increase (NCES, 2000). When achievement gaps were examined across gender and racial groups with graduating students, gaps increased between males and females as well as between white and black students. These gaps began in Grade 8 (Bacharach, Baumeister, & Furr, 2003). This study also showed that the average early increase in academic achievement was greater for males than females. Also, females' attitudes towards science were reported to become increasingly negative by Grade 10 (Alexakos & Antoine, 2003). Oakes (1990) suggests that this difference in attitudes could be attributed to a decrease in encouragement from teachers for females to succeed in the sciences. Another study also suggests that females create self-imposed limitations on career choices in the sciences because of their less favorable attitudes (Lindstrom & Tracy, 2003).

Colleges often use the Scholastic Aptitude Test (SAT) as part of their criteria for student admission. The SAT often shows achievement gaps between males and females. Wolfe and Rossner (1990) state that the SAT shows lower academic achievement for females, even though females outperform males in their classes. These low scores on the SAT might discourage female students from attempting to gain admission into more prestigious colleges. It has also been suggested by Wolfe and Rossner that males' willingness to make educated guesses could explain their higher SAT scores when compared with females who are less likely to take chances. When asked questions about physical science content and predominantly masculine activities, such as contact sports, females are more likely to select the option of 'I don't know' rather than to take a chance. After the 'I don't know' option was removed, Wolfe and Rossner noticed that the gender gap shifted and slightly favored females over males. This shows that, because of differences in learning and testing styles, achievement methods must be changed.

"By utilizing inquiry methods, females and males are provided the opportunities to explore and support their own ideas, within the constraints of the curriculum" (Wolf, 2006 p. 61). In inquiry situations, females benefit from the males' confidence, while males benefit from the females' though processes (S. E. Lee, 2003). The Survey of Laboratory Practices (SLAP) was used in a study with a sample of middle-school students to determine differences in students' views of their learning environment and attitudes between inquiry and non-inquiry classes (Wolf & Fraser, 2008). One aim of this study was to determine if inquiry-based lessons were differentially effective for males and females. Through the use of a two-way MANOVA, Wolf found significant gender-by-instruction interactions. Task Orientation, Cooperation, Equity and Attitudes scores for males were lower for the non-inquiry group than for the inquiry group. However, females in the non-inquiry group had higher Equity and Attitudes scores and similar Task Orientation and Cooperation scores when compared with females in the inquiry group. These findings suggest that inquiry-based lessons can be differentially effective for males and females. Overall, males perceived more favorable learning environments and held more positive attitudes in inquiry classrooms, while females had more positive perceptions of these same two areas in non-inquiry classrooms.

2.4.2 Addressing Gender Differences

According to the National Research Council (1997), teachers have a responsibility to maintain a gender-fair environment which allows equal access to education for both males and females. Because of this, preservice teachers are often required to take courses that address these issues. It is also important for current teachers to notice gender inequities in their classes so that they can be adequately addressed.

Fifteen common college psychology textbooks were analyzed to identify biases that can affect preservice teachers during their training (Yanowitz & Weathers, 2004). It was found that males and females engaging in science activities showed no significant differences in expressions of feminine traits or in positive masculine/feminine traits. Males were more often referred to in stereotypical masculine activities than females. Although females were not often associated with negative masculine traits, such as aggression, males were often referred to as possessing these traits. Through the lack of female stereotypes, it is evident that some work needs to be undertaken to address gender issues in collegiate textbooks. But, because gender bias still exists, this work is not yet complete.

Sanders (2003) conducted a study with a sample of 353 teacher-education methods instructors in mathematics, science and technology. It was found that these educators believed it important to consider gender issues in their instruction, but felt that there was little time to incorporate them into their teaching. This is supported in that most respondents reported that, on average, they spend less than two hours per semester addressing the issue of gender equity. Of the time that is spent during their instruction in addressing gender issues, often the focus is biased interaction rather than teaching methods for creating more gender equity in the classroom.

To promote a gender-fair environment, teachers must be provided with strategies to address this. Five methods for teachers to utilize have been suggested by S. E. Lee (2003). First, there must be a continuous evaluation of the classroom dynamics. For example, it is important to be sure that there is sufficient wait time (i.e. how long a teacher waits for students to answer questions) for both genders and to accommodate the different communication styles of males and females. Regardless of the quality of their answers, usually males are more confident, quick, and aggressive in their participation (Hall, 1982). Because they tend to reflect upon their answers before they are given, females typically take more time to respond and to choose their words more carefully. Females are less likely than males to respond frivolously (Hall, 1982; Wolfe & Rossner, 1990). It is often useful for a teacher to keep a tally of responses by males and females to be sure that there is equity in the classroom (S. E. Lee, 2003). If both teacher and students are conscious about not directing negative attention to a student who gives a wrong answer, then it can help in promoting more participation by all students in the class. Brewer and Daane (2002) explain that this is key to promoting a risk-free classroom environment. The participation of students in class discussions is vital in promoting a positive learning environment. The Involvement scale of the WIHIC can be used to assess this.

Another method to promote greater gender equity in the classroom is to personalize the classroom structure to create a feeling of community among the students (S. E. Lee, 2003). To accomplish this, special attention is given to spacing out males and females evenly throughout the room to allow students to discuss their answers with peers before they present them to the class. The teacher should be sure to move the students around the room during the school year so that they interact with many different students, which allows students a greater exposure to different alternatives to questions posed by the instructor. This sharing of ideas can help to create a more supportive environment in the classroom, which could be measured through use of the Student Cohesiveness scale of the WIHIC.

Lee (2003) suggests that establishing a cooperative learning environment is a key aspect of promoting a gender-fair classroom. Students should be placed in groups and work together to arrive at a common solution to problems. These study groups teach the students to work with each other, support one another, and work more collectively. Pairing males and females together can benefit both genders. Females can learn to be more confident and willing to participate publicly in class, while males can learn to think through their responses in more depth. To assess how effective a teacher is in addressing this method of promoting gender-equity in the classroom, the Cooperation scale of the WIHIC can be used.

The fourth method for promoting gender equity in the classroom is to provide diverse role models for the students (S. E. Lee, 2003). Noticing that most well-known scientists are males, female students conclude that females are minorities in the scientific community. It would be useful to concentrate on female and minority scientists during the course of the curriculum. It is important to concentrate on the human characteristics instead of gender or race when discussing scientists (Plucker, 1994). Scientists are often different from non-scientists. For example, Albert Einstein is often viewed as a genius with wild frizzy hair and a thick moustache (Fraser, 1977b; Mead & Metraux, 1957; Plucker, 1994). Promoting the normality behind these well-known scientists can help students to feel a greater possibility of success. Female science teachers also naturally promote the idea to students that females can also be successful in science. This realization that students themselves can become scientists can increase their interest in science, their motivation, and their feelings about the importance of science, which all could be assessed through the use of the Task Orientation scale of the WIHIC.

It is also useful for teachers to make themselves readily available to the students (S. E. Lee, 2003). This can be achieved through the willingness of the teacher to meet with students before school, after school, or during lunch, or simply leaving the door to their classroom open can help the students to feel more invited. This availability of the teacher to the students outside of the classroom can help students to feel a more personal connection with their teacher, and this can lead to increased student motivation and provide a more comfortable environment in which these students can seek help. These meetings with the teacher, whether they be one-on-one or in small groups, can help the student to gain confidence as well. The Teacher Support and Equity scales of the WIHIC could help the teacher to assess the effectiveness of their teacher-student interactions.

Plucker (1994) built on Lee's methods by adding that an increased exposure to hands-on visual-spatial problem-solving can help females to develop confidence when confronted with such problems. This can also be achieved by providing an environment in which the males who excel in these areas can work with and help female students to develop these skills. Also, a greater exposure to higher cognitive thinking at earlier ages can help female students to build more confidence in science, which is likely to remain with them through later years (Alexakos & Antoine, 2003). To assess how effective the teacher is in this area, the Investigation scale of the WIHIC could be used.

It often benefits both male and female students to connect science content to real-life experiences (Plucker, 1994) because learning usually is best achieved by building upon students' previous knowledge and experiences (Hess & Trexler, 2005; Jensen, 1998; Windschitl, 2002). To accomplish this, teachers must obtain information from students about their personal interests and life experiences in order to build a connection between these interests and experiences and the science curriculum. It is also useful to expose students to a wide overarching concept and subsequently zoom into smaller more abstract concepts (Green & Gredler, 2002). Females can gain confidence in science if they are able to build the connections between small ideas and larger whole concept (Rop, 1997).

2.5 Student Response Systems

Because my study involved the effectiveness of Student Response Systems (SRS) in terms of learning environment, attitudes, and achievement, a detailed review of SRS is needed. It is important to first understand what SRS are (Section 2.5.1), where/how they are currently used (Section 2.5.2), and why teachers might use this technology (Section 2.5.3). A review of past studies involving the use of SRS (Section 2.5.4) is likely to help to connect the findings of my study to what is already known on the effects of SRS. As with all technology and teaching methods, not only are there positive outcomes, but there are negative consequences as well. Section 2.5.5 details specific problems associated with SRS, which lead to recommendations for future research (Section 2.5.6).

2.5.1 What are Student Response Systems?

Student Response Systems (SRS), also commonly referred to as Personal Response Systems (PRS) and other various names, provide communication between individual students and the teacher. These systems consist of numerous parts. Each student has a transmitters, often called a 'clicker', which resembles a small television remote control (Draper & Brown, 2004). When the students respond to a question, they aim their transmitter at a sensor, which is connected to a computer. Running on this computer is a program that tabulates the results, which are then projected onto a screen for all to see.

Questions can be presented to the class orally, projected onto a screen, or provided on sheets of paper. When the students respond, their answers are anonymous. However, the instructor has the option of copying students' identification numbers from their transmitters so that he/she can see students' individual results. When the responses are projected for the class to view, none of the students know how each other responded.

2.5.2 Who Uses Student Response Systems?

Many institutions, predominantly at the higher education level, have invested in Student Response Systems. These institutions include community colleges, liberal arts colleges and large research universities, such as MIT, University of Massachusetts-Amherst, Harvard, Yale, Brown, University of Virginia, Vanderbilt, and Duke. Most of these universities have implemented the response systems in their large biology and physics lecture courses (West, 2005).

Christopher Fisher, a graduate teaching assistant to Biology lecturer Ann Auleb of San Francisco State University, states that over 40 instructors are using student response systems at his university (Gilbert, 2005).

One of the largest clicker companies, eInstruction, says that more than 700 universities are now using their devices. Its Ohio competitor, Turning Technologies, has sold its product to more than 250 universities as well (Gilbert, 2005).

2.5.3 Why Use Student Response Systems?

Douglas Duncan, a professor of Astrophysical and Planetary Sciences at the University of Colorado and Director of Fiske Planetarium, lists in his book *Clickers in the Classroom: How to Enhance Science Teaching Using Classroom Response Systems* what the wise use of clickers enable a teacher to do (Duncan, 2005):

- Measure what students know before you start to teach them (pre-assessment)
- Measure student attitudes
- Find out if the students have done the reading
- Get students to confront common misconceptions
- Transform the way of doing any demonstrations
- Increase students' retention of what you teach
- Test students' understanding
- Make some kinds of grading and assessment easier
- Facilitate testing of conceptual understanding
- Facilitate discussion and peer instruction
- Increase class attendance.

He expands this list during his PowerPoint presentation as keynote speaker at the Inaugural Conference on Classroom Response Systems (Duncan, 2008). Duncan adds that the use of clickers can improve student attitudes and can get honest answers to 'touchy questions' such as those that involve race, gender, or politics.

Student response systems allow instant feedback to the students as well as to the teacher, which is a benefit found in previous studies (Julian, 1995; Skiba, 2006; Steinert & Snell, 1999). Ohio State professor, Neal H. Hooker, who uses these response systems, states: "This is the MTV era… It's the instant-gratification generation. They don't like doing a quiz and hearing the responses in three days. They want to see if they've got it right or wrong right then." Christina Grimsley, a 16-year-old junior at Coeur d'Alene High School in Idaho, first used clickers in her third-year Spanish class. She supports Hooker's statement with her own: "You don't have to wait for someone to sit down and grade them [class assignments] by hand. Right away you're able to get your answers back" (Associated Press, 2005).

This instant feedback can immediately alert teachers about which students need help and if the class is accurately grasping the information being presented.

Through using the personal response systems, anonymous answers can be provided, which helps to ensure more class participation, even from the shy students. It also prevents the class from being dominated by the more vocal students. Through the responses being anonymous, the instructor can also obtain more honest answers to personal questions (Associated Press, 2005; Duncan, 2008; Johnson, 2004; Martyn, 2007). Numerous other researchers have found that the anonymity of responses is beneficial (Homme, Asay, & Morgenstern, 2004; Skiba, 2006; Steinert & Snell, 1999; Wieman & Perkins, 2005; Wood, 2004).

Two professors, from the departments of Psychology and Computing Sciences at the University of Glasgow, UK, listed some benefits of using handsets to vote in lectures (Draper & Brown, 2004):

- Using the handsets is fun and breaks up the lecture.
- Makes lectures more interactive/interesting and involves the whole class.
- The student likes contributing his/her opinion to the lecture and it lets him/her see what others think about it too.
- The anonymity allows students to answer without embarrassing themselves.
- Gives the student an idea of how he/she is doing in relation to the rest of the class.
- Checks whether you understand it as well as you think you do.
- Allows problem areas to be identified
- Lecturers can change what they do depending on what students are finding difficult.
- Gives a measure of how well the lecturer is putting the ideas across.

Other benefits include saving paper that is normally used in quizzes, saving time while grading, preventing grading errors, and actively engaging students during the whole class period (Associated Press, 2005; Martyn, 2007).

2.5.4 Past Research on Effectiveness of Student Response Systems

Technology similar to SRS was used in the 1960s and 1970s and consisted of hardwired systems that were typically made in-house. These systems were more cumbersome than the modern technology. Even though students had positive attitudes towards using these devices, research provided no evidence of a measureable gain relative to regular classroom instruction (Judson & Sawada, 2002). Casanova (1971) states that it is possible that the positive attitudes of students led to decreased attrition, which led to lower overall scores compared to the control group. These early devices were typically used as quizzing devices to provide answers to questions to the instructor, with very little class discussion about the results. Littauer (1972) reports that these devices 'accidentally' fostered student collaboration.

Most research on the effectiveness of SRS has been at the college level. It has been noted that, in many classrooms in which Student Response Systems are used, more class discussion takes place. Often, teachers allow students to discuss the answers to questions when there is a diversity of answers obtained through use of the clickers. Peer instruction can raise interest and enjoyment in science (Duncan, 2005). These discussions usually move the group towards the correct answer and student understanding increases. Not only do students understand the information better, but their retention can increase as well (Duncan, 2006; Mazur, 1997). Kathy Keairns, a senior instructional design coordinator at the University of Denver, adds that typically there is more active participation and cooperative learning when SRS are used. She supports this argument when she mentions a political science professor who used SRS and observed an improvement in the quality of discussions (Guess, 2008). In a study undertaken at the University of Wisconsin, most students responded with 'agree' and 'strongly agree' when asked if clickers (1) led them to be more engaged in class and (2) increased the frequency of their participation in the course (Joosten & Kaleta, 2006).

In courses in which clickers are used to take attendance, a marked increase in attendance has been reported (Draper & Brown, 2004). In a study undertaken in a Statistics for Psychologists course at the University of Glasgow, specific class meetings were chosen. In these class meetings, attendance rates prior to the use of the clicker system were around 32% and, after implementing SRS, they increased to around 57% (Wit, 2003). Kathy Keairns reported that her university experienced an increase in attendance in the courses that implemented the clicker system (Guess, 2008). Also, Burnstein and Lederman (2001), Duncan (2008), and Homme, Asay, and Morgenstern (2004) have all reported this increase in class attendance in their research.

Improvements have also been noted in examination scores. At Ohio State University, recent studies have reported that final examination scores were about 10% higher for classes in which SRS were used when compared with classes in which this technology was not used (Guess, 2008). Mazur (1997) found that there were large pre-post gains in students' knowledge in physics classes when SRS were used relative to students who did not use SRS. In one of the most comprehensive studies of SRS, it was found that the pass rate for students who used SRS was approximately 50% greater than for students who did not use these systems. Also, the standard deviation for the SRS groups was substantially lower than the non-SRS groups, suggesting a more consistent understanding among students who used SRS (Poulis, Massen, Robens, & Dilbert, 1998). Martyn (2007) also suggests that mean scores were consistently higher for students who used clickers.

Students' attitudes towards their classes in which SRS were used also improved (Duncan, 2008; Martyn, 2007). In a general science chemistry class, 90% of the students responded with 'useful' or 'very useful' when asked how they rated the use of clickers in the class (Guess, 2008). Most students also responded with 'agree' or 'strongly agree' when asked to respond to a statement about whether they thought that the use of SRS was associated with class interest and enjoyment (Duncan, 2008). Most students responded with 'agree' or 'strongly agree' when answering about whether they were happy with using clickers. The same was seen when students were asked if they would take another course that involved SRS (Joosten & Kaleta, 2006). Students viewed using the SRS as 'fun' (Roberts, 2005; Siau, Sheng, & Nah, 2006). Numerous other studies support the effectiveness of using SRS in terms of student attitudes (Burnstein & Lederman, 2001; Crouch & Mazur, 2001; Judson & Sawada, 2002; Poulis et al., 1998).

When asked if clickers enhance student learning, Kathy Keairns responded: "It depends." She also stated that the effectiveness of SRS depend on how they are used. They must be used properly in conjunction with well-thought-out questions and class discussions (Guess, 2008). In a Journalism 1 course, students had the least favorable attitudes towards the use of clickers. It was noted that, in this class, the professor was relatively new to using clickers and primarily used them to take attendance. Discussion was neither used nor encouraged, with an average of 1–3 clicker questions per class. Often, guest speakers who work 'in the field' were invited into the class; on these days, clickers were not used at all (Duncan, 2008). In a course about stars and planets, students had positive attitudes towards the use of clickers. In this class, the lecture focused on assigned reading. The SRS punctuated every lecture. Various types of questions were used with the clickers to facilitate student discussions in addition to promoting critical thinking (Duncan, 2008).

SRS have been found to increase student collaboration (C. Brewer, 2004; Burnstein & Lederman, 2001; Robertson, 2000; Wieman & Perkins, 2005; Wood, 2004), attentiveness (Burnstein & Lederman, 2001; Carnevale, 2005; Roberts, 2005; Steinert & Snell, 1999), participation (Wampler, 2006), interactivity (Homme et al., 2004), and cooperation (Skiba, 2006). Skiba (2006) reported that the use of SRS encouraged active learning and student-teacher interaction. SRS can enhance communication in the classroom, help students to become invested in their learning, and place more accountability on the students (Wieman & Perkins, 2005). SRS are beneficial when used for formative assessment (Burnstein & Lederman, 2001; Carnevale, 2005; Duncan, 2006; Hatch, Jensen, & Moore, 2005; Homme et al., 2004; Lightstone, 2006; Roberts, 2005; Wieman & Perkins, 2005; Wood, 2004) and can lead to increased student engagement (Julian, 1995; Lightstone, 2006; Wood, 2004).

How clickers are used in the classroom, as well as the teacher's methods of incorporating them into the classroom, seem to affect student responses most when questioned about how they feel about the use of SRS (Duncan, 2008). Examples of positive comments made in Duncan's (2008) study were:

> I like clicker questions because it helps me understand key concepts and it makes me read the chapters in the book. I think clickers are critical to learning more information about the topic being taught. (slide 38)

> A lot of people hate [clickers] because they say it is the only reason that they go [to class,] but that is bullshit. They just want to skip [class] without losing 'points'. I like the interaction and using clickers helps me know what I need to study more. Most kids who don't like them, I feel, don't have too many 'solid' reasons. (slide 40)

In a study by Gilbert (2005), a student from San Francisco made the following negative comment about the use of SRS:

> Personally, I felt kind of like it was a waste of money because they didn't work most of the time… I felt like I didn't even use them. I kind of gave up on them. (p. 2)

Some neutral comments made by students in Duncan's (2008) study were:

> It's not that I like [clickers], as a matter of fact, I hate them: but I think that they're really useful. (slide 38)

> In this class, no, they do not help us learn class material. It feels like she [the professor] uses them just for attendance purposes and then doesn't really fully go over them. It's mostly just a waste of time… My physics professor used them very well… let us discuss them with our classmates, and then went over the right answer, thoroughly explained [the clicker question], and then told us why the other options were wrong. That really helped. (slide 39).

2.5.5 Problems with Student Response Systems

Even with all of the benefits of Student Response Systems, it is important to understand that there can be many problems as well. Knowing about these problems and preparing for them can help to eliminate or reduce them. When students are first introduced to the clicker systems, they might not welcome the idea that they can no longer go through a class without paying attention or answering any questions, and that the answers that they give will be recorded (Duncan, 2005). Duncan (2005, p. 3) explains that "it is essential that you discuss with them the benefits clickers bring; otherwise they may concentrate on the disadvantages and be unhappy".

Some instructors use the clicker devices as a way to take attendance. However, some students give their clickers to other students in their class to log them in, therefore avoiding being marked absent (Gilbert, 2005).

Draper and Brown (2004) state that, because many teachers are pressed for time and often do not finish what they would like to in a given class, the introduction of new technology could take up even more time. This concerns many teachers when beginning to use the clickers. They would need to learn how to most effectively incorporate the use of clickers to prevent this problem. Draper and Brown continue to list some problems with using the handsets in lectures:

- Setting up and use of handsets takes up too much time in lectures.
- Clickers can distract students from the learning point entirely.
- Sometimes it is not clear what students are supposed to be voting for.
- The main focus of lecture seems to be on handset use and not on course content.
- The questions sometimes seem to be for the benefit of the lecturer and future students rather than the current students.
- Some annoying students persist in pressing their buttons and cause problems for people trying to make an initial vote.
- Not completely anonymous in some situations.
- Some students could vote randomly and mislead the lecturer.
- Sometimes the lecturer seems to be asking questions just for the sake of it.

The findings of many other studies agree with these ideas of Draper and Brown. Duncan (2006) suggests that the use of SRS can lead to covering less material in the course, because using SRS slows the rate of the class and takes away lecture time (Burnstein & Lederman, 2001; Lightstone, 2006). Instructors also have claimed that they do not like the limited question format when using SRS (Steinert & Snell, 1999; Wampler, 2006). Other problems with SRS emerging from past studies include technical problems (Duncan, 2006; Hatch et al., 2005; Robertson, 2000), instructor discomfort and lack of preparation (Duncan, 2006).

2.5.6 Response Systems in the Future

Much research is still needed on Student Response Systems. The majority of past studies have reported improvements in learning environments and student outcomes. Even with this information, it is important to see if these changes are attributable to the clickers themselves or a change in teaching pedagogy (Judson & Sawada, 2002; Martyn, 2007; West, 2005). Research also is needed into changes in student attitudes as a result of using the Student Response Systems.

Another problem has arisen because numerous companies manufacture Student Response Systems. The systems from one company are often not compatible with those of another company. Some companies are researching a way to eliminate this problem by making their products compatible with more common devices that most students already own, such as cell telephones and laptop computers (Gilbert, 2005).

2.6 Summary

As evident in this chapter, there has been extensive and varied research conducted in the fields of learning environments and student attitudes. As these fields continue to grow, the instruments used to measure learning environments and attitudes continue to be modified and multiplied. Further research in these fields is crucial in order to generate knowledge that can help to keep students engaged in their learning. These fields continue to be valuable to educators and are likely to continue to flourish in the future.

Because my study investigated the effectiveness of Student Response Systems (SRS) in terms of students' views of their learning environment, a detailed literature review of this field was provided. Section 2.2.4 reviewed many of these studies that have been carried out, focusing on ten types of research including: associations between student outcomes and environment, differences between student and teacher perceptions of actual and preferred environment, evaluation of educational innovations, determinants of classroom environment, use of qualitative research methods, cross-national studies, teacher education, school psychology, teachers' attempts to improve classroom environment, and transition from primary to high school. Most of this research has used classroom environments scales that were described in Section 2.2.2.

Many classroom environment instruments measure specific scales based on Moos' (1974) scheme for classifying the characteristics of any human environment into three distinct areas. Table 2.1 outlines nine (LEI, CES, MCI, QTI, SLEI, CLES, WIHIC, TROFLEI, and COLES) specific and common environment instruments, the educational level at which they are best used, who developed them, in what year they were developed, the number of items per scale, and the classification of scales according to Moos' scheme. Many of these instruments have been used worldwide and translated into numerous different languages including Chinese, Arabic, Korean, Indonesian, Turkish, and Spanish.

My study used an instrument that incorporates numerous scales from the What is Happening In this Class? (WIHIC) questionnaire. Because of this, an in-depth literature review was provided for this instrument (Section 2.2.3). The WIHIC builds on previous instruments that were used to measure classroom learning environments, but also incorporates additional important constructs such as equity and constructivism. The WIHIC contains two forms, one for students to fill out as individuals and another form for the students to fill out based on the class as a whole (Fraser et al., 1996). The first version of the WIHIC consisted of 90 items, but evolved after numerous studies to its final version consisting of seven scales with 8 items per scale for a total of 56 items. Section 2.2.3.2 reviews numerous studies that have validated this questionnaire. The WIHIC, as with numerous other instruments, has been used around the world and in many different languages. Because of the WIHIC's relevance to my study, four scales (Involvement, Task Orientation, Cooperation, and Equity) from it were used in my research.

The American Heritage® Dictionary of the English Language (2000) defines the word 'attitude' as a means to describe a variety of ideas, such as an opinion or feeling about something, physical posturing, or assertiveness. This can be used to describe a wide array of situations (Klopfer, 1971). When Klopfer (1976) noticed the problem of having no consistent definition of the word 'attitude' when describing students' attitudes towards science, he delineated six different categories of conceptually-different attitudinal aims. As my research investigated the effect of SRS on students' attitudes towards science, a literature review of past research on student attitudes was provided (Section 2.3). Students' attitudes towards their middle-school science classes are important because they often influence these students' choices of science courses in their later years of schooling (Misiti et al., 1991).

Section 2.3.1 reviewed some instruments that have been validated and used to measure students' attitudes. One scale (Enjoyment of Science Lessons) from one of these instruments, the Test of Science Related Attitudes (TOSRA), was included in my study. Section 2.3.2 provided a literature review related to the TOSRA. Similar to the WIHIC, the TOSRA has been used around the world and translated into many different languages. The validity and usefulness of TOSRA has been replicated around the world and in cross-national studies.

My study also investigated if the use of SRS is differentially effective for males and females in terms of learning environments, attitudes, and achievement. Because of this, knowledge of existing gender issues is essential According to the National Research Council (1997), all students, irrespective of race or gender, are entitled to equal opportunities to become scientifically literate. Many past studies, as described in Section 2.4.1, show inequity in science education between males and females. This is an important issue to address, beginning at young ages, as children's perceptions of science can begin to develop before the age of nine years (Joyce & Farenga, 1999). Typically there are small differences between males and females attitudes towards science in their elementary-school years (Alexakos & Antoine, 2003), but these differences become more apparent in the middle-school (NCES, 2000).

Researchers have investigated why these inequities exist. Farenga and Joyce (1997b) describe how males and females experience different interactions with science outside of the classroom, which could influence their attitudes towards this subject. Oakes (1990) suggests that some attitude differences towards science between males and females could occur because of a decrease in encouragement from teachers for females to succeed in science. Lindstrom and Tracy (2003) explain that, as a result of these less favorable attitudes, females tend to create self-imposed limitations on career choices in the sciences.

Teachers have a responsibility to maintain a gender-fair environment which allows equal access to education for both males and females (NRC, 1997). There are numerous techniques that can be used to address this idea, as described in Section 2.4.2. Although the first step in maintaining a gender-fair environment is teacher training, most instructors spend less than two hours per semester discussing this issue (Sanders, 2003). Of those two hours, much of the conversation is concentrated on appropriate interactions with students of both genders rather than on teaching methods that can be used to promote equity. Some gender bias has been noted in Yanowitz and Weathers' (2004) analysis of 15 common college psychology books.

S. E. Lee (2003) devised five methods for teachers to use to help in promoting gender equity, which were expanded on by Plucker (1994). Plucker explains that providing an increased exposure to hands-on visual-spatial problem-solving can help females to develop confidence. To assess if a teacher is successful in incorporating Lee's and Plucker's ideas, specific scales from the WIHIC can be used.

Before conducting my study on Student Response Systems (SRS), it was important for me to understand as much about them as possible. Section 2.5 provided a detailed review of literature relevant to this technology, including what they are (Section 2.5.1) and who currently uses them (Section 2.5.2). As previously stated, there are many reasons why a teacher might use SRS as part of his/her instruction (Section 2.5.3). Douglas Duncan (2005) lists some of these possible reasons in his book *Clickers in the Classroom: How to Enhance Science Teaching Using Classroom Response Systems*. SRS allow instant feedback for both the students and teachers (Julian, 1995; Skiba, 2006; Steinert & Snell, 1999), which immediately alerts the instructor as to which students need help and whether the class as a whole is accurately grasping the information being presented. When asking personal questions, more honest answers are usually obtained because of the anonymity of responses (Associated Press, 2005; Duncan, 2008; Johnson, 2004; Martyn, 2007).

A review of past research on the effects of SRS, most of which has been conducted at the college level, was provided in Section 2.5.4. Past research has focused on learning environments, attitudes, and achievement, as in my study. These studies have revealed that the use of SRS usually leads to more classroom discussions, better examination scores, and increased attendance. Student attitudes have also been found to improve when SRS are used.

As with all teaching methods, there are negative features associated with SRS as described in Section 2.5.5. Draper and Brown (2004) list some of these problems: much more work is needed on the effect that this fairly new technology has on students, especially on gender differences, the effects of SRS at younger ages, and the effect it has on students' comfort, all of which my study addressed. It has also been suggested that any observed changes during the use of SRS in the classroom might not be attributable to the technology itself, but rather to a change in teaching pedagogy (Judson & Sawada, 2002; Martyn, 2007; West, 2005). More research needs to be conducted on this as well. Because SRS, as with all technology, will continue to evolve (see Section 2.5.6), research is needed into whether these changes provide a positive or negative impact on students.

Because Student Response Systems are fairly new to the field of education, so much more research is needed. Much of the past research into the use of this technology has provided positive support for its use in classrooms. As with all research, different outcomes might be found at different levels of education. Past research on the effectiveness of SRS, mainly in higher education, suggests that students achieve better with the use of the SRS.

All of this past research on learning environments, attitudes, gender differences, and Student Response Systems is important and significant. Further studies in these areas, and the impact that they have on one another, is needed. This literature review has provided a better understanding of what currently is known about the fields of learning environments, attitudes, gender differences, and SRS, as well as some of the research that still needs to be undertaken. This chapter therefore provides a backdrop for better understanding my study and its findings.

Chapter 3

Research Methods

3.1 Introduction

The main purpose of this study was to examine the effectiveness of Student Response Systems in terms of the students' perceptions of their learning environment, their attitudes, and their achievement. To address these issues, it was necessary to gather data in several ways. Quantitative data were collected through the use of the How Do You Feel About This Class? (HDYFATC) questionnaire, which combines four learning environment scales (Involvement, Task Orientation, Equity, and Cooperation) from the What Is Happening In this Class? (WIHIC) and one created by the researcher (Comfort), and an attitudes scale (Enjoyment) from the Test of Science Related Attitudes (TOSRA). Students' achievement was assessed by taking the average of their examination scores.

This chapter describes the research methods used in the present study in terms of: the research questions guiding the study (Section 3.2); the instrument used to collect the data (Section 3.3); data collection (Section 3.4); the sample selected (Section 3.5); administration of the surveys (Section 3.6); data entry (Section 3.7); and data analysis (Section 3.8).

3.2 Research Questions

The four research questions, outlined below, were the focus of the current study.

To examine whether the HDYFATC questionnaire was a valid and reliable measure of students' perceptions of their classroom learning environment and their attitudes to science, the first research question was delineated:

Research Question 1:

> Is the How Do You Feel About This Class? questionnaire valid and reliable with Grade 7 and Grade 8 science students in New York?

To examine the effectiveness of Student Response Systems in terms of students' views of their learning environment, their attitudes, and their achievement, the second research question was delineated:

Research Question 2:

> Is the use of Student Response Systems effective in terms of:
> (a) the learning environment?
> (b) student attitudes?
> (c) student achievement?

To investigate the differential effectiveness of Student Response Systems among different genders, the third research question was delineated:

Research Question 3:

> Is the use of Student Response Systems differentially effective for males and females in terms of:
> (a) the learning environment?
> (b) student attitudes?
> (c) student achievement?

To examine whether a relationship exists between students' perceptions of the classroom learning environment and student outcomes, the fourth research question was delineated:

Research Question 4:

> Are there associations between the Learning environment and:
> (a) student attitudes?
> (b) student achievement?

3.3 Instrument Used to Collect Data

The instrument (HDYFATC) used in this study to assess students' perceptions of their learning environment and their attitudes includes scales from already well-known and widely-used questionnaires. These scales were chosen because of their relevance to the study. The original version of the questionnaire consisted of five of the seven learning environment scales contained in the WIHIC: Involvement, Student Cohesiveness, Task Orientation, Cooperation, and Equity. The WIHIC scales left out from this original version of the HDYFATC are Teacher Support and Investigation. These scales were omitted because they do not assess constructs that were highly relevant to my study. In my study, I also omitted the Student Cohesiveness scale, as it was not found valid and reliable with a similar sample in a prior study for my Masters degree (see Section 4.2.4). The WIHIC was previously discussed in Section 2.2.3 and is discussed further in Section 3.3.1.

To comprehensively assess students' perception of their learning environment and their attitudes, two more scales were added. A learning environments scale, Comfort, was created by the researcher to assess how comfortable students are in their science class. The Enjoyment of Science Lessons scale was used to assess students' attitudes by compiling questions found in the Test Of Science-Related Attitudes (TOSRA). The TOSRA was discussed in Section 2.3.2 and is discussed further in Section 3.3.3.

3.3.1 What Is Happening In this Class? (WIHIC) Questionnaire

3.3.3.1 What Is It?

My study involved the use of selected scales from the WIHIC questionnaire that allows the researcher to assess learning environments in a quantitative manner. The WIHIC has been successfully used with university students (Fraser, Aldridge, & Soerjaningsih, 2010; MacLeod & Fraser, 2010; Martin-Dunlop & Fraser, 2007), secondary students (Cakiroglu, Telli, & Cakiroglu, 2003; Cakiroglu, den Brok, Tekkaya, & Telli, 2009; Chionh & Fraser, 2009; Fraser, Aldridge, & Adolphe, 2010; Zandvliet & Fraser, 2004, 2005), middle-school students (den Brok, Fisher, Rickards, & Bull, 2006; Kim, Fisher, & Fraser, 2000; Ogbuehi & Fraser, 2007; Wolf & Fraser, 2008), and elementary-level students (Allen & Fraser, 2007; Pickett &

Fraser, 2009). It measures seven different scales that cover Moos's scheme (previously discussed in Section 2.2.3), which includes three basic types of dimensions. The WIHIC's scales are: Student Cohesiveness, Teacher Support, Involvement, Investigation, Task Orientation, Cooperation, and Equity. It has eight items per scale that are each measured on a frequency scale, ranging from Almost Never to Very Often (Fraser, Fisher, & McRobbie, 1996).

The WIHIC is unique in that it is offered in two versions, one for the student to answer as an individual and the other for the student to answer based on how they feel about a class. Another valued feature of the WIHIC is that it has a form for the students to answer based on what is actually happening in class and another for them to fill out based on what is preferred. This is useful for the researcher for taking into account the overall classroom climate and to compare what is actually occurring versus what the students would like.

3.3.1.2 Why Use It?

Teacher observations and student performance only give a limited picture of the whole story. There are a lot of factors that affect student outcomes which can be measured by the WIHIC. As stated previously, the WIHIC specifically is unique in the fact that it has two versions, to measure how the student feels as an individual and the other to measure the student's perceptions as a part of the class as a whole. This is important because student perceptions can change based on from what viewpoint they are answering the questions (Fraser et al., 1996).

Another advantage of some of these instruments, such as the WIHIC, is that they measure both actual versus preferred student responses. This allows the researcher to identify what the students view as the ideal classroom environment versus what is actually happening in that class. By analyzing this information, the instructor can make changes in an attempt to make the actual classroom climate as close to the preferred as possible. Researchers can then investigate whether the students perform better when the actual environment is more similar to the preferred environment.

A very important justification for choosing scales from the WIHIC for my study is its proven validity and usefulness in past research. Section 2.2.3.2 reviewed many different studies that have found the WIHIC to be valid and useful in numerous languages and locations, including: California (den Brok et al., 2006; Ogbuehi & Fraser, 2007), Turkey (Cakiroglu, Telli, & Cakiroglu, 2003; Cakiroglu, den Brok, Tekkaya, & Telli, 2009), Australia (Fraser, Aldridge, & Adolphe, 2010; Zandvliet & Fraser, 2004, 2005), Indonesia (Fraser, Aldridge, & Adolphe, 2010), Canada (Zandvliet & Fraser, 2004, 2005), and Singapore (Chionh & Fraser, 2009; Khoo & Fraser, 2008).

3.3.1.3 How to Use It

It is fairly simple to implement the WIHIC. First, because not all scales are important in every study, the researcher can determine which aspects of the learning environment they would like to measure. Once this has been determined, the researcher would select the appropriate scales and then give all students a copy of the modified version of the WIHIC to fill out. After all of these data have been collected, one would then score them and obtain the average for each of the items in all scales being measured. This could be done with all versions (actual, preferred, individual, and class) of the WIHIC for the best results. This can give a useful quantitative overview of the classroom climate.

A review of literature relevant to the WIHIC can be found in Section 2.2.3.

3.3.2 Comfort

A learning environments scale, Comfort, was created by the researcher to assess how comfortable students are in their science class. To develop the comfort scale, I asked about numerous characteristics that are common among students who are comfortable in a classroom setting. Comfort is currently measured as a learning environment scale of the 1994 Strong Interest Inventory (SII) and is one of 12 scales of the College Student Inventory (CSI) (Spreda & Donnay, 2000). These two sources are most often used with college-level freshmen to help them to determine for what career their personality is best suited. Typically, students who are more comfortable in an academic setting have higher scores, while students who are not as comfortable tend to have lower grades and are at risk of dropping out of school (Hansen & Campbell, 1985).

3.3.3 Test of Science Related Attitudes (TOSRA)

3.3.3.1 What Is It?

My study involved attitudes as one of the criteria for assessing the SRS. The TOSRA (Fraser, 1981) assesses secondary students' attitudes towards science using seven distinct science-related scales: Social Implications of Science, Normality of Scientists, Attitude to Scientific Inquiry, Adoption of Scientific Attitudes, Enjoyment of Science Lessons, Leisure Interest in Science and Career Interest in Science. Only one of these scales, Enjoyment of Science Lessons, was chosen to be used in my study because of its relevance to what was being researched. The TOSRA can be administered within one average class period and is suitable for group administration. It has been carefully developed and extensively field tested. These field tests have shown that the TOSRA is highly valid and reliable.

TOSRA can be used by curriculum evaluators, researchers, or teachers to monitor student progress towards achieving attitudinal aims. The TOSRA is best used to evaluate a group of students rather than individual students. To monitor students' attitudes, the TOSRA can be administered numerous times throughout the school year to track any changes.

The TOSRA's response formant requires students to express their degree of agreement with each statement on a five-point response system consisting of the responses Strongly Agree (SA), Agree (A), Not Sure (N), Disagree (D) and Strongly Disagree (SD). Each item is designated as positive (+) or negative (-). To score the TOSRA, each response is assigned a value based on whether that question is positively or negatively worded. These values for positive items are 5, 4, 3, 2, 1 for responses SA, A, N, D, and SD respectively. The values for items designated as negative are 1, 2, 3, 4, 5 for responses SA, A, N, D, and SD respectively.

3.3.3.2 Why Use It?

The TOSRA can be used by teachers or researchers to monitor students' attitudes towards science and help progress to specific goals as an individual or as a whole class. One advantage of the TOSRA, unlike many other science attitudes instruments, is that it yields a separate score for a number of distinct attitudinal aims instead of an overall score (Fraser, 1981). These separate scale scores make it possible to create a profile of attitudes scores for a group of students.

When interpreting scores obtained from the TOSRA, relative interpretations are often more meaningful than absolute ones. Administering the TOSRA at different times during the year can enable the tracking of trends in the students' or groups' attitudes as a response to changes that might have taken place in the classroom. Also, the TOSRA makes it possible to compare two different groups of students, each having specific unique classroom routines and cultures more effective.

Because there are inherent difficulties in making absolute interpretations of scores on the TOSRA, it is often useful for teachers and researchers to compare the scores obtained by one specific group of students with those of a much larger sample. Profiles can be drawn and graphed for each group of students, which makes it easy to compare groups. After this, it will be relatively easy for the teacher to see if their students' scores are above or below those of the larger sample. When this is done, teachers should not be overly concerned if their scores deviate from the mean profiles of larger broader samples.

Based on the experience of researchers and teachers who have used the TOSRA in classrooms, it appears that its administration usually has been smooth and useful (Fraser, 1981). Some TOSRA scales can be, and have been, used in science curriculum evaluation studies (Fisher & Fraser, 1980; Fraser, 1979). Studies of relationships between students' science-related attitudes and their perceptions of psychosocial characteristics of their classroom learning environment can be, and have also been, conducted using all of the scales obtained in the TOSRA (Fraser & Butts, 1982) as well as specific scales from an earlier version of the TOSRA (Fraser, 1979).

A very important justification for choosing a scale from the TOSRA is its proven validity and usefulness in past research. Section 2.3.2.1 reviewed many different studies that found TOSRA to be useful and valid in numerous languages and locations: Singapore (Wong & Fraser, 1996), Indonesia (Fraser, Aldridge, & Adolphe, 2010), and Australia (Fraser, Aldridge, & Adolphe, 2010; Fraser & Butts, 1982; Schibeci & McGaw, 1980).

3.3.3.3 How To Use It

Because the TOSRA assesses attitudes, and not classroom environment, it is often useful to use it in conjunction with the WIHIC for investigating connections between environment and attitudes. To score the TOSRA, each item needs to be determined as to which of the seven scales it is allocated to and if the item is positive (+) or negative (-) in respect to scoring. For positive (+) items, responses SA, A, N, D, and SD are scored 5, 4, 3, 2, and 1, respectively. For negative (-) items, responses SA, A, N, D, and SD are scored 1, 2, 3, 4, and 5, respectively. Questions that are omitted or invalidly answered are given a score of 3. To obtain the seven separate scale scores, the scores obtained for each item contained in that scale are added together. Because each scale contains 10 items, the minimum score possible is a 10 and the maximum possible score is a 50. It is not accurate to add the seven scale scores together to obtain a total test score. I did not use any of these negatively-worded reverse-scored items in my study (see Section 3.4.1).

Scoring can be completed by computer or by hand. Once the information for each of the seven scales has been scored for each student, the researcher then interprets the results by obtaining the mean for each scale of the TOSRA and graphing or plotting this information. This can also be compared to other samples from field-testing.

Literature relevant to TOSRA's development, validation, and shortcomings, together with suggested future research, was previously reviewed in Section 2.3.2.

3.4 Data Collection

The current study of effectiveness of Student Response Systems in terms student attitudes, achievement, and perceptions of the learning environment required two main methods of data collection, as discussed in this section. The students responded to the HDYFATC questionnaire to provided quantitative data about their perceptions of the learning environment and their attitude towards science class (Section 3.4.1), whereas their achievement was measured through obtaining their scores on examinations for the duration of the study (Section 3.4.2).

3.4.1 How Do You Feel About This Class? (HDYFATC) Questionnaire

The HDYFATC questionnaire combines four eight-item learning environment scales (Involvement, Task Orientation, Cooperation, and Equity) from the What is Happening In this Class? (WIHIC), one eight-item learning environment scale (Comfort) created by the researcher, and an attitude scale (Enjoyment) based on the Test of Science Related Attitudes (TOSRA). The Enjoyment scale was created by selecting 8 items from the TOSRA. These WIHIC and TOSRA scales were selected based on their relevance to my study. Original TOSRA items with negative wording and reverse scoring were avoided or reworked to make the questionnaire more simple for students to answer.

To maintain consistency when using items from different questionnaires, the original frequency response alternatives of the WIHIC (Never, Seldom, Sometimes, Often, and Very Often) were changed to match those of the TOSRA. To respond to each item, students circle 1, 2, 3, 4, or 5 which correspond with Strongly Disagree, Disagree, Not Sure, Agree, and Strongly Agree, respectively. To see the complete HDYFATC questionnaire, refer to Appendix A.

3.4.2 Achievement

During the present study, both groups of students took their teachers' normal quizzes and examinations. The use of the same assessments allowed for consistency. At the end of the study, an average score was determined based on each quiz and examination grade. These averages were then divided by 20 for consistency with the range of scores possible for HDYFATC scales. The assessment of achievement is discussed further in Section 4.3.2.

3.5 Sample

This section discusses the sample of students who responded to the HDYFATC and whose achievement was investigated in my study. The sample consisted of 1097 students from 47 classes in three schools in New York State. These middle-school students (Grade 7 and Grade 8) were distributed between 10 different teachers. Table 3.1 provides a breakdown of the sample sizes for the SRS and non-SRS groups by gender and teacher. All schools that participated in this study were coeducational public schools in southern New York State. These schools had a relatively even mix of males and females as shown in Table 3.1.

To help to minimize the teacher as a variable when collecting and analyzing data, each teacher who participated in the study used SRS in half of his/her classes, but not in the other half. In the case in which teachers taught an odd number of classes, the researcher either directed the teacher to use SRS in an extra class or to not use it in that class. This helped the researcher to keep a balanced number of students in the control (consisting of 278 males and 287 females for a total of 565 students) and in the experimental group (consisting of 266 males and 266 females for a total of 532 students). If a teacher taught different science subjects or grade levels, the researcher directed him/her to in which classes he/she should use or not use SRS. This also helped to keep a balance between grades and subjects to minimize them as a variable in the study.

Table 3.2 shows the ethnic, socioeconomic, and language demographics of the schools that participated in this study. Because the students did not personally answer questions about their racial background, eligibility for free or reduced-cost lunch, or limited English ability, these statistics are school-wide percentages.

3.6 Administration of Questionnaire

Quantitative data were collected by administering the How Do You Feel About This Class? (HDYFATC) questionnaire to 1097 students in 47 classes in three schools in New York.

Ten (10) teachers administered the HDYFATC to their science classes after the approximately four months of the study period. The teachers had a meeting with the researcher at the beginning of the study (which was purposely started close to the beginning of the school year so that the students did not possess a prior feeling of the class), which included explaining the questionnaire. The questionnaires were mailed to the participating teachers when they were needed. The teachers personally administered the questionnaire so that they could answer any questions that the students might have. The questionnaires for each class were collected in separate envelopes and handed directly to the researcher for data entry and analysis.

Table 3.1 Size of Student Sample by Teacher, Student, Gender, and Instructional Method

Teacher ID	Gender	Sample Size SRS	Non-SRS	Total
1	Male	36	21	57
	Female	38	28	66
		74	49	123
2	Male	24	36	60
	Female	21	40	61
		45	76	121
3	Male	26	33	59
	Female	26	35	61
		52	68	120
4	Male	35	25	60
	Female	33	20	53
		68	45	113
5	Male	19	34	53
	Female	21	34	55
		40	68	108
6	Male	20	25	45
	Female	21	22	43
		41	47	88
7	Male	24	35	59
	Female	24	33	57
		48	68	116
8	Male	24	22	46
	Female	23	28	51
		47	50	97
9	Male	21	18	39
	Female	22	21	43
		43	39	82
10	Male	37	29	66
	Female	37	26	63
		74	55	129

Table 3.2 A Comparison of Ethnic, Socioeconomic, and Language Factors for the Three Schools

School ID	Ethnic Background (%) Asian or Native Hawaiian/ other Pacific Islander	Black or African American	Hispanic or Latino	White	Eligible for Free or Reduced-Price Lunch (%)	Limited English Proficient (%)
1	12	2	7	79	4	1
2	2	3	10	85	16	1
3	3	5	7	85	6	1
Average	11.7	3.3	8.0	83	8.7	1

Students were reminded numerous times that, even though their names, grades, genders, teachers, schools, and class periods were requested on the cover of the questionnaire, their teacher would not look at the responses and the information would be coded anonymously once it was received by the researcher. Once the unique ID code was issued, it was written on the questionnaire and the cover sheet so that their identifying information could be destroyed to preserve their confidentiality and anonymity.

3.7 Data Entry

To be able to correlate student responses on the questionnaire with their achievement scores, each student provided his/her name, gender, grade, school, teacher, and science class period on the cover of the HDYFATC questionnaire. After this, each school, teacher, and student was issued a unique ID number. Once students' identifying information was replaced by their ID number, any identifying information was destroyed to ensure confidentiality and anonymity.

The students' ID numbers, responses to the questionnaire items, and examination averages were input into a spreadsheet in Microsoft Excel XP. To ensure accuracy, the researcher input all of the data himself. After all of the student responses to the questionnaire and students' examination averages had been accurately input, the data were analyzed using SPSS version 11.5 (see Section 3.8 about analysis).

To satisfy ethical concerns, confidentiality was maintained for all parties. The unique ID numbers given to each student were assigned arbitrarily rather than using an algorithm. This was done to prevent any possibility of decoding which could lead to the identification of students.

During data entry, two main issues arose. One problem involved typographical errors (Section 3.7.1). The other issue involved student errors when completing the questionnaire (Section 3.7.2).

3.7.1 Typographical Issues

When dealing with such a large number of numeric responses, it is easy for the person inputting the data (the researcher) to mistype information. To help to deal with this, a feature in Microsoft Excel XP was used. This feature highlighted empty cells or cells with invalid responses (such as those with more than one digit). This feature gave a clear visual identification of any mistakes that needed to be corrected, which was immediately completed with the corresponding survey in hand. To ensure a high accuracy rate between the survey data and the information entered for analysis, after each page of the survey was input the data from the survey was compared to the information input in the computer and corrected if necessary.

3.7.2 Student Errors

Three main errors were made by the students when responding to the questionnaire. One error involved students leaving a few answers blank. Another error involved entire pages of the questionnaire being left blank. Finally some students circled more than one response to the same questions.

In situations where students left a few blank responses, the class gender mean was inserted for that student for that question. For example, if a female student skipped Item 8, the class mean among females for Item 8 was used in the blank cell. In situations where gender class means were too small, such as less than five females in the class, the whole-class mean for that item was used to fill in the missing information.

If a student neglected to respond to an entire page of the survey, all of their data were discarded. Of the surveys completed in this study, however, only two were discarded for this reason. These two students were not part of the sample size of 1,097 students used for analysis.

If a student circled more than one response for a single item, the mean of the two circled numbers was used. For example, if a student circled both responses 4 and 5 for an item, then 4.5 was used as their response to that item.

3.8 Data Analysis

Quantitative data analyses were undertaken using SPSS version 11.5 statistical package. This section describes the statistical analyses conducted to answer each research question.

3.8.1 Research Question 1: Validity and Reliability of HDYFATC Scales

To examine the reliability and validity of the HDYFATC when used with Grade 7 and Grade 8 students in New York, factor analysis, Cronbach alpha reliability, and the ability to differentiate between the perceptions of students in different classes were examined.

First, to examine the internal structure of the final 48-item, six-scale How Do You Feel About This Class? questionnaire, principal axis factoring followed by varimax rotation and Kaiser Normalization was used. In order for an item to be retained, it needed a factor loading of at least 0.40 on its *a priori* scale and not above 0.40 on another scale. The percentage of the total variance extracted with each factor and the eigenvalue for each scale were also calculated.

Next, internal consistency reliability was estimated for two units of analysis (the student and the class mean). The Cronbach alpha reliability coefficient was used as an index of scale internal consistency.

Finally, through using an ANOVA, the ability of each learning environment scale of the HDYFATC to differentiate between perceptions of students in different classrooms was determined. ANOVA indicates if students in the same class perceive their learning environment in a similar way, while mean class perceptions vary from class to class. (This is not relevant for the attitude scale.) The eta^2 statistic, which represents the proportion of variance in scale scores accounted for by class membership, was also calculated.

3.8.2 Research Question 2: Effectiveness of Student Response Systems

To determine the effectiveness of the use of SRS in terms of learning environment, attitudes, and achievement, each scale's average item mean (the scale mean divided by the number of items in a scale) and average item standard deviation were determined. As recommended by Thompson (1998, 2002), effect sizes were calculated to determine the magnitude of the difference between the SRS and control groups. Effect sizes show the differences between means expressed in standard deviation units (the difference between the means of two groups divided by the pooled standard deviation).

To ascertain the statistical significance of differences between the two groups, a one-way multivariate analysis of variance (MANOVA) was conducted with the six learning environment scales and two student outcome scales (achievement and enjoyment) as the dependent variables and the use or non-use of SRS as the independent variable. Because the multivariate test using Wilks' lambda criterion yielded a statistically significant result overall for the whole set of seven dependent variables, the univariate ANOVA results were interpreted separately for each individual dependent variable.

3.8.3 Research Question 3: Differential Effectiveness of Student Response Systems Among Different Genders

The third research question of this study was created to determine if using SRS was differentially effective for males and females. A two-way MANOVA was used to explore interactions between the method of instruction (use and non-use of SRS) and gender for each learning environment and student outcome scale. The independent variables were the use/non-use of SRS and gender, and the dependent variables were the five learning environment scales and the two student outcome scales (attitudes and achievement).

Because the multivariate test yielded statistically significant differences overall when Wilks' lambda criterion was used, the individual two-way ANOVA was interpreted for each of the seven dependent variables. Differential effectiveness was indicated by the presence of statistically significant instruction-by-gender interactions.

3.8.4 Research Question 4: Associations between Learning Environment, Attitudes, and Achievement

The fourth research question of this study involved associations between the students' perceptions of their learning environment and their attitudes and achievement. To investigate relationships between students' perceptions of their learning environment and the student outcomes of attitudes and achievement, simple correlation and multiple regression analyses were used. Simple correlation was used to examine the bivariate relationship between each student outcome and each learning environment scale. Multiple regression analysis was carried out to determine the joint influence of the set of the learning environment scales on each student outcome. Regression coefficients were used to provide information about which environment scales contributed to variance in students' attitudes or achievement when all other environment scales were mutually controlled.

3.9 Summary

This study used quantitative methods of collecting and analyzing data. The instrument used to obtain the data on students' perceptions of their learning environment and their attitudes was the How Do You Feel About This Class? (HDYFATC) questionnaire. The HDYFATC combines four learning environment scales from the What Is Happening In this Class? (WIHIC) questionnaire (Involvement, Task Orientation, Cooperation, and Equity), one learning environment scale created by the researcher (Comfort) and one attitudes scale from the Test of Science Related Attitudes (TOSRA) (Enjoyment). Further quantitative data were collected through the students' examination scores for the duration of the study.

The sample for the present study consisted of 1097 Grade 7 and Grade 8 students from 47 classes in three public schools in New York. About half of the students did use Student Response Systems (SRS) in their science class and the others did not.

To check if the HDYFATC was valid and reliable, the data obtained were analyzed with SPSS software version 11.5. Principal axis factoring followed by varimax rotation and Kaiser normalization was used to examine the internal structure. Next, Cronbach alpha reliability coefficients were used as an index of scale internal consistency. An ANOVA was used to check whether each learning environment scale could distinguish perceptions of students from different classes. Further information on the validity and reliability of this questionnaire is found in Section 4.2.

To answer the second research question, involving whether the use of SRS are effective in terms of students' perceptions of their learning environment, their attitudes, and their achievement, the data obtained through the HDYFATC were subjected to a one-way multivariate analysis of variance (MANOVA). This MANOVA was conducted with the five learning environment scales and the two outcome scales as the dependent variable and the use or non-use of SRS as the independent variable. The results of these analyses are found in Section 4.3.

To determine if the use of SRS is differentially effective for males and females, a two-way MANOVA was used. The independent variables were the use/non-use of SRS and gender, and the dependent variables were the five learning environment scales and the two student outcomes. Because the multivariate test yielded statistically significant differences overall when Wilks' lambda criterion was used, the individual two-way ANOVA was interpreted for each of the seven dependent variables. Differential effectiveness was identified based on the statistical significance of instruction-by-gender interactions. The results of this analysis are reported in Section 4.4.

Simple correlation and multiple regression analyses were used to investigate the relationships between students' perceptions of the learning environment and the student outcomes of attitudes and achievement. Simple correlation was used to examine the bivariate relationship between each student outcome and each of the five learning environment scales. Multiple regression analysis was carried out to determine the joint influence of the set of learning environment scales on each student outcome. The regression coefficient was used to provide information about which environment scales contributed to variance in students' attitudes or achievement when all other environment scales were mutually controlled.

The result of these data analyses are discussed in detail in Chapter 4.

Chapter 4

Data Analyses and Results

4.1 Introduction

This chapter describes the data analyses and findings for the quantitative data collected using the How Do You Feel About This Class? (HDYFATC) questionnaire as well as qualitative data obtained through interviews. As discussed in Chapter 3, this questionnaire consists of four scales (namely, Involvement, Task Orientation, Cooperation, and Equity) from the What Is Happening In This Class? (WIHIC) questionnaire for assessing students' perceptions of the learning environment. A learning environment scale created by the researcher, Comfort, was added to the WIHIC. In addition, one scale from the Test of Science Related Attitudes (TOSRA) was used to assess students' attitudes in their science classes. Students' examination scores during the study were used as a measure of achievement.

Prior to this doctoral study, the How Do You Feel About This Class? questionnaire had been checked for validity and reliability by the researcher as part of a Masters degree project. Based on the data obtained in that original study, the questionnaire was slightly modified before being administered to the students in the present study. The data obtained in this previous study is discussed further in Section 4.2.4.

To answer the four research questions that guided my study, the HDYFATC was administered to a sample of 1097 Grade 7 and Grade 8 students from 47 classes in 3 schools in New York. The results for the first research question pertaining to the validity and reliability of the HDYFATC are reported in Section 4.2. The results of the second research question related to the effectiveness of the use of SRS are the focus of Section 4.3. The results of the third research question pertaining to the differential effectiveness of SRS according to student gender is discussed in Section 4.4. Finally, the results of the fourth research question about associations between learning environment and attitudes and achievement are reported in Section 4.5.

4.2 Validity and Reliability of the HDYFATC Questionnaire

To answer the first research question below, the responses of 1097 students in 47 classes to the HDYFATC were analyzed:

> Research Question 1: Is the How Do You Feel About This Class? (HDYFACT) questionnaire valid and reliable with Grade 7 and Grade 8 science students in New York?

This section reports the factor structure of the HDYFATC questionnaire (Section 4.2.1), its internal consistency reliability (Section 4.2.2), its ability to differentiate between classrooms (Section 4.2.3), and the consistency of my study's results with past research (Section 4.2.4).

4.2.1 Factor Structure of HDYFATC

To examine the internal structure of the final 48-item, six-scale HDYFATC questionnaire (assessing Involvement, Task Orientation, Cooperation, Equity, Comfort and Attitudes), principal axis factoring followed by varimax rotation and Kaiser Normalization was used. Item numbers shown in Table 4.1 refer to the question number in the HDYFATC (Appendix A).

In order for an item to be retained, it needed a factor loading of at least 0.40 on its *a priori* scale and less than 0.40 on another scale. Table 4.1 shows that the factor loadings for all items of the HDYFATC were above 0.40 on their *a priori* scale, ranging from 0.43 to 0.79. No item had a loading greater than 0.40 on a different scale. Therefore all 48 items and all six scales were retained.

The percentage of the total variance extracted with each factor and the eigenvalue for each scale are also recorded at the bottom of Table 4.1. The percentage of variance varied from 2.70% to 53.38% for different scales, with the total variance accounted for being 76.13%. The largest contribution to variance was for Enjoyment (53.38%). The eigenvalues ranged from 1.29 to 25.62. The results of the factor analysis shown in Table 4.1 strongly support the factorial validity of the final 48-item, six-scale version of the HDYFATC when used with my sample of 1097 middle-school students in New York.

4.2.2 Internal Consistency Reliability of HDYFATC

Internal consistency reliability is a measure of the extent to which items in the same scale measure a common theme. For each of the six scales of the HDYFATC, the reliability was estimated for two units of analysis (the student and the class mean). The Cronbach alpha reliability coefficient was used as an index of scale internal consistency. Table 4.2 shows that, when the individual was used as the unit of analysis, the internal consistency reliability (Cronbach alpha coefficient) for different scales of the HDYFATC ranged from 0.94 to 0.95. When the class mean was used as the unit of analysis, the internal consistency reliability was 0.99 for all scales. As expected, reliability estimates were higher when the class mean was used as the unit of analysis.

4.2.3 Ability of the HDYFATC to Differentiate Between Classrooms

Through using an ANOVA, the ability of each learning environment scale of the HDYFATC to differentiate between perceptions of students in different classrooms was determined. ANOVA indicates if students in the same class perceive their learning environment in a similar way, while mean class perceptions vary from class to class. The ANOVA results in the last column of Table 4.2 reveal that a significant difference ($p<0.001$) between students' perceptions in different classes for each learning environment scale of the HDYFATC when the student is used as the unit of analysis. (This characteristic is not relevant for the Enjoyment scale.)

The eta^2 statistic represents the proportion of variance in scale scores accounted for by class membership. The eta^2 values ranged from 0.50 to 0.60 for the different learning environment scales measured by the HDYFATC.

4.2.4 Consistency of My Study's Results for HDYFATC with Past Research with WIHIC

Because the HDYFATC contains five scales from the WIHIC, it is important to compare my reliability and validity results for those scales with previous studies involving the WIHIC. The present study's findings are consistent with other studies that provide evidence supporting the WIHIC's factor structure, reliability, and ability to differentiate between classes. One such study was conducted by Aldridge and Fraser (2000) involving 1081 junior high school students in 50 classes from

Table 4.1 Factor Analysis Results for the How Do You Feel About This Class? Questionnaire

Item No	Enjoyment	Involvement	Task Orientation	Cooperation	Equity	Comfort
1	0.60					
2	0.73					
3	0.76					
4	0.65					
5	0.63					
6	0.62					
7	0.65					
8	0.79					
9		0.66				
10		0.75				
11		0.68				
12		0.66				
13		0.63				
14		0.70				
15		0.66				
16		0.70				
17			0.74			
18			0.57			
19			0.65			
20			0.72			
21			0.66			
22			0.61			
23			0.63			
24			0.77			
25				0.43		
26				0.71		
27				0.72		
28				0.50		
30				0.56		
31				0.70		
32				0.53		
33					0.72	
34					0.68	
35					0.58	
36					0.65	
37					0.66	
38					0.65	
39					0.73	
40					0.69	
41						0.59
42						0.65
43						0.72
44						0.63
45						0.76
46						0.74
47						0.73
48						0.78
% Variance	53.38	6.60	5.39	4.61	3.45	2.70
Eigenvalue	25.62	3.17	2.58	2.21	1.65	1.29

N = 1097 students in 47 Classes.
Factor loadings less than 0.40 have been omitted from the table.
Principal axis factoring with varimax rotation and Kaiser normalization.

Table 4.2 Internal Consistency (Cronbach Alpha Reliability) and Ability to Differentiate between Classrooms (ANOVA Results) for Learning Environment and Enjoyment Scales for Two Units of Analysis

Scale	Unit of Analyses	Alpha Reliability	ANOVA *eta*^{2}
Learning Environment			
Involvement	Student	0.95	0.59*
	Class	0.99	
Task Orientation	Student	0.95	0.52*
	Class	0.99	
Cooperation	Student	0.94	0.50*
	Class	0.99	
Equity	Student	0.94	0.55*
	Class	0.99	
Comfort	Student	0.95	0.60*
	Class	0.99	
Enjoyment	Student	0.95	
	Class	0.99	

N= 1097 *p<0.001
The sample consisted of 1079 students in 47 classes.
The eta² statistic (which is the ration of 'between' to 'total' sums of squares) represents the proportion of variance explained by class membership.

Australia and 1879 junior high school students in 50 classes in Taiwan. This study used multiple research methods from different paradigms in exploring the classroom learning environments. Data analysis supported the reliability and factorial validity of the questionnaire. Also, differences between Taiwanese and Australian classrooms were revealed.

In another study whose results are consistent with the present study, Chionh and Fraser (2009) found a strong factor structure and a high alpha reliability for each learning environment scale of the WIHIC with a sample of 2310 Singaporean Grade 10 students (aged 15 years) from 75 geography and mathematics classes in 38 school. In this study, it was found that better examination scores were found in classrooms that had higher student cohesiveness. Self-esteem and attitudes were more positive in classrooms that had more teacher support, task orientation, and equity. Relative to differences between the students' actual and preferred views of their classroom environments, little differences between the environments of geography and mathematics classes were found.

For a sample of 1434 students in 71 classes in the United States, Wolf and Fraser (2008) found the learning environment and attitude scales included in their questionnaire (Survey of Laboratory Practices, SLAP) were valid, reliable, and related to each other for this sample. The SLAP included all 7 learning environment scales from the WIHIC (Student Cohesiveness, Teacher Support, Task Orientation, Collaboration, Involvement, Investigation) and 10 items from the TOSRA to assess student attitudes. For a subsample of 165 students in 8 classes, it was found that inquiry instruction promoted more student cohesiveness and non-inquiry instruction. Inquiry-based laboratory activities were found to be differentially effective for male and female students.

Other studies, as discussed further in Section 2.2.3.2, that revealed similar reliability and validity results for the WIHIC as the present study are described below:

- den Brok, Fisher, Rickards, and Bull (2006) investigated science students' perceptions of their classroom learning environment with a sample of 665 students in California from 11 different schools.
- When MacLeod and Fraser (2010) simultaneously administered English and Arabic versions of the WIHIC to 763 college students in 82 classes, data analyses confirmed sound factorial validity and internal consistency for both the actual and preferred forms for both languages.
- The WIHIC was used to evaluate how effective a mentoring program for new teachers was in terms of the learning environment of their classrooms. This study took place in Miami with 573 elementary school students in Grades 3–5 (Pickett & Fraser, 2009).
- 1040 senior high-school students in 81 schools in Australia and Canada were involved in a study that used the WIHIC to assess students' perceptions of their learning environments (Zandvliet & Fraser, 2004, 2005).
- 525 female students from 27 classes at a large urban university in the United States responded to the WIHIC as part of an evaluation of the effectiveness of an innovative course aimed at improving elementary teachers' perceptions towards laboratory-based learning environments. The sample's age range was 20–52 years with an average age of 24 years and a median age of 23 years (Martin-Dunlop & Fraser, 2007).

- In California, Ogbuehi and Fraser (2007) administered the WIHIC to 661 middle-school mathematics students from 22 classrooms in four inner-city schools in California.

- 250 adults in 23 computer courses in four Singaporean computing schools helped to support the WIHIC's validity (Khoo & Fraser, 2008).

- A modified version of the WIHIC was cross-validated simultaneously in Indonesia and Australia with a sample of 1161 students (594 students from 18 classes in Indonesia and 567 students from 18 classes in Australia) (Fraser, Aldridge, & Adolphe, 2010).

- Turkish high school students' perceptions of their learning environment in their biology classrooms were investigated with samples of 399 Grade 9 and Grade 10 students (Cakiroglu, Telli, & Cakiroglu, 2003) and 1474 students (Cakiroglu, den Brok, Tekkaya, & Telli, 2009).

- A modified version for young students and their parents was administered to 520 Grade 4 and Grade 5 students and 120 parents (Allen & Fraser, 2007).

- In Australia, a sample of 978 secondary school students (Dorman, 2008) responded to the WIHIC.

- Both English and Spanish versions have been validated in Florida with 172 kindergarten science students and 78 parents (Robinson & Fraser, in press).

- Helding and Fraser (in press) validated English and Spanish versions of the WIHIC when used with 924 students from 38 Grade 8 and Grade 10 science classes.

- In the United Arab Emirates, an Arabic version of the WIHIC was validated with 352 college students in 33 classes (Afari, Aldridge, Fraser, & Khine, in press).

The researcher has also conducted a previous study of the reliability and validity of the HDYFATC as part of a Masters' degree project with a sample of 144 students. Principal axis factoring followed by varimax rotation and Kaiser Normalization confirmed a refined structure for the instrument comprising of 43 items in six scales.

For an item to be retained, it needed a factor loading of 0.40 or above in both its own scale and less than 0.40 in other scales. The scale that was lost as a result of this was Student Cohesiveness, which therefore was not included in the present study. All remaining items had a loading of at least 0.40 on their *a priori* scale and no other scale (see Appendix F), with the exception of Item 51, which loaded at least a 0.40 in its own scale as well as the Enjoyment scale. The percentage of the total variance extracted with each factor, which is also recorded at the bottom Appendix F, varied from 3.86% to 29.84% for different scales, with the total variance accounted for being 60.97%.

Appendix G reports the Cronbach alpha coefficient for each of the remaining six scales for two units of analysis (individual and class mean) for the previous study. Using the individual as the unit of analysis, scale reliability estimates ranged from 0.79 to 0.92. Generally reliability figures were even higher with the class mean as the unit of analysis, which ranged from 0.82 to 0.96.

An analysis of variance (ANOVA) was also used in the previous study to determine the ability of each learning environment scale to differentiate between the perceptions of students in different classes. For each one-way ANOVA, class membership was the independent variable and the individual student was used as the unit of analysis. Appendix G reports the ANOVA results and shows that each of the five questionnaire scales differentiated significantly between classes ($p<0.01$). Thus, students within the same class perceived the environment in a relatively similar manner, while the within-class mean perceptions of the students varied between classes. The eta^2 statistic (an estimate of the strength of association between class membership and the dependent variable) ranged from 0.08 to 0.17 for different scales.

The factor structure, reliability, and ability to differentiate between classes for the HDYFATC were all satisfactory in the present study and consistent with considerable prior research.

4.3 Effectiveness of Student Response Systems

To answer the second research question below, responses to the HDYFATC and an attitude scale from the same 1097 students in 47 classes were analyzed in various ways:

> <u>Research Question 2:</u> Is the use of Student Response Systems effective in terms of:
> (a) the learning environment?
> (b) student attitudes?
> (c) student achievement?

To enable the researcher to be able to identify differences between students who do use SRS and those who do not, it was important to have two instructional groups (a non-SRS or control group and an SRS group). To minimize the teacher as a variable in the students' responses to the HDYFATC, each teacher used SRS in half of his/her classes and not in the other half. Both classes received the same assessments and content, with the only difference being the use/non-use of SRS. To determine the effectiveness of the use of SRS in terms of learning environment, attitudes, and achievement, each scale's average item mean (the scale mean divided by the number of items in a scale) and average item standard deviation were calculated and are shown in Table 4.3. As recommended by Thompson (1998, 2002), effect sizes were calculated to determine the magnitude of the difference between the SRS and control groups. Effect sizes show the differences between means expressed in standard deviation units (the difference between the means of two groups divided by the pooled standard deviation). These results for my study are shown in Table 4.3.

To ascertain the statistical significance of differences between the two instructional groups, a one-way multivariate analysis of variance (MANOVA) was conducted with the five learning environment scales and student outcome scales (achievement and enjoyment) as the dependent variables and the use or non-use of SRS as the independent variable. Because the multivariate test using Wilks' lambda criterion yielded a statistically significant result overall for the whole set of seven dependent variables, the univariate ANOVA results were interpreted separately for each individual dependent variable. Table 4.3 provides the *F* value and statistical significance from ANOVA, as well as the effect size, for each of the seven learning environment and student outcome variables.

Discussion of the results for the effectiveness of using Student Response Systems reported in Table 4.3 is organized below in terms of learning environment scales (Section 4.3.1) and the student outcomes of student attitudes and achievement (Section 4.3.2).

Table 4.3 Average Item Mean, Average Item Standard Deviation and Differences Between SRS and Control Groups (*F* and Effect Size) in Students' Perceptions of Learning Environment, Enjoyment and Achievement

Scale	Average Item Mean		Average Item SD		Difference	
	SRS	Control	SRS	Control	*F*	Effect Size
Learning Environment						
Involvement	3.91	1.93	0.83	0.81	6.29*	2.45
Task Orientation	3.87	2.08	0.76	1.01	5.77*	2.00
Cooperation	3.86	2.09	0.94	0.86	5.69*	1.96
Equity	3.88	2.06	0.86	0.81	5.98*	2.17
Comfort	4.07	2.06	0.77	0.86	6.36*	2.46
Student Outcomes						
Enjoyment	3.88	2.00	0.82	0.89	6.01*	2.19
Achievement	3.52	3.18	0.29	0.28	4.41*	1.17

*$p < 0.0001$
Sample consisted of 532 students in SRS group and 565 students in control group.
Achievement scores were divided by 20 to make their range consistent with the range of questionnaire scales.

4.3.1 Effectiveness of Student Response Systems in Terms of Learning Environment

According to the results presented in Table 4.3, students in classes in which SRS were used had statistically significantly higher scores on all learning environment scales contained in the HDYFATC than did students in the control group. Table 4.3 shows that effect sizes ranged from 1.96 to 2.46 standard deviations. These effect sizes are remarkably large according to Cohen (1992), who defines a 'large' effect sizes as over 0.40 standard deviations.

The profile (Figure 4.1) shows that the average item means for students who used SRS were higher on all scales of the HDYFATC than those students who did not use SRS. As seen in Chapter 2, based on prior studies, it was expected that students would have more positive perceptions of their learning environment in science classes if they use SRS:

- My findings of greater Involvement when using SRS is consistent with previous studies (Duncan, 2008; Johnson, 2004; Joosten & Kaleta, 2006; Julian, 1995; Lightstone, 2006; Martyn, 2007; Wampler, 2006; Wood, 2004).

- Previous studies (Associated Press, 2005; Duncan, 2008; Johnson, 2004; Martyn, 2007) showed that using SRS was associated with greater equity, as in my research.

- Students perceiving more comfort in their science class when using SRS is consistent with previous studies (Duncan, 2008; Martyn, 2007).

- In my study, Task Orientation and Cooperation were greater when SRS are used, which is consistent with a previous study (Guess, 2008; Skiba, 2006).

4.3.2 Effectiveness of Student Response Systems in Terms of Student Outcomes (Attitudes and Achievement)

As shown in Table 4.3, students who used SRS enjoyed science classes statistically significantly more than students who did not use SRS. For students who did use SRS, the average item mean for Enjoyment was 3.88 compared to 2.00 for students who did not use SRS in their science classroom. The effect size for the between-group difference for Enjoyment was 2.19 standard deviations which is very large according to Cohen (1992). This statistically significant difference in Enjoyment is consistent with previous studies (Duncan, 2008; Joosten & Kaleta, 2006; Roberts, 2005; Siau, Sheng, & Nah, 2006) discussed in Section 2.5.4.

To assess student achievement in this study, students' averages on examinations during the study period were divided by 20 to maintain consistency with the range of scores possible for other scales in this study. As seen in Table 4.3, the average item mean for achievement was 3.52 for students who did use SRS and 3.18 for students who did not. The effect size for achievement differences between the two instructional groups was 1.17 standard deviations, which is large according to Cohen's criteria (1992). Table 4.3 indicates that there was a statistically significant difference between the two groups in achievement, which is consistent with previous studies (Guess, 2008; Martyn, 2007; Mazur, 1997; Poulis, Massen, Robens, & Dilbert, 1998; Skiba, 2006) discussed previously in Section 2.5.4.

Figure 4.1 illustrates the average item mean of SRS and control students for each learning environment and outcome scale. This graph gives a visual representation of the average item mean for each scale whose response alternatives are 1 (Strongly Disagree), 2 (Disagree), 3 (Not Sure), 4 (Agree), and 5 (Strongly Agree). Students who used SRS scored higher on all HDYFATC, attitude and achievement scales than the control group. In this graph, the line for the SRS group corresponds to the Agree response alternative, while the line for the control group corresponds to the Disagree response alternative.

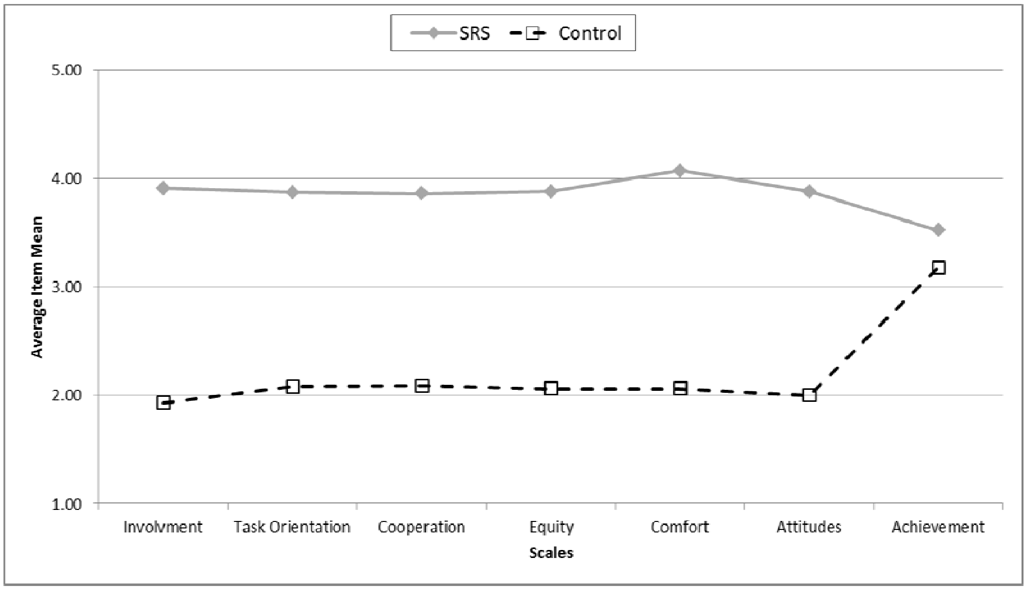

Figure 4.1 Comparison of SRS and Control Groups in Terms of Learning Environment and Attitudes and Achievement

4.4 Differential Effectiveness of Using Student Response Systems for Different Genders in Terms of Learning Environment, Attitudes, and Achievement

The differential effectiveness of the use of Student Response Systems for males and females was examined with my sample of 1097 students from 47 classes to answer the third research question:

> Research Questions 3: Is the use of Student Response Systems differentially effective for males and females in terms of:
> (a) the learning environment?
> (b) student attitudes?
> (c) student achievement?

Previously, Section 4.3 reported the use of a one-way MANOVA in exploring differences between classes that did use SRS and classes that did not. In contrast, this section reports the use of a two-way MANOVA aimed at identifying the differential effectiveness of these instructional methods according to student gender.

For the two-way MANOVA, the independent variables were the use/non-use of SRS and gender, and the dependent variables were the five learning environment scales and the two student outcome scales (enjoyment and achievement). Because the multivariate test yielded statistically significant differences overall when Wilks' lambda criterion was used, the individual two-way ANOVA was interpreted for each of the seven dependent variables. The presence of a statistically significant instruction-by-gender interaction was considered to indicate differential effectiveness for different genders.

Table 4.4 reports the results of the two-way ANOVA for each of the seven measures in terms of *F* values, statistical significance, and effect sizes. Eta^2 is an indicator of the proportion of variance explained. Table 4.4 shows each scale's average item mean and average item standard deviation separately according to instructional group and by gender.

Table 4.4 Item Mean and Item Standard Deviation for Two Instructional Groups and Two Genders and Instruction-by-Gender Interaction (Two-way ANOVA) for each Learning Environment and Attitude Scale

Scale	Gender	Average Item Mean		Average Item SD		Interaction	
		SRS	Control	SRS	Control	*F*	Partial Eta^2
Learning Environment							
Involvement	Male	3.90	2.00	0.87	0.88	2.49	0.00
	Female	3.91	1.86	0.80	0.73		
Task Orientation	Male	3.79	2.12	0.82	1.05	4.98*	0.01
	Female	3.96	2.04	0.66	0.97		
Cooperation	Male	3.81	2.09	0.99	0.84	1.02	0.00
	Female	3.91	2.08	0.89	0.88		
Equity	Male	3.82	2.07	0.92	0.83	1.86	0.00
	Female	3.94	2.05	0.79	0.80		
Comfort	Male	4.09	2.01	0.77	0.76	1.87	0.00
	Female	4.05	2.11	0.78	0.95		
Student Outcomes							
Achievement	Male	4.39	3.97	0.35	0.35	0.00	0.00
	Female	4.40	3.98	0.38	0.35		
Enjoyment	Male	3.85	1.98	0.85	0.84	0.00	0.00
	Female	3.90	2.02	0.80	0.94		

Sample consists of 544 boys and 553 girls
532 students in SRS group (266 boys and 266 girls) and 565 students in control group (278 boys and 287 girls)
*$p < 0.05$
Achievement scores were divided by 20 to be consistent with the range of scores for learning environment and attitude scales.

Table 4.4 shows that the use of SRS was differentially effective for males and females only for the one scale of Task Orientation. Males who did use SRS had an average item mean of 3.79 compared to 2.12 for males who did not use SRS. Females who did use SRS had an average item mean of 3.96 compared to 2.04 for females who did not use SRS. This pattern of means is illustrated graphically in Figure 4.2 for Task Orientation.

Figure 4.2 shows that, although both genders had higher Task Orientation means when they used SRS, females benefited slightly more from SRS than did males. When SRS was not used, males had slightly higher Task Orientation scores.

The degree of differential effectiveness of SRS found in the present study for males and females for the Task Orientation scale can be seen to be very small in Figure 4.2. The effect size for this interaction was quite small (only 0.01 of variance accounted for) according to Table 4.4. Overall, the magnitude of the differential effectiveness of using SRS for males and females was of quite minor educational importance.

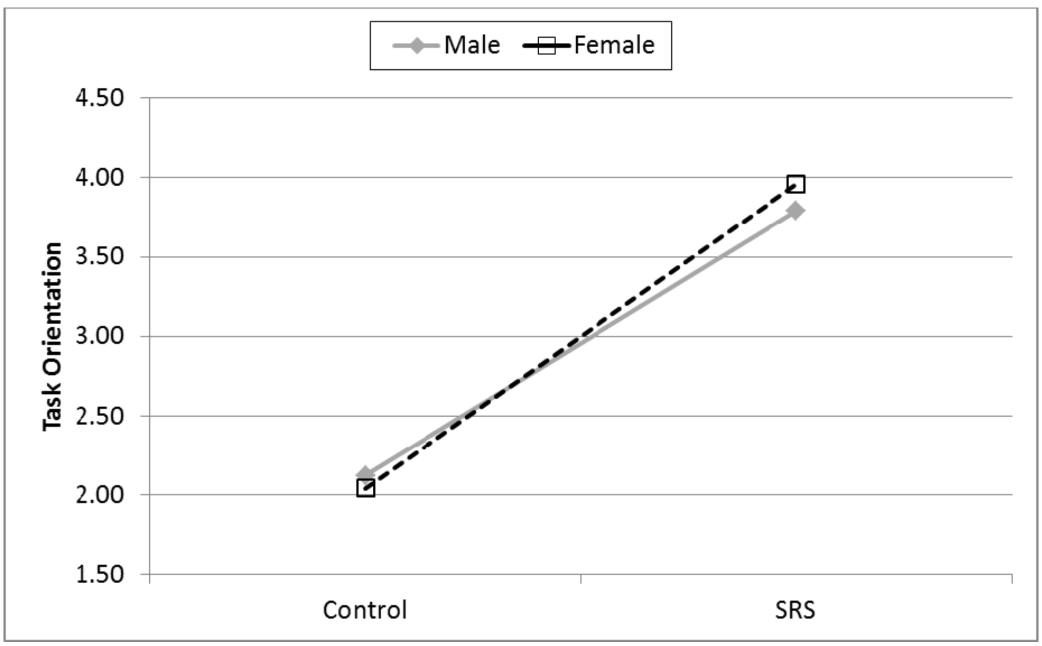

Figure 4.2 Task Orientation Item Means for Male and Females Who Did Use SRS and Who Did Not Use SRS

4.5 Associations between Learning Environment and Attitudes and Achievement

To answer the fourth research question below, I analyzed data from administration of the HDYFATC questionnaire and an achievement measure to the sample of 1097 students in 47 classes:

> Research Questions 4: Are there associations between the learning environment and:
> (a) student attitudes?
> (b) student achievement?

Simple correlation and multiple regression analyses were used to investigate the relationships between students' perceptions of the learning environment and the student outcomes of attitudes and achievement. Simple correlation was used to examine the bivariate relationship between each student outcome with the five learning environment scales of the HDYFATC. Multiple regression analysis was carried out to determine the joint influence of the set of learning environment scales on each student outcome. The regression coefficient was used to provide information about which environment scales contributed to variance in students' attitudes or achievement when all other environment scales were mutually controlled.

Attitudes were assessed with the Enjoyment scale (10 items) of the TOSRA (Section 3.3.3), whereas achievement was assessed using students' examination scores during the study (Section 3.4.2).

This section reports the results of the associations between students' perception of their learning environment and student attitudes (Section 4.5.1) and student achievement (Section 4.5.2). Also this section provides information regarding the consistency of my results with past studies (Section 4.5.3).

Table 4.5 reports the results for the simple correlation and multiple regression analyses for associations between the five learning environment scales and the student outcomes of enjoyment and achievement. This table provides the simple correlation between each learning environment scale and each outcome scale, the multiple correlation between the set of five learning environment scales and each outcome, and the standardized regression coefficient for each learning environment scale for each outcome.

4.5.1 Associations between Learning Environment and Attitudes

When associations between the learning environment and attitudes were investigated through correlation analyses, Table 4.5 shows that all five learning environment scales of the HDYFATC correlated positively and significantly ($p<0.01$) with the Enjoyment scale.

Table 4.5 also shows the multiple correlation between the five learning environment scales of the HDYFATC and students' attitudes was 0.79. This multiple correlation was statistically significant ($p<0.01$) and suggests an association between the set of learning environment scales and student attitudes.

Table 4.5 Associations between Learning Environment Scales and Student Outcomes (Enjoyment and Achievement) Using Simple Correlation and Multiple Regression Analyses

Scale	Outcome-Environments Associations			
	Enjoyment		Achievement	
	r	β	*r*	β
Involvement	0.69**	0.33**	0.38**	0.10*
Task Orientation	0.68**	0.37**	0.34**	0.05
Cooperation	0.61**	-0.03	0.34**	0.02
Equity	0.61**	-0.01	0.37**	0.08*
Comfort	0.67**	0.26**	0.40**	0.16**
Multiple Correlation *R*		0.79**		0.45**

N= 1097 *p<0.05, **p<0.01

Standardized regression coefficients were used to identify which of the five learning environment scales of the HDYFATC contributed uniquely to the variance in the student outcome of attitudes when the other four environment scales were mutually controlled. The results shown in Table 4.5 show that three scales (Involvement, Task Orientation, and Comfort) that were statistically significant ($p<0.01$) independent predictors of student attitudes. For those scales for which associations between the learning environment and attitudes were statistically significant, the regression weights were positive. Overall these analyses suggest that students' perceptions of the learning environment were positively linked to their enjoyment of the class.

4.5.2 Associations between Learning Environment and Achievement

Table 4.5 shows that a positive and statistically significant correlation existed between each of the five learning environment scales of the HDYFATC and achievement ($p<0.01$).

The multiple correlation between the set of all five learning environment scales and student achievement, as shown in Table 4.5, was 0.45 and statistically significant ($p<0.01$). The standardized regression coefficients reported in Table 4.5 indicate that Involvement, Equity, and Comfort each were positive, statistically significant, and independent predictors of student achievement.

Overall these results indicate that students' perceptions of the learning environment were positively linked to their achievement in the class.

4.5.3 Consistency of My Results with Past Studies

My results for outcome-environment associations are consistent with past research as described in Section 2.2.4. In past classroom environment research, the strongest tradition has involved investigating associations between students' cognitive and affective learning outcomes and their perceptions of psychosocial characteristics of their classrooms (Fraser & Fisher, 1982; Haertel, Walberg, & Haertel, 1981; McRobbie & Fraser, 1993). A compilation of 40 past studies shows that the relationships between outcome measures and the way in which students perceive their classroom environment has been replicated for a variety of cognitive and affective outcome measures, a variety of classroom environment instruments and a variety of samples that include numerous countries and grade levels (Fraser, 1994, 2002). Specifically in Asia, associations between students' outcomes and how they perceive their classroom environment have been found in many studies that have involved numerous learning environment instruments, student outcomes, grade levels and school subjects (Chionh & Fraser, 2009; Goh & Fraser, 1998; Wong & Fraser, 1996).

4.6 Summary

This chapter reported the results for the current study's four research questions that included validation of the instrument used (HDYFATC) and the effectiveness of student response systems in terms of the learning environment, attitudes, and achievement. The study also examined whether the use of SRS is differentially effective for males and females in terms of the learning environment, attitudes, and achievement. Associations between the learning environment and the student outcomes of attitudes and achievement were also analyzed. To assess students' perceptions of the learning environment, I used four scales from the WIHIC, together with one new scale (Comfort) created for the purposes of this study. To assess students' attitudes, I used the Enjoyment scale from TOSRA. The validation of these scales was carried out with a sample of 1097 students from 47 classes in New York.

Principal axis factoring followed by varimax rotation and Kaiser normalization was used to confirm the factor structure of the HDYFATC questionnaire. All items had a factor loading of at least 0.40 on their *a priori* scale and less than 0.40 on other scales. The factor loadings for all items ranged from 0.43 to 0.79 on their *a priori* scale. No item had a factor loading of above 0.40 on other scales.

The percentage of variance varied from 2.70% to 53.38% for different scales, with the total variance accounted for being 76.13%. The largest contribution to variance was 53.38% for the Enjoyment scale. Eigenvalues ranged from 1.29 to 25.62 for different scales.

Internal consistency reliability for each scale was estimated for two units of analysis (the student and class mean) using the Cronbach alpha coefficient. When the individual was used as the unit of analysis, the internal consistency reliability (Cronbach alpha coefficient) for different scales of the HDYFATC ranged from 0.94 to 0.95. When the class mean was used as the unit of analysis, the internal consistency reliability was 0.99 for all scales. Reliability estimates were higher when the class mean was used as the unit of analysis. These internal consistency indices are comparable to those in past studies that have used the WIHIC (Aldridge & Fraser, 2000; Chionh & Fraser, 2009).

The ability of each learning environment scale of the HDYFATC to differentiate between perceptions of students in different classes was determined through the use of ANOVA. The ANOVA analyses revealed a significant difference ($p<0.001$) between students' perceptions in different classes for each learning environment scale measured in the HDYFATC, with eta^2 values ranging from 0.50 to 0.60 for the different learning environment scales.

The effectiveness of the use of SRS in terms of learning environment, attitudes, and achievement was also reported in this chapter. The data obtained from the sample of

1097 students in 47 classes were analyzed through a MANOVA to identify differences between SRS and non-SRS students. About half of the students were exposed to the use of SRS in their science class while the other half was not. To maintain a balance, each teacher used SRS in half of their classes but not in the others. All five learning environment scales (Involvement, Task Orientation, Cooperation, Equity, and Comfort) and the two student outcomes of Enjoyment and Achievement scores were used as the dependent variables.

Effect sizes were calculated to indicate the magnitude of the differences between the SRS and control groups, on the learning environment, attitude and achievement scales.

The effect sizes (differences between means expressed in standard deviations) for between-treatment differences for all five learning environment scales of the HDYFATC were remarkably large according to Cohen (1992). The effect sizes ranged from 1.96 to 2.45 for the learning environment scales and were 2.19 for the Enjoyment scale and 1.17 for achievement, respectively. The results of MANOVA and ANOVA revealed statistically significantly higher scores on all learning environment, attitude and achievement scales when SRS was used compared to the control group which did not use SRS. The results for the effectiveness of SRS are consistent with many past studies in terms of students' perceptions of their learning environment (Associated Press, 2005; Duncan, 2008; Guess, 2008; Johnson, 2004; Joosten & Kaleta, 2006; Julian, 1995; Lightstone, 2006; Martyn, 2007; Skiba, 2006; Wampler, 2006; Wood, 2004), their attitudes (Bullough, 1991; Crouch & Mazur, 2001; Duncan, 2008; Judson & Sawada, 2002; Martyn, 2007; Poulis et al., 1998; Roberts, 2005; Siau et al., 2006), and their achievement (Guess, 2008; Martyn, 2007; Mazur, 1997; Poulis et al., 1998).

A two-way MANOVA was used to determine if the use of SRS was differentially effective for males and females. For the two-way MANOVA, the independent variables were the use/non-use of SRS and gender, and the dependant variables were the five learning environments scales and two student outcomes scales (enjoyment and achievement). Task Orientation was the only scale for which a statistically significant interaction emerged, suggesting a degree of differential effectiveness of the use of SRS for males and females.

For Task Orientation, males who did use SRS had an average item mean of 3.79 compared to 2.12 for males in the control group. Females who did use SRS had an average item mean of 3.96 compared to 2.04 for females in the control group. Although both genders had higher task orientation means when they used SRS, females benefited slightly more from SRS than did males. When SRS were not used, males had slightly higher Task Orientation scores. The degree of differential effectiveness found in this present study for males and females and use of SRS was small and of very little educational importance.

Simple correlation and multiple regression analyses were used to investigate the relationships between students' perceptions of the learning environment and the student outcomes of attitudes and achievement. Use of simple correlation analysis revealed that all five learning environment scales of the HDYFATC were correlated positively and significantly ($p<0.01$) with both student attitudes and achievement. Use of multiple regression analysis revealed that Involvement, Task Orientation, and Comfort were statistically significant independent predictors of student attitudes, while Involvement, Equity, and Comfort were statistically significant independent predictors of student achievement. The multiple correlation of the five learning environment scales with student attitudes was 0.79 and with achievement was 0.45, which was statistically significant ($p<0.01$) in each case. These findings of associations between the learning environment and students' attitudes and achievement are consistent with numerous past studies (Chionh & Fraser, 2009; Fraser & Fisher, 1982; McRobbie & Fraser, 1993).

A discussion of these results appears in the following chapter. Implications for classroom practices and limitations of the current study are also discussed.

Chapter 5

Discussion

5.1 Introduction

My study explored the effectiveness of Student Response Systems in terms of student perceptions of the learning environment, attitudes towards science, and achievement, as well as the differential effectiveness of SRS for males and females. The previous chapters have focused upon the rationale and significance of the study (Chapter 1), the literature that supported this work (Chapter 2), the methods used to collect and analyze data (Chapter 3), and the results from analyses of the data to answer the study's four research questions (Chapter 4).

The current chapter includes a summary of Chapters 1–3 (Section 5.2), a summary of the results (Section 5.3), the study's significance and implications (Section 5.4), its limitations (Section 5.5), and recommendations for further research (Section 5.6). Finally, the end of this chapter provides a conclusion of the thesis (Section 5.7).

5.2 Summary of Chapters 1–3

To correctly focus the following discussion of the results of my study, a summary of the thesis is provided, structured around the four research questions that drove the research. Current changes in education which call for an increase in use of technology in the classroom was the rationale for the current study, which was discussed in Section 1.2. The specific type of technology on which this study focused involved electronic student response systems (SRS). I compared the use and non-use of SRS in terms of students' perceptions of the learning environment, attitudes towards the science and achievement. The differential effectiveness of the use of SRS was also examined for males and females.

The thesis started with an introduction (Chapter 1) which included the research problem and questions that drove the study (Section 1.3). Also included was the theoretical framework that guided the research and which clarified of how the research problem and questions were decided upon (Section 1.4). The problem and questions were created based on knowledge of technology, current trends in education, and past research on these two topics.

A brief explanation of the methods used in this study were introduced in Section 1.5. The significance of the study was explained in Section 1.6, especially how it contributed to the field of learning environments. Significant aspects of the study included contributing a new questionnaire that measures learning environment (including comfort) and attitudes, helping schools to determine if investing in this technology is beneficial, determining if the use of SRS is differentially effective for males and females, and providing a research focus at the Grade 7 and Grade 8 levels because most past studies on SRS have concentrated on the college level. A section on the context of the study (Section 1.7) provided an outline of how different aspects of the study were interconnected.

Chapter 2 provided a detailed literature review of literature relevant to the current study. Extensive research has been conducted in the fields of learning environments (Section 2.2) and student attitudes (Section 2.3). As these fields continue to grow, the instruments utilized to measure these constructs continue to be modified and multiplied. The modifications include use at different levels of education, as well as their translation into and validation in different languages. Research on learning environments and student attitudes needs to continue because its findings could guide attempts to keep students engaged in their learning.

Gender differences in science education were reviewed in Section 2.4. All students are entitled to equal opportunities to become scientifically literate. Past research suggests that there are inequities, specifically between males and females. There are small differences in the attitudes of males and females towards science in their elementary years, but the gap typically grows during their middle-school years and into high school. There are numerous suggestions about why these gender gaps exist and how to address them.

Student response systems (SRS) (Section 2.5) allow each student in a classroom to respond to questions posed by the teacher, who can instantly see the answers that each student gives and therefore can gauge their understanding of concepts. SRS can also be used for test and quizzes to instantly provide a grade for each student. There is also an option to have the answers anonymous in order to promote more honest answers when asking personal questions.

SRS are used at all levels of education as well as within corporations. Most of the research on the effectiveness of SRS has been conducted at the college level and has shown that using SRS can improve students' views of the learning environment, their attitudes, and their achievement. There are numerous conditions, however, that can impact on the outcome of these studies. As with all technology, there are also negative consequences associated with the use of SRS, such as slowing down the pace of the class and causing less material to be covered, limited question format, and technical problems.

Chapter 3 explained the research methods that were used in the present study. The sample for this study consisted of 1097 Grade 7 and Grade 8 students from 47 classes in three public schools in New York. More information about the sample was provided in Section 3.5. About half of the sample used SRS while the other half did not. At the conclusion of the study, the students provided the researcher with quantitative data through responding to the items in the How Do You Feel About This Class? (HDYFATC) questionnaire. This questionnaire consists of four learning environment scales from the What Is Happening In this Class? (WIHIC) questionnaire, a learning environment scale created by the researcher to assess comfort, and an attitudes scale from the Test of Science Related Attitudes (TOSRA). Other quantitative data were obtained using students' examination scores during the study. More information regarding data collection was provided in Section 3.4.

The quantitative data were analyzed in numerous ways to answer the research questions. To determine the validity and reliability of the HDYFATC (Section 3.8.1), principal axis factoring (with varimax rotation and Kaiser normalization), Cronbach alpha reliability coefficients, and an ANOVA (to check the ability of each learning environment scale to differentiate between classrooms) were used. To determine if using SRS was effective in terms of students' perceptions of their learning environment, their attitudes, and their achievement (Section 3.8.2), a one-way multivariate analysis of variance (MANOVA) was used with the five learning environment scales and the two outcome scales as the dependent variable and the use or non-use of SRS as the independent variable. To determine if the use of SRS was differentially effective for males and females (Section 3.8.3), a two-way MANOVA was used with the two independent variables being the use/non-use of SRS and gender, and the dependent variables were the five learning environment scales and two student outcomes. Because this multivariate test yielded statistically significant differences overall when Wilks' lambda criterion was used, the individual two-way ANOVA was interpreted for each of the seven dependent variables. To answer the final research question concerning relationships between the learning environment and the student outcomes of attitudes and achievement (Section 2.8.4), simple correlation and multiple regression analyses were used.

5.3 Summary of Results

Results for the first research question, which deals with the validity and reliability of the How Do You Feel About This Class? questionnaire, are discussed in Section 5.3.1. The findings for the second research question, which deals with the effectiveness of SRS in terms of students' perceptions of the learning environment, attitudes and achievement, are discussed in Section 5.3.2. Results for the third research question, dealing with the differential effectiveness of the use of SRS for males and females, are discussed in Section 5.3.3. Finally, findings for the fourth question, which deals with associations between the classroom learning environment and students' attitudes and achievement, are summarized in Section 5.3.4.

5.3.1 Research Question 1

Research Question 1:

> Is the How Do You Feel About This Class? questionnaire valid and reliable with Grade 7 and Grade 8 students in New York?

The instrument used in this study to assess students' perceptions of their learning environment and their attitudes mainly includes scales from already well-known and widely-used questionnaires. These scales were chosen because of their relevance to the study. The original version of the questionnaire consisted of five of the seven learning environment scales contained in the What Is Happening In this Class? (WIHIC): Involvement, Student Cohesiveness, Task Orientation, Cooperation, and Equity. The WIHIC scales of Teacher Support and Investigation were omitted because they do not assess constructs that were highly relevant to my study. The WIHIC was previously discussed in Section 2.2.3 and Section 3.3.1.

To accurately assess students' perception of their learning environment and their attitudes, two more scales needed to be added. A learning environments scale, Comfort, was created by the researcher to assess how comfortable students are in their science class. The Enjoyment of Science Lessons scale was used to assess students' attitudes. This scale was created by selecting and adapting questions found in the Test Of Science-Related Attitudes (TOSRA). The TOSRA was discussed in Section 2.3.2 and Section 3.3.3.

Both the WIHIC (Fraser, Fisher, & McRobbie, 1996) and TOSRA (Fraser, 1981) have been used in numerous countries, in numerous languages, at various age levels, in many content areas, and with many thousands of students. Both instruments have been consistently found to be valid, reliable, able to distinguish between different classes, and useful in a variety of research applications (see Section 2.2.3.2 and Section 2.3.2.2).

The 48-item, six-scale How Do You Feel About This Class? (HDYFATC) questionnaire was administered to 1097 Grade 7 and Grade 8 students from 47 classes in three schools in New York State. The sample was described in more detail in Section 3.5. To examine the internal structure of the HDYFATC, principal axis factoring followed by varimax rotation and Kaiser Normalization was used.

In order for an item to be retained, it needed a factor loading of at least 0.40 on its *a priori* scale and less than 0.40 on another scale. Table 4.1 shows that the factor loadings for all items of the HDYFATC were above 0.40 on their *a priori* scale, ranging from 0.43 to 0.79. No item had a loading greater than 0.40 on a different scale. Therefore all 48 items and all six scales were retained.

The percentage of the total variance extracted with each factor ranged from 2.70% to 53.38% for different scales, with the total variance accounted for being 76.13%. The largest contribution to variance was for Enjoyment (53.38%). The eigenvalues ranged from 1.29 to 25.62 for different scales. The results of the factor analysis strongly support the factorial validity of the final 48-item, six-scale version of the

HDYFATC when used with my sample of 1097 middle-school students in New York.

Internal consistency reliability is a measure of the extent to which items in the same scale measure a common theme. For each of the six scales of the HDYFATC, the reliability was estimated for two units of analysis (the student and the class mean). The Cronbach alpha reliability coefficient was used as an index of scale internal consistency. When the individual was used as the unit of analysis, the internal consistency reliability (Cronbach alpha coefficient) for different scales of the HDYFATC ranged from 0.94 to 0.95. When the class mean was used as the unit of analysis, the internal consistency reliability was 0.99 for all scales. Reliability estimates were higher when the class mean was used as the unit of analysis.

Through using an ANOVA, the ability of each learning environment scale of the HDYFATC to differentiate between perceptions of students in different classrooms was determined. ANOVA indicates if students in the same class perceive their learning environment in a similar way, while mean class perceptions vary from class to class. Results revealed that a significant difference between students' perceptions in different classes for each learning environment scale of the HDYFATC. The eta^2 statistic, which represents the proportion of variance in scale scores accounted for by class membership, ranged from 0.50 to 0.60 for the different learning environment scales. (This characteristic is not relevant for the Enjoyment scale.)

As in considerable past research (Afari, Aldridge, Fraser & Khine, in press; Aldridge & Fraser, 2000; Chionh & Fraser, 2009; den Brok, Fisher, Rickards, & Bull, 2006; Dorman 2008; Helding & Fraser, in press; MacLeod & Fraser, 2010; Martin-Dunlop & Fraser, 2007; Robinson & Fraser, in press; Wolf & Fraser, 2008), scales from the WIHIC and TOSRA showed a strong validity and reliability.

5.3.2 Research Question 2

Research Question 2:

Is the use of Student Response Systems effective in terms of:

(a) the learning environment?

(b) student attitudes?

(c) student achievement?

The teachers who participated in this study used SRS in half of their classes and kept all other variables as constant as possible between the control and experimental classes. This was done to minimize the impact that the teacher had on the students' perceptions of their learning environment, their attitudes, and achievement. To determine the effectiveness of the use of SRS in terms of learning environment, attitudes, and achievement, MANOVA was used. As recommended by Thompson (1998, 2002), effect sizes were calculated to determine the magnitude of the difference between the SRS and control groups expressed in standard deviation units (the difference between the means of two groups divided by the pooled standard deviation). To assess student achievement, average examination scores were used.

To ascertain the statistical significance of differences between the two instructional groups, a one-way multivariate analysis of variance (MANOVA) was conducted with the six learning environment scales and student outcome scales (achievement and enjoyment) as the dependent variables and the use or non-use of SRS as the independent variable. Because the multivariate test using Wilks' lambda criterion yielded a statistically significant result overall for the whole set of seven dependent variables, the univariate ANOVA results were interpreted separately for each individual dependent variable. The F values and statistical significance result for the ANOVA, as well as the effect size, for each of the seven learning environment and student outcome variables were determined.

Students in classes in which SRS were used had statistically significantly higher scores on all learning environment scales contained in the HDYFATC than did students in the control group. Effect sizes ranged from 1.96 to 2.46 standard deviations. Also, students who used SRS enjoyed science classes statistically significantly more than students who did not use SRS, with an effect size of 2.19 standard deviations, and had statistically significantly higher achievement, with an effect size of 1.17 standard deviations. These effect sizes are remarkably large according to Cohen (1992), who defines a 'large' effect sizes as over 0.40 standard deviations.

Previous studies of the effectiveness of using SRS have revealed similar results and have reported improvements in involvement (Duncan, 2008; Johnson, 2004; Joosten & Kaleta, 2006; Julian, 1995; Lightstone, 2006; Martyn, 2007; Wampler, 2006;

Wood, 2004), equity (Associated Press, 2005; Duncan, 2008; Johnson, 2004; Martyn, 2007), students' feelings of comfort in their science class (Duncan, 2008; Martyn, 2007), attitudes (Burnstein & Lederman, 2001; Crouch & Mazur, 2001; Duncan, 2008; Judson & Sawada, 2002; Martyn, 2007; Poulis, Massen, Robens, & Dilbert, 1998; Roberts, 2005; Siau, Sheng, & Nah, 2006), achievement (Guess, 2008; Martyn, 2007; Mazur, 1997; Poulis et al., 1998), and task orientation and cooperation (Guess, 2008; Skiba, 2006).

5.3.3 Research Question 3

Research Questions 3:

> Is the use of Student Response Systems differentially effective for males and females in terms of:
>
> (a) the learning environment?
> (b) student attitudes?
> (c) student achievement?

To answer my third research question, a two-way MANOVA was used with the independent variables being the use/non-use of SRS and gender, and the dependent variables being the five learning environment scales and the two student outcome scales (enjoyment and achievement). Because the multivariate test yielded statistically significant differences overall when Wilks' lambda criterion was used, the individual two-way ANOVA was interpreted for each of the seven dependent variables. The presence of a statistically significant instruction-by-gender interaction was considered to indicate differential effectiveness for different genders. Effect sizes were determined using eta^2 an indicator of the proportion of variance explained.

The use of SRS was found to be differentially effective for males and females only for the one scale of Task Orientation. Although both genders had higher Task Orientation means when they used SRS, females benefited slightly more from SRS than did males. When SRS were not used, males had slightly higher Task Orientation scores. However, the degree of differential effectiveness of SRS for males and females for the Task Orientation scale was very small, with only 0.01 of variance accounted for. Therefore, the magnitude of the differential effectiveness of using SRS for males and females can be considered to be of quite minor educational importance.

5.3.4 Research Question 4

Research Questions 4:

Are there associations between the learning environment and:

(a) student attitudes?

(b) student achievement?

Simple correlation and multiple regression analyses were used to investigate the relationships between students' perceptions of the learning environment and the student outcomes of attitudes and achievement. Simple correlation was used to examine the bivariate relationship between each student outcome with each of the five learning environment scales of the HDYFATC. Multiple regression analysis was carried out to determine the joint influence of the set of correlated learning environment scales on each student outcome. The regression coefficient provided information about which environment scales contributed to variance in students' attitudes or achievement when all other environment scales were mutually controlled.

The simple correlation analyses revealed that all five learning environment scales were correlated positively and significantly with both enjoyment and achievement.

The multiple correlation between the five learning environment scales was 0.79 for students' attitudes and 0.45 for achievement, and was statistically significant in both cases.

Standardized regression coefficients were used to identify which of the five learning environment scales contributed uniquely to the variance in student outcomes when the other four environment scales were mutually controlled. Involvement, Task Orientation, and Comfort were statistically significant independent predictors of student attitudes. Involvement, Equity, and Comfort each were positive, statistically significant, and independent predictors of student achievement. For those scales for which associations between the learning environment and outcomes were statistically significant, the regression weights were positive.

These results, indicating that students' perceptions of the learning environment were positively linked to their attitudes and achievement, are consistent with past research (Fraser & Fisher, 1982; Haertel, Walberg, & Haertel, 1981; McRobbie & Fraser, 1993). A compilation of 40 past studies shows that the relationships between outcome measures and the way in which students perceive their classroom environment has been replicated for a variety of cognitive and affective outcome measures, a variety of classroom environment instruments and a variety of samples that include numerous countries and grade levels (Fraser, 1994, 2002). Specifically in Asia, associations between students' outcomes and how they perceive their classroom environment have been found in many studies that have involved numerous learning environment instruments, student outcomes, grade levels and school subjects (Chionh & Fraser, 2009; Fraser, Aldridge, & Adolphe, 2010; Goh & Fraser, 1998; Wong & Fraser, 1996).

5.4 Significance and Implications

This evaluation of SRS at the middle school (Grade 7 and Grade 8) level is distinctive because most past research on the effectiveness of SRS has been conducted at the higher levels of education.

The questionnaire used in this current study, How Do You Feel About This Class? (HDYFATC) (Appendix A) was shown to be reliable and valid for the sample of Grade 7 and Grade 8 students (see Section 4.2). This questionnaire, which took only approximately 10 minutes for students to complete, can be used with confidence by future researchers and teachers to assess students' perceptions of the learning environment and student attitudes.

Based on the findings of this study, the use of SRS in science classrooms can help to improve student perceptions of the learning environment, their attitudes towards science, and their achievement. School districts can use the findings from this study to help them to decide if investing a portion of their monetary budget on this specific technology is likely to be beneficial to their students. Although many schools attempt to maintain the latest technology when possible, this new technology is very expensive, especially during the current economic crisis. Districts might only wish to invest in technology that has been shown by research to have a positive impact on students. School district personnel could turn to my study for guidance about whether purchasing SRS is likely to be a worthy investment.

The use of SRS can help to address the needs and desires of adolescent learners. Because these students typically favor active over passive learning experiences and have a preference for interactions with peers during educational activities (Kellough & Kellough, 2008), the conversations developed as a result of the use of SRS in the classroom can address these desires. Also, these adolescent learners have a strong need to belong to a peer group because peer approval becomes more important while adult approval becomes less important (Scales, 2003). Therefore, the anonymity of SRS can prevent students from feeling singled out when responding to questions.

Both males and females greatly benefited from the use of SRS in their science classes. The only scale that was differentially effective was Task Orientation. Female scores were slightly higher than males on this scale when SRS were used. The degree of differential effectiveness found in this study for males and females and the use of SRS was small and of very little educational importance. This could be relevant for educators trying to promote gender equity in their classrooms.

All five learning environment scales of the HDYFATC correlated positively and significantly with both student outcomes of attitudes and achievement. It was also found that Involvement, Task Orientation, and Comfort were statistically significant independent predictors of student attitudes. Involvement, Equity, and Comfort were statistically significant independent predictors of student achievement. The practical implication of these findings is that changing the learning environment to emphasize these dimensions could lead to better student achievement and more student interest in enrolling in more science courses later on in their education and possibly pursuing a science-oriented career.

5.5 Limitations

Because it is not possible for a single study to encompass all possible variables, some limitations are unavoidable. Because of this, various methods were implemented to reduce the effects of these unavoidable variables in the study.

Most past studies have has the same limitation related to their samples. The larger the sample, the more accurate the results will be. My sample size was limited by the availability of resources (SRS sets). Not only is the size of the sample a limitation in this study, but also its representativeness was restricted because the ethnic background, socioeconomic background and geographic location of the sample were limited.

Because my study involved quantitative data obtained through students responding to the HDYFATC questionnaire, it could not provide explanations of why students responded in the way that they did. Much progress has been made in incorporating both qualitative and quantitative research methods in the same study of learning environments (Fraser & Tobin, 1991; Tobin & Fraser, 1998). In some notable studies, qualitative methods, such as interviews with small groups of students, were used to check the suitability of a learning environment questionnaire and modifying it before using it in a large-scale study (Aldridge, Fraser, & Huang, 1999; Fraser, Aldridge, & Soerjaningsih, 2010).

Another limitation in this study was the length of time over which the study took place. It was only possible for this study to run for about four months. If the study had a longer time range, perhaps the results would have given a clearer picture of the effectiveness of SRS in terms of the students view of their learning environment, their attitudes, and their achievement.

Although all participants in this study used the same type of SRS, there are many companies now that manufacture this type of technology, each with its own benefits and methods of use. Because this study only provided insight for one specific type of SRS, my results of this study cannot be generalized to the use of other types of SRS.

How students feel and perform in their classes can be influenced by their teacher's personality. Because some students like certain teachers while others do not, it can be difficult to generalize my findings to other teachers. To minimize the impact of the teacher in the study, my study's design involved each teacher teaching a similar number of students in both the control and experimental groups. This also minimized the impact of teaching styles and assessment methods on the outcomes of the study.

5.6 Recommendations for Further Research

Even with the limitations discussed in Section 5.4, this study has provided much valuable information that can help to guide future research on the effectiveness of

SRS. Future studies on this topic should accommodate the limitations stated in an attempt to gain a deeper understanding of the effect that using SRS has on students.

Subsequent studies should involve larger and more representative samples of students. These students should be selected from a larger geographic area, more schools, different socio-economic backgrounds, and different ethnicities in order to obtain more generalizable findings about the effectiveness of SRS.

Future studies should also take place over a longer period of time than the four-month duration in my study. This would help in determining if the findings of this study are valid for the full course or just for the first few months of the school year. Students' perceptions of their learning environment, their attitudes, and their achievement could change throughout the year.

Further research should incorporate qualitative methods for obtaining data as recommended by Tobin and Fraser (1998). This would allow for a deeper understanding of why the students responded in the way that they did to the HDYFATC questionnaire. This information could also lead to a better understanding of what specifically students like about the SRS and what they do not like. The teacher could modify their lessons to address these findings.

Researchers also could conduct similar studies in other content areas besides science to see if my findings are generalizable to other subjects as well. The effectiveness of SRS at other grade levels, specifically those for which there is limited or no past research (elementary and lower/middle-school grades), also could be investigated.

It would be desirable to investigate the effectiveness of SRS for students of different levels of ability. It would be interesting to see if SRS is differentially effective for special-education students and students with advanced abilities.

Different types of SRS should also be evaluated in future studies to see if the results of my study are replicated with other manufacturers' designs for SRS, or if the findings in this study are specific to only the brand of SRS that I used.

The effect of teacher gender on the use of SRS might be investigated in terms of students' perceptions of their learning environment, their attitudes, and achievement.

A larger sample of students from more schools and from a larger geographic region would help in making this type of study possible.

While having each teacher who participated in this study teach both the control and experimental groups helped to minimize the influence of the teacher and his/her methods of teaching as variables that would influence the findings of this study, it might be beneficial to require all teachers in future studies to teach the same lessons in the same way and to use common assessment methods. But it could be difficult to find teachers willing to participate in a study like this, as they often enjoy their freedom of teaching practices and tend to stick with teaching methods with which they are comfortable and familiar.

5.7 Conclusion

It was felt that there was much to learn from investigating the effect that student response systems (SRS) have on students' perceptions of their learning environment, their attitudes, and their achievement. After finding that the How Do You Feel About This Class? (HDYFATC) questionnaire scales were valid and reliable when used with Grade 7 and Grade 8 students in New York State, comparisons were made between the use and non-use of SRS using these scales. The results of this study could help in showing the importance of new technology in classrooms for promoting better learning environments, attitudes, and achievement for students, while still meeting the curricular and assessment requirements of different locations. This technology could offer more equitable classroom participation to all students and could help teachers to assess all students' learning.

My study investigated the effectiveness of SRS in terms of students' perceptions of the learning environment, their attitudes, and achievement in science. The use of SRS was found to be effective in terms of all five learning environment scales (involvement, task orientation, cooperation, equity, and comfort) and the two outcomes of enjoyment and achievement. Effect sizes were unusually large for all scales.

Both males and females benefited from the use of SRS in their science class. Of all the scales contained in the HDYFATC, the learning environment of Task Orientation was the only one that was found to be slightly more beneficial for females than males.

This study identified associations between students' perceptions of their learning environment and their attitudes and achievement. All five learning environment scales of the HDYFATC were correlated positively and significantly with student attitudes and achievement. Involvement, Task Orientation, and Comfort were statistically significant independent predictors of student attitudes. This suggests that a more favorable perception of the learning environment can improve students' enjoyment of the class. Involvement, Equity, and Comfort were statistically significant independent predictors of student attitudes, suggesting that a more favorable perception of the learning environment can improve students' achievement in the class.

Within the context of my study, the use of SRS appeared to be effective in improving the learning environment, attitudes, and achievement in the middle grades. Through implementing this technology, student enjoyment increased and the students felt more comfortable in the classroom. For schools that have the monetary resources available, it appears to be wise for them to consider purchasing some sets of SRS.

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Appendices

The following pages contain the appendices related to this research. These include the questionnaires used in my study as well as the results of some analyses based on data collected by administering previous iterations of the questionnaires.

Appendix A: How Do You Feel About This Class? Questionnaire Revised..........138
Appendix B: Participant Information Sheet..........141
Appendix C: Consent Form..........142
Appendix D: Letter to Teacher Participants..........143
Appendix E: How Do You Feel About This Class? Questionnaire..........144
Appendix F: Factor Analysis Results for Learning Environment and Attitude Scales for Previous Study..........147
Appendix G: Internal Consistency Reliability (Cronbach Alpha Coefficient), Discriminate Validity (Mean Correlation with Other Scales), and Ability to Differentiate Between Classrooms (ANOVA Results) for Learning Environment and Attitude Scales for Previous Study..........148

Appendix A: How Do You Feel About This Class? Questionnaire Revised

HOW DO YOU FEEL ABOUT THIS CLASS?

This survey contains a number of statements about this science class and practices that take place here.

There are no "right" or "wrong" answers". Your opinion is all that is wanted.

Think about each statement and draw a circle around:

1	if you	**STRONGLY DISAGREE**
2	if you	**DISAGREE**
3	if you are	**NOT SURE**
4	if you	**AGREE**
5	if you	**STRONGLY AGREE**

For example: Suppose you **agree** with the statement "It would be interesting to read more science-related books." You then circle **4** next to the statement. If you change your mind, cross out your answer and circle the correct one.

Although some statements might appear to be similar, please respond to every statement contained in this questionnaire.

YOUR ANSWERS ON THIS QUESTIONNAIRE WILL HAVE NO IMPACT ON YOUR GRADES OR RELATIONSHIP WITH YOUR TEACHER, SO <u>PLEASE BE HONEST</u>.

Name: __________________________

Are you a *(circle one)*: Male or Female

Teacher's Name: __________________________ Class Period: ____

School: __________________________

Grade: ___

		Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
1	Science lessons are fun.	1	2	3	4	5
2	School should have more science lessons each week.	1	2	3	4	5
3	Science lessons are interesting to me.	1	2	3	4	5
4	Science lessons are important.	1	2	3	4	5
5	I like science lessons.	1	2	3	4	5
6	Science is one of the most interesting subjects.	1	2	3	4	5
7	I enjoy going to science class.	1	2	3	4	5
8	I look forward to science class.	1	2	3	4	5
		Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
9	I discuss ideas in class.	1	2	3	4	5
10	I give my opinions during class discussions.	1	2	3	4	5
11	The teacher asks me questions.	1	2	3	4	5
12	My ideas and suggestions are used during classroom discussions.	1	2	3	4	5
13	I ask the teacher questions.	1	2	3	4	5
14	I explain my ideas to other students.	1	2	3	4	5
15	Students discuss with me how to go about solving problems.	1	2	3	4	5
16	I am asked to explain how I solve problems.	1	2	3	4	5
		Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
17	Getting a certain amount of work done is important to me.	1	2	3	4	5
18	I do as much as I set out to do.	1	2	3	4	5
19	I know the goals for this class.	1	2	3	4	5
20	I am ready to start this class on time.	1	2	3	4	5
21	I know what I am trying to accomplish in this class.	1	2	3	4	5
22	I pay attention during this class.	1	2	3	4	5
23	I try to understand the work in this class.	1	2	3	4	5
24	I know how much work I have to do.	1	2	3	4	5
		Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
25	I cooperate with other students when doing assigned work.	1	2	3	4	5
26	I share my books and resources with other students when doing assignments.	1	2	3	4	5
27	When I work in groups in this class, there is teamwork.	1	2	3	4	5
28	I work with other students on projects in this class.	1	2	3	4	5

In this questionnaire, items 1–8 are based on the *Test of Science-Related Attitudes* (TOSRA; Fraser, 1981) described in Section 2.3.2 and items 9–40 come from the *What Is Happening In this Class?* (WIHIC; Aldridge & Fraser, 2000) questionnaire described in Section 2.2.4. These questionnaire items were used in my study and included in this thesis with the authors' permission. Items 41–48 were developed by me.

		Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
29	I learn from other students in this class.	1	2	3	4	5
30	I work with other students in this class.	1	2	3	4	5
31	I cooperate with other students on class activities.	1	2	3	4	5
32	Students work with me to achieve class goals.	1	2	3	4	5
		Strongly Disagree	**Disagree**	**Not Sure**	**Agree**	**Strongly Agree**
33	The teacher gives as much attention to my questions as to other students' questions.	1	2	3	4	5
34	I get the same amount of help from the teacher as do other students.	1	2	3	4	5
35	I have the same amount of say in this class as other students.	1	2	3	4	5
36	I am treated the same as other students in this class.	1	2	3	4	5
37	I receive the same encouragement from the teacher as other students do.	1	2	3	4	5
38	I get the same opportunity to contribute to class discussions as other students.	1	2	3	4	5
39	My work receives as much praise as other students' work.	1	2	3	4	5
40	I get the same opportunity to answer questions as other students.	1	2	3	4	5
		Strongly Disagree	**Disagree**	**Not Sure**	**Agree**	**Strongly Agree**
41	I raise my hand when I know the answer to questions.	1	2	3	4	5
42	I am happy to ask questions in this class.	1	2	3	4	5
43	I participate in science class more than I do in my other classes.	1	2	3	4	5
44	I am happy to answer questions in this class.	1	2	3	4	5
45	I am comfortable when raising my hand to participate in this class.	1	2	3	4	5
46	I raise my hand at the end of the class as much as I do when the class first begins.	1	2	3	4	5
47	I don't worry about what other students think about my answers to questions.	1	2	3	4	5
48	I am happy to tell the teacher when I don't understand.	1	2	3	4	5

Appendix B: Participant Information Sheet

Curtin University of Technology
School of Science and Mathematics Education

Participant Information Sheet

My name is Stephen Cohn. I am currently completing a piece of research for my Doctor of Philosophy in Science Education at Curtin University of Technology.

Purpose of Research
I am investigating the effect that a common piece of technology has on students. I am interested to see if this technology in the classroom has any affect on the students' views of their learning environment as well as their comfort level and achievement in this class.

Your Role
I will be asking you to take a brief survey at the conclusion of my study. This survey will take approximately 5 minutes to complete. I will also request your test grades, obtained during this study only, from your teacher. Some students may be asked to participate in brief interviews as well, but not required.

Consent to Participate
Your involvement in the research is entirely voluntary. You have the right to withdraw at any stage without it affecting your rights or my responsibilities. When you have signed the consent form, I will assume that you have agreed to participate and allow me to use your data in this research.

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

Further Information
This research has been reviewed and given approval by Curtin University of Technology Human Research Ethics Committee (approval number SMEC-11-09). If you would like further information about the study, please feel free to contact me by phone (845) 680-1100 ext. 7249, or by e-mail scohn@socsd.org. Alternatively, you can contact my supervisor, Professor Barry Fraser, by phone (Australia) +61 (0)8-9266-7896, or e-mail b.fraser@curtin.edu.au.

Thank you for your involvement in this research.
Your participation is greatly appreciated.

Appendix C: Consent Form

CONSENT FORM

- I understand the purpose 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, 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.

Participant's Name: ____

Participant's Signature: ___________________________ Date: _____________

Parent/Guardian's Signature: ______________________ Date: _____________

By signing this paper, you agree to participate in the study by completing the questionnaire at the conclusion of the study as well as allow the teacher to provide the researcher with your test grades obtained during the study. This DOES NOT mean that you agree to be interviewed. To agree to be eligible to participate in interviews, please check the box below:

☐ **I would like to be considered to be interviewed about my experiences during this study.**

Appendix D: Letter to Teacher Participants

July 22, 2009

Who To
School
Address

Dear name,

Thank you for your willingness to help with the data collection for my doctoral research. I've enclosed a few items for you and have listed them below:

- Participant Information Sheet outlining specific information about the study for students and their guardians
- Consent Form to be filled out by each student and their guardian granting permission to participate in the study
- A survey instrument called the How Do You Feel About This Class? questionnaire that will be given to each student at the conclusion of the study
- A letter of approval from the Human Research Ethics Committee at Curtin University of Technology acknowledging that my study is ethically acceptable
- My candidacy proposal outlining the goals of this study, significance, background information, research methods and ethics considerations as well as other useful information for your reference

I will be providing copies of any material that will be handed out to the students. I will also be providing the Student Response Systems required to complete this study.

At the conclusion of the study, I may be returning to your school to interview a few students, provided you give me permission to do so.

Thank you again! Please contact me if there are any questions or problems.

Sincerely,

Stephen T. Cohn
914-262-2068
scohn@socsd.org

Appendix E: How Do You Feel About This Class? Questionnaire

HOW DO YOU FEEL ABOUT THIS CLASS?

This survey contains a number of statements about this science class and practices that take place here.

There are no "right" or "wrong" answers". Your opinion is all that is wanted.

Think about each statement and draw a circle around:

1	if you	**STRONGLY DISAGREE**
2	if you	**DISAGREE**
3	if you are	**NOT SURE**
4	if you	**AGREE**
5	if you	**STRONGLY AGREE**

For example: Suppose you **agree** with the statement "It would be interesting to read more science-related books." You then circle **4** next to the statement. If you change your mind, cross out your answer and circle the correct one.

Although some statements might appear to be similar, please respond to every statement contained in this questionnaire.

ENJOYMENT OF SCIENCE LESSONS		Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
1	Science lessons are fun.	1	2	3	4	5
2	School should have more science lessons each week.	1	2	3	4	5
3	Science lessons are interesting to me.	1	2	3	4	5
4	Science lessons are important.	1	2	3	4	5
5	I like science lessons.	1	2	3	4	5
6	Science is one of the most interesting subjects.	1	2	3	4	5
7	I enjoy going to science class.	1	2	3	4	5
8	I look forward to science class.	1	2	3	4	5
INVOLVEMENT		**Strongly Disagree**	**Disagree**	**Not Sure**	**Agree**	**Strongly Agree**
9	I discuss ideas in class.	1	2	3	4	5
10	I give my opinions during class discussions.	1	2	3	4	5
11	The teacher asks me questions.	1	2	3	4	5
12	My ideas and suggestions are used during classroom discussions.	1	2	3	4	5
13	I ask the teacher questions.	1	2	3	4	5
14	I explain my ideas to other students.	1	2	3	4	5
15	Students discuss with me how to go about solving problems.	1	2	3	4	5
16	I am asked to explain how I solve problems.	1	2	3	4	5
STUDENT COHESIVENESS		**Strongly Disagree**	**Disagree**	**Not Sure**	**Agree**	**Strongly Agree**
17	I make friendships among students in this class.	1	2	3	4	5
18	I know other students in this class.	1	2	3	4	5
19	I am friendly to members of this class.	1	2	3	4	5
20	Members of this class are my friends.	1	2	3	4	5
21	I work well with other class members.	1	2	3	4	5
22	I help other class members who are having trouble with their work.	1	2	3	4	5
23	Students in this class like me.	1	2	3	4	5
24	In this class, I get help from other students.	1	2	3	4	5
TASK ORIENTATION		**Strongly Disagree**	**Disagree**	**Not Sure**	**Agree**	**Strongly Agree**
25	Getting a certain amount of work done is important to me.	1	2	3	4	5
26	I do as much as I set out to do.	1	2	3	4	5
27	I know the goals for this class.	1	2	3	4	5
28	I am ready to start this class on time.	1	2	3	4	5
29	I know what I am trying to accomplish in this class.	1	2	3	4	5
30	I pay attention during this class.	1	2	3	4	5
31	I try to understand the work in this class.	1	2	3	4	5
32	I know how much work I have to do.	1	2	3	4	5

In this questionnaire, items 1–8 are based on the *Test of Science-Related Attitudes* (TOSRA; Fraser, 1981) described in Section 2.3.2 and items 9–48 come from the *What Is Happening In this Class?* (WIHIC; Aldridge & Fraser, 2000) questionnaire described in Section 2.2.4. These questionnaire items were used in my study and included in this thesis with the authors' permission. Items 49–56 were written by me.

COOPERATION		Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
33	I cooperate with other students when doing assigned work.	1	2	3	4	5
34	I share my books and resources with other students when doing assignments.	1	2	3	4	5
35	When I work in groups in this class, there is teamwork.	1	2	3	4	5
36	I work with other students on projects in this class.	1	2	3	4	5
37	I learn from other students in this class.	1	2	3	4	5
38	I work with other students in this class.	1	2	3	4	5
39	I cooperate with other students on class activities.	1	2	3	4	5
40	Students work with me to achieve class goals.	1	2	3	4	5

EQUITY		Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
41	The teacher gives as much attention to my questions as to other students' questions.	1	2	3	4	5
42	I get the same amount of help from the teacher as do other students.	1	2	3	4	5
43	I have the same amount of say in this class as other students.	1	2	3	4	5
44	I am treated the same as other students in this class.	1	2	3	4	5
45	I receive the same encouragement from the teacher as other students do.	1	2	3	4	5
46	I get the same opportunity to contribute to class discussions as other students.	1	2	3	4	5
47	My work receives as much praise as other students' work	1	2	3	4	5
48	I get the same opportunity to answer questions as other students.	1	2	3	4	5

COMFORT		Strongly Disagree	Disagree	Not Sure	Agree	Strongly Agree
49	I raise my hand when I know the answer to questions.	1	2	3	4	5
50	I am happy to ask questions in this class.	1	2	3	4	5
51	I participate in science class more than I do in my other classes.	1	2	3	4	5
52	I am happy to answer questions in this class.	1	2	3	4	5
53	I am comfortable when raising my hand to participate in this class.	1	2	3	4	5
54	I raise my hand at the end of the class as much as I do when the class first begins.	1	2	3	4	5
55	I don't worry about what other students think about my answers to questions.	1	2	3	4	5
56	I am happy to tell the teacher when I don't understand.	1	2	3	4	5

Appendix F: Factor Analysis Results for Learning Environment and Attitude Scales for Previous Study

	Factor Loadings					
Item No	Involvement	Task Orientation	Cooperation	Equity	Comfort	Enjoyment
INV 9	0.73					
INV 10	0.81					
INV 12	0.48					
INV 14	0.48					
INV 16	0.47					
TO 25		0.52				
TO 26		0.64				
TO 27		0.63				
TO 28		0.58				
TO 29		0.52				
TO 30		0.65				
TO 31		0.67				
TO 32		0.63				
CO 33			0.48			
CO 34			0.57			
CO 35			0.60			
CO 36			0.48			
CO 38			0.77			
CO 39			0.80			
CO 40			0.51			
EQ 41				0.63		
EQ 42				0.64		
EQ 43				0.72		
EQ 44				0.68		
ED 45				0.80		
EQ 46				0.79		
EQ 47				0.66		
EQ 48				0.68		
CF 49					0.51	
CF 50					0.68	
CF 51					0.53	0.52
CF 52					0.61	
CF 53					0.75	
CF 54					0.66	
CF 55					0.64	
CF 56					0.62	
ENJ 1						0.73
ENJ 2						0.60
ENJ 3						0.75
ENJ 5						0.72
ENJ 6						0.72
ENJ 7						0.81
ENJ 8						0.76
% Variance	3.86	5.59	4.28	29.84	7.63	9.77
Eigenvalue	1.66	2.40	1.84	12.83	3.28	4.20

The sample consisted of 144 students.
Factor loadings smaller than 0.40 have been omitted from the table.
Principal axis factoring with varimax rotation and Kaiser normalization.
Total proportion of variance = 60.97%
Items 11, 13, 15, 37 and 4 were omitted.

Appendix G: Internal Consistency Reliability (Cronbach Alpha Coefficient), Discriminate Validity (Mean Correlation with Other Scales), and Ability to Differentiate Between Classrooms (ANOVA Results) for Learning Environment and Attitude Scales for Previous Study

Scale	No of Items	Unit of Analysis	Alpha Reliability	Mean Correlation	ANOVA *Eta*^{2}
Learning Environment					
Involvement	5	Student	0.79	0.38	0.08
		Class	0.82	0.33	
Task Orientation	8	Student	0.89	0.44	0.17**
		Class	0.95	0.48	
Cooperation	7	Student	0.83	0.36	0.10
		Class	0.84	0.39	
Equity	8	Student	0.92	0.44	0.13*
		Class	0.96	0.55	
Comfort	8	Student	0.88	0.38	0.11
		Class	0.92	0.41	
Enjoyment	7	Student	0.91		
		Class	0.97		

The sample consisted of 144 students in 10 classes.
* p<0.05, ** p <0.01