Science and Mathematics Education Centre

An Evaluation of Elementary School Science Kits in Terms of Classroom Environment and Student Attitudes

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DECLARATION

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

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

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ABSTRACT

The purpose of this evaluation study was to compare students' perceptions of their science classroom environment when using science kits, textbooks or a combination of science kits, textbooks and teacher-created materials. This year-long study involved using a learning environment questionnaire, namely the *My Class Inventory (MCI)*, interviews and observations to assess which of the three treatments leads to a more positive learning environment. Three questions investigated were whether (1) the learning environment can be reliably and validly assessed among Grade 3–5 students in Texas, (2) instruction using textbooks, science kits, or a combination of textbooks and science kits is more effective in terms of changes in student attitudes and learning environment perceptions, and (3) there are associations between student attitudes toward science classes and the classroom environment? Administrators and teachers in Texas are searching for ways to improve the scores received on standardized tests. For more than 40 years, research has shown that positive classroom environments can lead to improvement in achievement. Therefore I chose to investigate the above questions using a learning environments framework.

This study was conducted in three urban elementary schools in North Texas. There were a total of 588 students in 28 classrooms with 16 different teachers involved in this research. The schools were similar in demographic features such as ethnicity and socioeconomic status.

Analyses of data collected with the *My Class Inventory* (MCI) supported the instrument's factorial validity, internal consistency reliability, and ability to differentiate between the perceptions of students in different classrooms. Also, simple correlation and multiple regression analyses indicated reasonably strong and positive associations between each classroom environment scale and the students' satisfaction. The Satisfaction scale was used as an outcome variable, following the lead of Majeed, Fraser and Aldridge (2002). Results from the MCI, interviews and observations indicated that students preferred a more positive classroom environment in terms of Cohesiveness, Competition, and Friction. Importantly, the group of students using science kits experienced greater pretest-posttest changes in satisfaction and classroom cohesiveness than did either the textbook group of the combination group.

This study supports previous research that combined qualitative and quantitative methods of data collection. Qualitative methods suggested that students preferred a more hands-on presentation of science lessons rather than a textbook presentation. This was suggested in interviews with students and teachers and by observations of students in their science classes.

This research evaluated three educational methods to determine which instructional method would produce a more positive learning environment and student satisfaction. These results suggest that the utilization of science kits achieves this goal as measured by student satisfaction and cohesiveness.

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INTRODUCTION

Students spend a huge amount of time at school. Jackson's (1968) *Life in Classrooms* estimates that this is as high as approximately 7000 hours by the end of primary school... Therefore, students certainly have a great interest in what happens to them at school… and students' reactions to and perceptions of their educational experiences are important.

-- Barry Fraser, 2001

1.1 Chapter Introduction

The purpose of this research was to compare students' classroom environment perceptions and attitudes toward science when using science kits, textbooks or a combination of science kits, textbooks and teacher-created materials. Using a learning environment questionnaire, interviews, and observations, students' perceptions of their classroom environment and their attitudes toward science were assessed. The goal of this study was to evaluate which of these approaches to science teaching creates a more favorable learning environment. While it is important to improve scores on standardized achievement tests, it is also important to create a positive classroom environment. As a science teacher, I have always had the goal of improving the learning environment and students' attitudes. By creating a favorable environment, students are likely to accomplish more and develop favorable attitudes.

In Chapter 1, Section 1.2 discusses background information, including a description of the context of the study. It details the reasons why this study was undertaken by giving background information about education in Texas. It also gives brief historical background to the field of learning environments. Section 1.3 delineates the research questions. The specific research questions addressed are established within the context of national, state and local science content and teaching requirements. Section 1.4 gives supporting evidence for the significance of the study. The discussion focuses on three main areas: evaluating educational programs, identifying methods to facilitate a positive learning environment, and comparing different teaching methods to facilitate lesson preparation and presentation. Research methods, including a description of the sample, data collection and data analyses, are briefly introduced in Section 1.5. The last section of this chapter gives an overview of contents of this thesis.

1.2 Background

In this section, some background information about the context of the study and a preliminary review of relevant literature are introduced. This research is placed within the framework of other research pertaining to learning environments. A more complete review of relevant literature is the focus of Chapter 2.

1.2.1 Context of the Study

Because this study of students' evaluation of their learning environment when different methods of instruction are used was undertaken in Texas, this chapter contains background information about the assessment of students' knowledge in various core subjects, the process involved in choosing appropriate educational materials to use in the classroom, and the statewide rating system used to evaluate individual schools and districts.

In 2000, the Texas Education Agency (TEA) was required by the Texas state legislature to develop the Texas Assessment of Knowledge and Skills (TAKS) to evaluate the competency of schools and school districts to educate students enrolled in public schools. The initial areas tested were reading, writing, and mathematics, with social studies and science added in later years. Subgroups, based on special education needs, ethnicity, and socioeconomic status, are evaluated separately. The scores of these subgroups and the majority group of students determine the rating that a school receives: Exemplary, Recognized, Acceptable, and Low Performing. Schools receiving a Low Performing rating are targeted by the Texas Education Agency (TEA) to establish protocols for improving their students' learning, performance on state tests and, therefore, the score of the school district. Teams of advisors from TEA move into a Low Performing school and scrutinize all of the programs that the school has in place to determine the strategies required for improvement. A rating of Acceptable indicates that a school is performing to a minimum passing standard. Schools performing above the minimum are awarded the rating of Recognized or Exemplary, with Exemplary being the highest rating. To achieve an Exemplary rating, schools must show a high percentage of passing students in all content areas, as well as high attendance and low dropout rates. While dropout rate is not a factor to be considered in elementary schools, attendance and scores in the tested areas are of great concern. Schools are seeking pedagogical, as well as motivational, methods to improve attendance and increase scores in the areas tested (Hamilton & Stecher, 2004).

In Texas, elementary school students traditionally have been taught very little science. Elementary teachers are commonly generalists, primarily trained in content areas such as reading, writing and, in some cases, mathematics. In the past, this knowledge has served teachers well because the subjects receiving the most emphasis are reading, writing and mathematics. Currently, schools stress these subjects not only to educate the students, but also to obtain a high rating on state standardized tests. The results on these tests are very important to schools, parents, and communities because schools are compared with other districts in the state. Parents review the ratings and consider which school district could provide a more complete and higher-quality education to their children. These ratings are published in local newspapers and in a statewide report generated by TEA and made available on its web site. Previously, science was tested only at the high school level. However, now the state of Texas has introduced another standardized test, namely, science, into the rating process in fifth grade. This is forcing teachers to revise their teaching to include science. The new test is based on statewide objectives prepared by TEA and endorsed by the state government.

The Texas Essential Knowledge and Skills (TEKS) are objectives for each grade level from Kindergarten to Grade 12. TEKS are designed for every subject taught. Subjects include but are not limited to reading, writing, mathematics and science. These subjects are designed to be vertically aligned by grade level. Each grade level is responsible for building on the previous year's lessons and laying a foundation for the next year's lessons. An example of a TEKS science concept for Grades 3 to 5 follows:

> Grade 3: (7) Science concepts. The student knows that matter has physical properties. The student is expected to:
>
> (A) gather information including temperature, magnetism, hardness, and mass using appropriate tools to identify physical properties of matter; and
>
> (B) identify matter as liquids, solids, and gases.
>
> Grade 4: (7) Science concepts. The student knows that matter has physical properties. The student is expected to:

(A) observe and record changes in the states of matter caused by the addition or reduction of heat; and

(B) conduct tests, compare data, and draw conclusions about physical properties of matter including states of matter, conduction, density, and buoyancy.

Grade 5: (7) Science concepts. The student knows that matter has physical properties. The student is expected to:

(A) classify matter based on its physical properties including magnetism, physical state, and the ability to conduct or insulate heat, electricity, and sound;

(B) demonstrate that some mixtures maintain the physical properties of their ingredients;

(C) identify changes that can occur in the physical properties of the ingredients of solutions such as dissolving sugar in water; and

(D) observe and measure characteristic properties of substances that remain constant such as boiling points and melting points. (Texas Administrative Code (TAC), Title 19, Part II Chapter 112. Texas Essential Knowledge and Skills for Science Subchapters 112.5, 112.6 and 112.7)

To ensure that elementary educators are teaching the required science content, TEA has developed, again as required by the state legislature, Texas Assessment of Knowledge and Skills (TAKS) in science to be administered in 5th grade, but covering the TEKS for Kindergarten through 5th grade. This test has precipitated the purchasing of resources for science teaching including laboratory and safety equipment. Adequate teaching is further supported through the provision of state-approved textbooks to the schools.

The Texas State Board of Education has adopted textbooks with ancillary materials and science kits to assist the teacher in teaching the required TEKS. The book publishers commit to meeting the state required objectives (TEKS), and must provide content that has been examined by committees that include scientists, educators, and members of the general public. Special interest groups also examine the textbooks to determine if they are free of prejudice. The Texas Education Agency reviews these materials prior to releasing them to be viewed by individual districts. Teachers, parents and school district administrators further review materials that are up for adoption in terms of accuracy, grade-level appropriateness, and adequacy for supporting the teaching of the TEKS. These individuals have an opportunity to discuss ideas and concerns with textbook publishers before the adoption process is completed. The publishers review suggestions in terms of accuracy and relevance to the TEKS and then make appropriate changes as needed.

Science kits, also reviewed through this painstaking process, are designed to contain all the non-consumable materials necessary for a class to perform a series of experiments based on a concept. These kits come with background and/or supplemental readings that support the concept, laboratory equipment and other materials for the lessons, a complete teacher's guide, and a videotape showing each of the activities in the kit. The kit is designed to be self-contained and self-sufficient for teachers ranging from novices to those who are highly experienced. The goal of the science kit developers was to provide a relevant hands-on experience appropriate to the students' age group. Each type of presentation, specifically using books with ancillary materials and science kits, is claimed by the manufacturer to be the best way to achieve higher academic scores.

Although the state of Texas screens and adopts texts with their ancillary materials and the science kits, it is most reliant on TAKS scores to evaluate the success of schools. These scores, however, indicate neither the climate of the classrooms nor the students' receptiveness to learning. Because student achievement is paramount to successful TAKS ratings, teachers, administrators, and superintendents are seeking ways to improve students' success in the classroom.

My study focused on the learning environments in Grades 3, 4, and 5 science classes. Three elementary schools, each using different state-approved teaching materials, participated in this study: the science kits school used state-approved science kits, the textbook school used a state-adopted textbook and ancillary materials, and the combination school used a combination of textbook and science kits. The criterion for state approval for adoption is that the book or kit must meet a high percentage of TEKS. As these objectives spiral through the state requirements, the materials (textbooks and kits) adopted by the state must present information in such a manner that each grade level's content connects to and builds on that of the previous year from kindergarten through to senior high. Therefore, the TEKS are designed to provide vertical teaming in the science classes.

In this section, the background for the testing policy in the state of Texas was discussed to help to define the basis for the rationale for the study. The reason for the study was to evaluate students' perceptions of the learning environment and their satisfaction within their classroom. Different modes of instruction were used by the teachers in the study and this instruction was evaluated using information obtained from administering a learning environment questionnaire called the *My Class Inventory*, from interviews with teachers and students, and from classroom observations.

1.2.2 Historical Background to Field of Learning Environments

My study drew on and contributed to the field of learning environments. The foundation for the study of learning environments began approximately 70 years ago with work by Lewin and Murray. In 1936, Lewin wrote about the relationship between the environment, its interaction with personal characteristics, and the effects on human behavior. His formula, $B=f(P,E)$, states that behavior is a function of the interactions between the person and the environment (Lewin, 1936). Murray (1938) followed Lewin's research on behavior and the environment, identifying a Needs-Press Model of interaction in which personal needs, or 'motivational personality characteristics', represent the tendency for individuals to move in the direction of goals, whereas the environmental press is the external situational counter-part that either supports or frustrates the expression of these needs (Fraser, 1986). Murray's Model suggests that external factors found in the individual classroom environment can influence behavior. This Needs-Press Model applies more to the study of personality rather than the teaching-learning process, but researchers have used it to identify situational variables or inconsistencies (Anderson & Walberg, 1974; Moos, 1974). Stern, (1970) proposed a Person-Environment Congruence Model that states that, when personal needs and environment are more in harmony, students' outcomes are improved. Getzels and Thelen (1960) proposed a model that describes the class as a unique social system and proposes that group behavior can be predicted by observing the interaction of personal needs, expectations and the classroom environment.

During the 1960s and 1970s, Herbert Walberg developed the *Learning Environment Inventory* (LEI) to use for an evaluation of Harvard Project Physics (Walberg & Anderson, 1968). At about the same time, Rudolf Moos and Edison Trickett (1987) developed the *Classroom Environment Scale* (CES), which consists of nine social-psychological scales. The purpose of these evaluation instruments is to determine how individuals and groups of individuals react to their educational environment and what elements affect their reaction to the environment.

Since the time of the pioneering work of Walberg and Moos, many questionnaires have been developed (see review of Fraser, 1998a). Some examples include the *What Is Happening In this Class?*, *Constructivist Learning Environment Survey*, and *Science Laboratory Environment Inventory*. These instruments have been used in several lines of research reviewed by Fraser (1998b), including investigations of associations between learning outcomes and classroom environments (McRobbie & Fraser, 1993), cross-national studies (Aldridge, Fraser, & Huang 1999; Aldridge, Fraser, Taylor, & Chen, 2000), and the evaluation of educational innovations (Maor & Fraser, 1996).

Students' perceptions of their learning environment have been shown to affect academic achievement and attitudes (Fraser, 1998b). Because academic achievement is paramount to teachers, schools and districts, classroom environments can be changed in an attempt to promote greater student achievement. The most common line of previous classroom environment research involves associations between students' perceptions of their learning environments and their cognitive and affective learning outcomes (Fraser, 1998b). Fraser (1994) tabulated 40 previous studies that investigated associations between student outcomes and the learning environment. The foci of these studies were to determine if there was a relationship between students' learning environment and the quality of student outcomes in different learning environments. These studies replicated outcome-environment associations in several countries and at various grade levels. Several investigations of associations between students' cognitive and affective outcomes in high school chemistry and biology classes involved using the *Science Laboratory Environment Inventory* (Fisher, Henderson, & Fraser, 1995, 1997; Fraser & McRobbie, 1995; McRobbie & Fraser, 1993; Riah & Fraser, 1998; Wong & Fraser, 1995, 1996; Wong, Young & Fraser, 1997). In these studies, students' cognitive and affective outcomes were found to be related to their learning environment. Associations between classroom environment, student achievement and student attitudes in computer-assisted classes were identified through research by Teh and Fraser (1995a, 1995b). The outcomes of this research showed that more positive classroom environments were linked with increased student achievement and other valued learning outcomes. While there are many variables that can be manipulated to change the classroom environment, pedagogy is one of the most important.

Realizing that the method of lesson presentation used influences the classroom environment, my study evaluated the relative effectiveness of textbooks, science kits, and a combination of textbooks and science kits instruction in terms of students' perceptions of the classroom environment and their attitudes to science. In Chapter 2, the learning environment literature is reviewed in greater detail.

1.3 Specific Research Questions

The importance of creating learning environments that meet the needs of students was the starting point for this study. Further, because previous studies have shown a relationship between environment and achievement, the learning environment also was important as a vehicle for improving achievement in schools. Because there was a choice in teaching materials, I wanted to know which type of presentation better promotes a more positive classroom environment and improves students' satisfaction with their classes. To investigate this problem, the following specific research questions were delineated for this study:

1. *Can the learning environment be reliably and validly assessed among Grade 3–5 students in Texas?*
2. *Is instruction using textbooks, science kits, or a combination of text-books and science kits more effective in terms of changes in student attitudes and learning environment perceptions?*
3. *Are there associations between student attitudes toward science classes and the classroom environment?*

1.4 Significance

In the following section, the significance of my study is discussed. Discussion focuses on evaluating educational programs, identifying methods to facilitate a positive learning environment, and comparing different teaching methods to facilitate lesson preparation and presentation.

First, research in the field of learning environments shows that classroom environment instruments can be used as a source of process criteria in the evaluation of educational innovations (Fraser, 1998a). One goal of this study was to compare educational materials used in the classroom in terms of their effectiveness for the students. My study adds to the relatively small list of studies that have used classroom environment dimensions in evaluating educational programs (e.g. Dryden & Fraser, 1996. 1998; Maor & Fraser, 1996, Nix, Fraser & Ledbetter, 2005). Fraser (1994) concluded that student perceptions of the learning environment are consistently related to student achievement. Because scores on the TAKS test are very important to the school and the district, administrators in the school districts are seeking effective ways to improve ratings. Further, schools want to receive high ratings; to this end, they are seeking the educational program that best suits their goals. One purpose of this study was to evaluate alternative methods of science instruction in terms of students' perceptions of their environment and student satisfaction.

Second, according to the textbook-based and science kit-based literature, the environment in the classroom directly affects learning (Daiker, 2001; Leach, 1992; Li, 2000). Each method is claimed to be the better way to ensure student satisfaction in the science classroom (see Chapter 2 for a review of this research). One of the outcomes of this study was the identification of methods to facilitate the creation of a positive learning environment in which students feel comfortable and accepted, and are more likely to participate in the learning process. Students' active participation has been shown as an important factor for increasing retention of knowledge (Fraser, 1994).

Third, the materials accompanying the textbooks and science kits provide lesson plan strategies and suggestions for instruction that are more learner interactive. It was interesting to see how the different teaching methods facilitated lesson preparation and presentation. One of the expected outcomes associated with moving the science TAKS test to fifth grade is that lessons would become interactive, with the teacher creating a learner-friendly classroom leading to more success in the classroom. In turn, the learner-friendly classroom could lead to higher TAKS scores. In Texas, TAKS scores are used to determine the effectiveness of the teaching at a school. Hopefully, when students begin having more success in their learner-friendly classroom, achievement scores might increase and the school's rating could improve. Information gained from this study is likely to be used in future textbook/science kit adoptions and to help administrators and teachers to improve science classrooms environments which, hopefully, could ultimately lead to improved student achievement on the TAKS.

1.5 Research Methods

In Section 1.1, an introduction to the study gave details about the rationale for undertaking the research. Section 1.2 explained background information and gave a brief literature review which is expanded in Chapter 2. Section 1.3 listed the specific research questions, while the significance of the study was discussed in Section 1.4. Section 1.5 introduces the research methods used in the study. A description of the schools chosen is given in Section 1.5.1 and an explanation is provided about how the data were collected (Section 1.5.2) and analyzed (Section 1.5.3). A more comprehensive description of my research methods is the topic of Chapter 3.

1.5.1 Sample

The purpose of this study was to examine the learning environments in science classes in three different schools using textbook instruction, science kit instruction, and a combination of textbook and science kit instruction. The three schools selected are in the Fort Worth area, have similar socioeconomic backgrounds, and have the same Exemplary rating from the Texas Education Agency. The science kits school chose science kits for instruction, the textbook school chose textbooks and ancillary materials for instruction, and the combination school chose to use textbooks with ancillary materials and science kits for instruction.

Teachers were selected based on the grade level that they taught and their willingness to participate in the study. There was a cross-section of classroom experience ranging from first year teachers to experienced teachers, having up to 31 years experience. Teachers who taught science classes in Grades 3–5 were interviewed and observed once during the school year. The students chosen were representative of the student population. The total sample size was 588 students in 28 classes, with an average size of 21 students per class.

It is worth sounding a caution regarding the possible confounding effect of between-school differences (other than the instructional method) and being unsure of the comparability of teachers in the three instructional groups.

1.5.2 Data Collection

Data were collected over a 12-month period, using both qualitative and quantitative methods as recommended by Tobin and Fraser (1998). I examined student perceptions of the classroom environment in terms of friction, competition and cohesiveness. In order to measure the level of satisfaction in the classroom, I needed an instrument that included satisfaction as one of the scales. I also needed a questionnaire that elementary students could easily read and understand. The *My Class Inventory* (MCI; Fraser & O'Brien, 1985; Majeed, Fraser & Aldridge, 2002; Goh, Young & Fraser, 1995) met these requirements.

The MCI was administered in September as a pretest to determine students' initial perceptions of their science class. The MCI was administered again in January and May to track changes in perceptions of the classroom environment. The preferred version of the MCI was given at the end of May to compare the students' actual perceptions of their classes with their preferred perceptions. The preferred version asks students what they would like their science class to be like. Because students had not received formal science instruction prior to the beginning of this study, I felt that the students would be unable to answer the preferred form at the beginning of the year. All students in all classes responded to the actual and preferred forms on the MCI. To maximize the quality of the data collected, I administered the MCI myself when the teacher was out of the room. Students were informed that their answers would remain confidential.

All teachers in the study were interviewed once. This was done to determine background information about their teaching experience, what college science classes they had studied, and what workshops and/or seminars they had attended. More in-depth interviews were conducted with one teacher from each grade level in each school. One class from each grade level was observed in each school to get a better idea of what happens in the elementary science classroom. Two students from the observed classes were also interviewed. Insights obtained from teacher and student interviews are reported in Section 4.6 in Chapter 4. These interviews were used along with the quantitative data-gathering methods that also are reported in Chapter 4 for the purpose of triangulating both types of information (Webb, Campbell, Schwartz & Sechrest, 1965).

1.5.3 Data Analyses

Analyses of the quantitative data were conducted to determine the validity and reliability of the MCI at the elementary school level in Texas. Examination of the data included factor and item analyses, internal consistency reliability (Cronbach alpha coefficient), discriminant validity, and ANOVA to determine whether the questionnaire could differentiate between the perceptions of students in different classes. To compare the relative effectiveness of the three instructional methods, ANCOVA was employed for each MCI scale with delayed posttest scores as the dependent variable and corresponding pretest scores used as the covariate. Further, simple and multiple correlation analyses were used to determine whether there was a relationship between students' perceptions of their learning environment and their satisfaction with their science classes.

Because data were also collected through interviews and classroom observations, triangulation of the different data was undertaken in order to provide greater sensitivity in examining patterns of results. Naturalistic inquiry uses intensive data collection on numerous variables over an extended period of time. While naturalistic inquiry is inappropriate for some studies, in my research, the use of interviews with teachers and students helped to further explain the results obtained from the questionnaire survey (Creswell, 2003).

1.6 Overview of Thesis

The purpose of this study was to evaluate three types of instructional materials in terms of student satisfaction and perceived classroom environment as assesses by the *My Class Inventory* (MCI). The three instructional materials used were textbooks, science kits, and a combination of textbooks, science kits and teacher-created materials. This study involved pretesting of the actual form of the (MCI) in September, posttesting of the actual form of the MCI in January and again in May, and administration of a preferred form of the MCI at the end of May. This was valuable for investigating changes in classroom environment and student satisfaction, and enabled comparison of actual and preferred perceptions. Further details of the testing schedule and rationale for the testing schedule are found in Chapter 3.

Chapter 1 discussed the rationale and significance for the study. The purpose of this study was to compare students' classroom environment perceptions and attitudes toward science when using science kits, textbooks and a combination of science kits, textbooks and teacher-created materials. Chapter 1 also contained a description of the context of the study and the rationale for this study. This included a description of the assessment practices in Texas and the importance of schools scoring well on the Texas Assessment of Academic Skills (TAKS) as these scores are made public.

Chapter 2 considers literature relevant to my study. Descriptions of various learning environment instruments are provided, including the MCI. It also provides a review of relevant literature on the evaluation of educational methods in Section 2.3.2, differences between student and teacher perceptions of perceived and preferred environments in Section 2.3.3, and whether students achieve better in their preferred classroom environment in Section 2.3.4. Also included are sections discussing teachers' practical attempts to improve their own classroom environments (Section 2.3.5) and studies which combine qualitative and quantitative methods in Section 2.3.6. Section 2.4 reviews literature related to textbooks, science kits and teacher-created materials.

Chapter 3 describes the research methods used for the study, including the validation of the learning environment instrument for elementary school grades and the selection of scales that are pertinent to the study. Three specific research questions are discussed. The research design is discussed in Section 3.3 and, in Section 3.3.2, the reasons for using both qualitative and quantitative methods are included. Section 3.3.3 explains my choice of the *My Class Inventory*, my sample is described in Section 3.3.4 and my data collection is discussed in Section 3.3.5.

Chapter 4 reports the results of my evaluation of the use of science kits and textbooks using both qualitative and quantitative information. Section 4.1 reports results for the validation of the learning environment questionnaire, the effectiveness of using a science kits-based intervention, and associations between student satisfaction and classroom environment. Results from my qualitative investigation are found in Section 4.2 and include teacher and student case studies at the three schools. The chapter closes with summaries of results emerging from the qualitative and quantitative data.

Finally, Chapter 5 provides a synopsis of the chapters of this thesis in Section 5.2. Chapter 5 also provides a summary of the research methods in Section 5.3, a summary of quantitative results in Section 5.4, a summary of qualitative results in Section 5.5, identification of limitations of this study in Section 5.6, and suggestions for further research in Section 5.7.

Chapter 2

LITERATURE REVIEW

In Chapter 1, background information and a preliminary review of literature pertaining to this study were provided. It also delineated the specific research questions that are the basis of this study, and provided a brief overview of the other chapters in the thesis. The purpose of this study was to compare students' classroom environment perceptions and attitudes toward science when using science kits, textbooks and a combination of science kits, textbooks and teacher-created materials. Data-collection and research methods were briefly examined in Chapter 1 and are discussed in more detail in Chapters 3 and 4. This chapter reviews literature relevant to this study.

Fraser (1994) describes classroom environment as the shared perceptions of the students in a particular setting. Although the concept of classroom environment is implied and nebulous (Fraser, 1989b), much progress has been made in terms of conceptualizing it, measuring it and analyzing its determinants and effects (Fraser, 1994). Research also continues to suggest ways in which to help classroom teachers to engage in action research in attempts to improve their classroom environments (Fraser, 1998a, 1998b).

For this study, it was necessary to review literature concerning learning environment research in school classrooms and instruments for assessing such environments. This chapter contains three sections. Section 2.1 provides historical background information regarding educational environment research. Section 2.2 describes the assessment of classroom environments, including previously-used instruments, such as the *What Is Happening In this Class?* (WIHIC) questionnaire and *My Class Inventory* (MCI). Section 2.3 reviews past research involving classroom environment instruments, including studies of associations between student outcomes and the nature of the classroom environment, evaluation of educational methods, differences between student and teacher perceptions of perceived and preferred environments, whether students achieve better in their preferred classroom environment, teachers' practical attempts to improve their own classroom environments, and studies which combine qualitative and quantitative methods. Finally, Section 2.4 reviews literature relevant to textbooks, science kits and teacher-created materials.

2.1 Historical Background of Educational Environments Research

Approximately 70 years ago, the study of learning environments began with work by Lewin and Murray. Lewin, in 1936, wrote about the environment, its interaction with personal characteristics, and its effects on human behavior. His formula, *B=f(P,E)*, states that behavior is a function of the person and the environment. Following Lewin's research on behavior and the environment, Murray (1938) identified a Needs-Press Model of interaction in which personal needs, or 'motivational personality characteristics', represent the tendency for individuals to move in the direction of goals, whereas the environmental press is the external situational counterpart that either supports or frustrates the expression of these needs (Aldridge & Fraser, 2000). Murray's model suggests that variables found in the individual classroom environment can affect behavioral inconsistencies. This Needs Press Model applies more to the study of personality than to the teaching-learning process, but researchers have used it to identify situational variables.

Herbert Walberg, during the 1960s and 1970s, developed the *Learning Environment Inventory* (LEI) to use for an evaluation of Harvard Projects Physics (Walberg & Anderson 1968). Rudolf Moos (1979), at about the same time, developed a range of evaluation instruments for use in various human environments including psychiatric hospitals and correctional institutions. This was the basis for the development of the *Classroom Environment Scale* (CES) for use in school classrooms. The purpose of these evaluation instruments was to determine how individuals and groups of individuals interact with their environment, as well as to determine how these interactions can affect participants' reactions to the environment. These studies, introduced by Walberg and Moos, led to major research programs and analytical reviews of this work in several books (Fraser, 1986; Fraser & Walberg, 1991; Goh & Khine, 2002; Moos, 1979; Walberg, 1979), literature reviews (Fraser, 1994, 1998a, 1998b) and monographs supported by American Educational Research Association's Special Interest Group on Learning Environments (Fisher, 1994).

This research led to the idea of assessing classroom environments as criteria of evaluation when a new method of teaching is developed (Maor & Fraser, 1996;

Mink & Fraser, 2005). My research builds on past work in that it investigated the classroom learning environment associated with an innovative method of science teaching involving the use of commercially-developed science kits as compared with more traditional methods associated with text-based teaching.

Three separate approaches have been used for assessing and studying learning environments (Fraser & Walberg, 1981). The first of these methods involves application of the techniques of naturalistic research or case study, in which an outside researcher records qualitative data involving his/her observations of the classroom and interviews. Stake and Easley (1978) provide an in-depth account of naturalistic classroom settings in Case Studies in Science Education. As with the study by Stake and Easley, the present study included interviews and observations of teachers and of their students.

The second approach concentrates on student and/or teacher perceptions of psychosocial factors in a classroom. This has the advantage of defining the classroom environment through the eyes of the actual participants. It also identifies additional information to which the observer might not attend or might consider unimportant (Fraser & Treagust, 1986). Students have a good vantage point for making judgments about their classrooms, as they spend much more time in the classroom experiencing different environments than do observers. Therefore, students are able to appraise teaching methods and styles used by individual teachers over a period of time. Although most teachers are inconsistent in their daily behavior, consistent patterns usually develop over time (Fraser & Treagust, 1986). These patterns of behavior are perceived by students and, thus, can be analyzed. Although students can perceive a teacher without consistent discipline as unfair, the teacher might not perceive himself or herself as unfair.

The third method for studying learning environments, referred to as interaction analysis, involves observation and a systemic method of coding classroom communication events according to some category system (Brophy & Good, 1986; Dunkin & Biddle, 1974; Peterson & Walberg, 1979). My study involved triangulation of data from classroom environment instruments and from interviews and observations assessing student perceptions of classroom environment.

The administration of questionnaires has been the method most often used in past research pertaining to classroom environments. Questionnaires can be utilized to investigate students' perceptions of their learning environment. Well-written questionnaires eliminate the need for training outside observers and the possibility of variations in interpretations of data by several different individuals making the observations. In this study, as the researcher, I was the only outsider involved in interviewing and observing students in their classroom settings. Questionnaires, representing quantitative data, and interviews and observations, representing qualitative data, were both instrumental in comparing science kits, textbooks and a combination of science kits, textbooks and teacher-created materials. As a questionnaire was used in the present study, the next section reviews several instruments that have been developed and used previously for assessing perceptions of classroom environments.

2.2 Learning Environment Instruments

This section describes various learning environment instruments, ranging from early questionnaires to contemporary ones, used by educators to identify the social climate of the classroom and the feelings that the inhabitants have about their classroom learning environment. This perspective is important because students spend many hours in the classroom observing and participating in a variety of learning environments (Fraser, 1989b). Further, with the emphasis on standardized test scores in the state of Texas, teachers and administrators are constantly seeking ways to improve learning. In the constructivist learning model, students' relationships with teachers and peers within the classroom environment are crucial to their success. Instruments have been developed to measure students' attitudes and interpretations of their surroundings.

Several instruments for assessing perceptions of the learning environment are described briefly in this section. These include the *Learning Environment Inventory* (LEI), *Classroom Environment Scale* (CES), *Constructivist Learning Environment Survey* (CLES), *College and University Classroom Environment Inventory* (CUCEI), *Individualized Classroom Environment Questionnaire* (ICEQ), *Questionnaire on Teacher Interaction* (QTI), *What Is Happening In this Class?* (WIHIC) and *My Class Inventory* (MCI). All of these instruments are suitable for group administration, can be scored by computer or hand, and have been shown to be reliable and valid (Fraser, 1998b). Table 1 gives an overview of learning environment instruments and the scales associated with each instrument.

Table 1. **Overview of Scales Contained in Nine Classroom Environment Instruments (LEI, CES, ICEQ, MCI, CUCEI, QTI, SLEI, CLES and WIHIC)***

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

*Based on Fraser (1998a)

2.2.1 *Learning Environment Inventory* (LEI)

One of the first instruments developed was the *Learning Environment Inventory* (LEI) (Walberg & Anderson, 1968). This instrument was used to evaluate Harvard Project Physics and it contains 15 scales, with 7 statements per scale and a total of 105 statements (Fraser & Walberg, 1981). As seen in Table 1, the scales are

Cohesiveness, Friction, Favoritism, Cliqueness, Satisfaction, Apathy, Speed, Difficulty, Competitiveness, Diversity, Formality, Material Environment, Goal Direction, Disorganization, and Democracy. The respondents have four choices of answers: Strongly Agree, Agree, Disagree, and Strongly Disagree. Examples of statements are "Pupils enjoy their schoolwork in my class" for Satisfaction and "Schoolwork is hard to do" for Difficulty (Fraser, 1989b, p. 3).

2.2.2 *Classroom Environment Scale* (CES)

Another early instrument was the *Classroom Environment Scale* (CES), developed by Rudolf Moos at Stanford University. It contains nine scales with ten items per scale (Fisher & Fraser, 1983a; Moos, 1979; Moos & Trickett, 1987). Scales are Involvement, Affiliation, Teacher Support, Task Orientation, Competition, Order and Organization, Rule Clarity, Teacher Control and Innovation (Fraser, 1998a). Its 90 statements are answered by choosing True or False.

2.2.3 *College and University Classroom Environment Inventory* (CUCEI)

The *College and University Classroom Environment Inventory* (CUCEI) was developed for use at the college level with classes of approximately 30 students in a seminar format (Fraser & Treagust, 1986; Fraser, Treagust, & Dennis, 1996). The final form of the CUCEI contains seven seven-item scales of Personalization, Involvement, Student Cohesiveness, Satisfaction, Task Orientation, Innovation, and Individualization. Each item has four responses (Strongly Agree, Agree, Disagree, Strongly Disagree) and approximately half of the items are of reversed polarity (Fraser, 1998b; Fraser, Williamson & Tobin, 1987).

2.2.4 *Individualized Classroom Environment Questionnaire* (ICEQ)

The *Individualized Classroom Environment Questionnaire* (ICEQ), developed by Fraser (1990), elaborated previous research concepts by assessing attributes, such as personalization and participation, of individualized classrooms rather than conventional teacher-centered ones (Fraser, 1989b; Rentoul & Fraser, 1979). The published version of the ICEQ contains a total of 50 items with 10 items in each of the five scales (Fraser, 1990). The five scales are Personalization, Participation, Independence, Investigation, and Differentiation. Answer choices include Very Often, Often, Sometimes, Seldom, and Almost Never, and the scoring is reversed on several of the items.

2.2.5 *Constructivist Learning Environment Survey* (CLES)

According to the constructivist model, students bring interpretations of experiences and/or conclusions to situations based on prior knowledge to explain their world (Fraser, 1998a, 1998b). The CLES was developed to assess how closely a teacher's practice is consistent in following constructivist theory. After examining the results, teachers could make adjustments in teaching techniques to conform more closely to the constructivist model (Fraser, 1998a). The CLES originally had 36 items with five response choices: Almost Never to Almost Always. After field testing the CLES, problems were found to exist. One problem was that students could associate relevancy to future learning rather than present learning. Another difficulty was that the negatively-worded statements were confusing to students. Also the order in which the statements were arranged made scoring difficult. In some instances, teacher centered-classrooms also scored high of the CLES (Taylor, Fraser, & Fisher, 1997).

To alleviate these problems, a new version of the CLES was developed which contained 30 items, with six items in each of the five scales of Personal Relevance, Uncertainty, Critical Voice, Shared Control, and Negotiation (Fraser, 1998b; Taylor, Fraser, & Fisher, 1997). The instrument was designed for use with secondary students and validated in Australia (Taylor, Dawson & Fraser, 1995), the USA (Dryden & Fraser, 1996; Nix, Fraser & Ledbetter, 2005; Johnson & McClure, 2000), Korea (Kim, Fisher, & Fraser, 1999), Taiwan (Aldridge, Fraser, Taylor, & Chen 2000), and South Africa (Sebela, Fraser, & Aldridge, 2003). The CLES has separate actual and preferred forms (Fraser 1998a; Sebela, Fraser, & Aldridge, 2003) as well as comparative student and comparative teacher forms (Nix, 2002).

2.2.6 *Questionnaire on Teacher Interaction* (QTI)

Research and development for the *Questionnaire on Teacher Interaction* (QTI) began in the Netherlands (Wubbels & Brekelmans, 1998; Wubbels & Levy, 1993). The purpose of this instrument is to identify characteristics of teacher and student interaction (Wubbels, Brekelmans, & Hooymayer, 1991). The concept of circular communication behavior implies that the behavior of the teacher is influenced by the behavior of the students and vice versa (Fisher, Rickards, & Fraser, 1996). The QTI is based on the Leary model (1957) involving a proximity dimension (Cooperation, Opposition) and an influence dimension (Dominance, Submission) to map the interaction between teachers and students (Fisher, Rickards, & Fraser 1996; Wubbels, Brekelmans, & Hooymayer, 1991). For each completed questionnaire, an eight-scale profile can be produced (Wubbels, Brekelmans, & Hooymayers, 1991) to portray student perceptions associated with the eight behavior aspects (Fraser 1998a, 1998b). The scales for the QTI are Helpful/Friendly, Understanding, Dissatisfied, Admonishing, Leadership, Student Responsibility and Freedom, Uncertain, and Strict. The QTI has five response alternatives ranging from Never to Always (Fraser, 1998b). The QTI has been found to be valid and useful in the USA (Wubbels & Levy, 1993), Australia (Fisher, Henderson, & Fraser 1995), Singapore (Goh & Fraser, 1998; Lee, Fraser, & Fisher, 2003; Quek, Wong, & Fraser, 2005), Brunei (Riah, Fraser, & Rickards, 1997; Scott & Fisher, 2004) and Korea (Lee & Fraser, 2002).

2.2.7 *Science Laboratory Environment Inventory* (SLEI)

Hands-on or laboratory experiences in science produce special classroom climates. The SLEI was designed to assess science laboratory classroom climates at the high school and university levels (Fraser, Giddings, & McRobbie, 1993, 1995; Fraser & McRobbie, 1995). The SLEI has five scales with the answer choices of Almost Never, Seldom, Sometimes, Often, and Very Often. The scales in this inventory are Student Cohesiveness, Open-endedness, Integration, Rule Clarity, and Material Environment (Fraser, Giddings, & McRobbie, 1993). All dimensions were validated by student and teacher interviews pertaining to the wording of the items. The choice of dimensions reflects concerns and findings in literature on science laboratory learning environments from such researchers as Hegarty-Hazel (1990), Tobin (1990), Woolnough (1991), and Fraser, Fisher and McRobbie(1996).

This instrument was field-tested in six countries, including the United States, Canada, Great Britain, Israel, Australia and Nigeria (Fraser, Giddings, & McRobbie, (1995), and cross-validated in Australia (Fisher, Henderson, & Fraser, 1997) and Singapore (Wong & Fraser, 1995). The SLEI was found to be valid and useful in a variety of studies, including Wong and Fraser (1996) and Quek, Wong, and Fraser (in press) in Singapore; Swain, Monk and Johnson (1999) and Kim and Lee (1997) in Korea; and Riah, Fraser and Rickards (1997) and Riah and Fraser (1998) in Brunei.

2.2.8 *What Is Happening In this Class?* Questionnaire (WIHIC)

The *What Is Happening In this Class?* (WIHIC) questionnaire was created by combining scales from several existing instruments with some new scales of contemporary relevance (Fraser, 1998a). The WIHIC is also unique in that it contains a separate Class form (to assess students' perceptions of the class as a whole) and a Personal form (to assess a students' perception of his/her own role in the classroom). Statistical analysis and interviewing of 355 junior high school students about the wording of the questionnaire items reduced the number of items from 90 to 54 (Fraser, Fisher & McRobbie, 1996). After changes were made, 1,081 students were tested in Australia and 1,879 students responded to a translated Chinese version in Taiwan (Aldridge & Fraser, & Huang, 1999). The final form of the WIHIC contains seven scales: Student Cohesiveness, Teacher Support, Involvement, Investigation, Task Orientation, Cooperation, and Equity.

The WIHIC was also used successfully in studies involving adult learners in Singapore (Khoo & Fraser, 1998) and Indonesia (Margianti, 2000; Margianti, Aldridge, & Fraser, 2004), and with high school students in Singapore (Chionh & Fraser, 1998), Canada (Zandvliet & Fraser, 2004), India (Koul & Fisher, 2002), Korea (Kim, Fisher, & Fraser, 2000), Brunei (Khine & Fisher, 2002; Riah & Fraser, 1998) and the USA (Martin-Dunlop & Fraser, 2004; Pickett & Fraser, 2004).

2.2.9 *My Class Inventory* (MCI)

The *My Class Inventory* is a simplified version of the LEI and is suitable for use with 8–12 year-olds (Fisher & Fraser 1981; Fraser, 1998a, 1998b; Fraser, Anderson, & Walberg, 1982; Fraser & O'Brien, 1985). It differs from the LEI in four major areas. First, the number of scales is reduced from 15 to 5. Second, the wording is simplified for younger students. Third, the number of response choices is reduced from four to two. Fourth, the students answer on the form to minimize transfer errors (Fraser, 1998a, 1998b; Fraser & O'Brien, 1985).

With these modifications, the MCI is suitable for use in primary schools and middle schools because of the lower reading level (Fraser, 1989b). The original MCI contained 38 items (Fraser, 1998a, 1998b), with from six to nine items per scale and the five scales of Cohesiveness, Friction, Satisfaction, Difficulty, and Competitiveness (Fraser & O'Brien, 1985). The number of items was reduced from 38 to 25along with other modifications, thus making hand scoring easier (Fraser, 1989a, 1998a). The MCI was validated with 2,305 American students (Fraser & Walberg, 1981) and then by Fraser and O'Brien (1985) with 758 Australian students. Goh and Fraser (1996) and Goh, Young, and Fraser (1995) successfully validated a modified version of the MCI in Singapore that included a Task Orientation scale and used a three-point response format (Seldom, Sometimes, and Most of the Time). The MCI was also used in non-science classrooms by Talmage and Walberg (1978) and Talmage and Hart (1977).

The MCI has both a preferred form and an actual form. Preferred form is concerned with the goals of the class. Fraser's (1998a) research found that, as the actual class perceptions came closer to the preferred, class achievement increased. The preferred form, with wording almost identical to that of the actual form, provides an indication of perceptions of an ideal class. An example of the wording is "The students enjoy their school work in my class" for the perceived form and "The students would enjoy their schoolwork in my class" for the preferred form (Fraser, 1989b).

Two recent studies involving the use of the MCI include Majeed, Fraser and Aldridge (2002) and Mink and Fraser (2005). Majeed and colleagues validated the MCI among 1565 Form 2 mathematics students in 81 classes in Brunei, Darussalam. They reported associations between student satisfaction and classroom environment, and identified grade-level differences in learning environment perceptions. Mink and Fraser (2005) used the MCI as a source of criteria of effectiveness in evaluating a K–5 mathematics program which integrates children's literature.

There are many learning environment instruments available, each applicable in different class settings. I chose the MCI because it assesses Satisfaction as well as Cohesiveness, Competition, Friction and Difficulty. I also decided to use the MCI for my study because of the easy readability of the instrument, the short length, provision for answering on the instrument, and the relevance of the scales evaluated. With Grade 3–5 students (8 to 10 years-olds) in my study, length, readability and having the students answer on the instrument were important factors. When students answer on a separate response sheet, mistakes can be made when transferring responses from the instrument to the answer sheet. Learners in this age group typically have short attention spans and can be careless when transferring information from one place to another. The MCI addresses these problems.

The next section discusses important developments relevant to classroom environments instruments, namely, the creation of separate forms to assess ‘perceived’ versus ‘preferred’ environments. The wording is similar on the two forms, with the actual form assessing how the classroom is currently and the preferred form assessing how students would like the class to be. Examples of the wording of actual and preferred statements are provided in the next section.

2.3 Perceived Versus Preferred Forms

An area of interest in my research involved the difference between students' perceived (actual) and preferred (ideal) environments. The difference between perceived and preferred environments has been an area of interest in past classroom environment research (Fisher & Fraser, 1983a; Fraser, 1998a). The perceived or actual forms assess the perceptions of the actual classroom. Preferred or ideal forms measure perceptions of the ideal or desired classroom environment. Wording of items for perceived and preferred forms are similar, but different directions are used for each. An example of this is “Some students in my class are mean” for the perceived form and “Some students in my class would be mean” for the preferred form (Fraser, 1989b).

Knowledge of both the students' preferred environment and their perceived environment can indicate areas that need to be addressed in order to create a more positive environment. In my study, the perceived instrument was used as a pretest and two posttests at different times. At the end of the year, the preferred form was administered and comparisons were made between the pretest, posttest, and delayed posttest and on the Preferred form. I decided to use the preferred form towards the end of the year rather than at the beginning because the students had not been receiving science instruction on a regular basis. I felt that the students would be better able to determine their preferred classroom environment after experiencing science instruction through the year. Chapter 4 discusses this more completely.

2.4 Research Involving Classroom Environment Instruments

This section reviews prior research involving the use of learning environment instruments. It includes descriptions of various lines of past learning environment research. For example, Fraser (1998b) identifies and reviews the following 12 lines of past classroom environment research:

1. associations between student outcomes and the nature of the classroom environment (McRobbie & Fraser, 1993)
2. evaluation of educational innovations (Teh & Fraser, 1994)
3. differences between student and teacher perceptions of perceived and preferred environments (Fisher & Fraser, 1983a)
4. whether students achieve better in their preferred classroom environment (Fraser & Fisher, 1983b)
5. teachers' practical attempts to improve their own classroom environment (Yarrow, Millwater, & Fraser, 1997)
6. studies which combine qualitative and quantitative methods (Tobin & Fraser, 1998)
7. use of learning environment ideas in school psychology (Burden & Fraser, 1993)
8. links between educational environments (Moos, 1991)
9. cross-national studies of classroom environments (Aldridge & Fraser, 2000)
10. studies of changes in learning environments across the transition from primary to secondary school (Ferguson & Fraser, 1999)
11. incorporation of learning environments ideas into teacher education (Fraser, 1994)
12. inclusion of learning environment dimensions in teacher assessment (Ellett, Loup, & Chauvin, 1989).

Based on the different lines of past research identified above, the following topics have been selected as the basis for further literature reviewing below:

- Section 2.4.1: Associations between student outcomes and the nature of the classroom environment
- Section 2.4.2: Evaluation of educational methods
- Section 2.4.3: Differences between student and teacher perceptions of perceived and preferred environments
- Section 2.4.4: Whether students achieve better in their preferred classroom environment

- Section 2.4.5: Teachers' practical attempts to improve their own classroom environments
- Section 2.4.6: Studies that combine qualitative and quantitative methods.

2.4.1 Associations Between Student Outcomes and the Nature of the Classroom Environment

Currently educators are concerned about students' cognitive and affective learning outcomes, including associations between the classroom learning environment and student outcomes, as well as ways to improve these outcomes. Fraser (1994) discussed 40 past studies in which various classroom environment instruments have been used to investigate associations among classroom environment and cognitive and affective outcomes in numerous countries and at various grade levels. Most recently, there have been numerous studies of outcome-environment associations in Asian countries (Goh & Khine, 2002). Classroom environment instruments have been translated into several languages for use in different countries.

In Singapore, studies have linked students' outcomes to their perceived classroom environment. Using the SLEI, Wong and Fraser (1996) involved 1592 Grade 10 chemistry students in 58 classes. Goh used both the MCI and QTI with 1512 primary mathematics students in 39 classes. In this study, associations were found to exist between the classroom environment and mathematics achievement and attitudes (Goh & Fraser, 1998, 2000). Teh and Fraser (1995b) found associations between classroom environment, student achievement and attitudes using an instrument designed for computer-assisted instruction classrooms among 671 high school geography students in 24 classes. Khoo and Fraser (1998) used the WIHIC with 250 adults in 23 computer classes and noted a link between student satisfaction and areas assessed by the instrument. Fraser and Chionh's (2000) comprehensive study found associations between WIHIC scales and student outcomes in the areas of examination results, attitudes and self-esteem. This study involved 2310 mathematics and geography students in 75 classes.

Studies in Brunei Darussalam revealed outcome-environment associations. In a study conducted by Majeed, Fraser, and Aldridge (2002) with 1565 Form 2 mathematics students in 81 classes using the MCI, associations were demonstrated between satisfaction and scales of the MCI. Khine (2001) and Khine and Fisher

(2001, 2002), using the WIHIC and QTI with 1188 Form 5 students in 54 classes, found a relationship between science attitudes and the scales of the WIHIC and QTI. Riah and Fraser (1998) used the WIHIC, QTI, and SLEI with a sample of 644 chemistry students in 35 classes from 23 secondary schools and found associations between achievement and attitudes and various classroom environment scales. Scott and Fisher (2001) investigated student enjoyment of science lessons with 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 Korea, several studies have reported outcome-environment associations. Using a Korean-language version of the SLEI, CLES, and QTI, Lee and Fraser (2001a, 2001b, 2002) found outcome-environment associations for students' attitudes toward science for a sample of 440 Grade 10 and 11 science students in 13 classes. Kim, Fisher, and Fraser (1999), using a Korean version of the CLES with a sample of 1983 science students in 24 classes and a Korean version of the QTI and WIHIC with a sample of 543 students in 12 schools, found a relationship between classroom environment and student attitudes toward science (Kim, Fisher, & Fraser, 2000). Further, in Taiwan, using a Chinese-language version of the CLES, a relationship was shown between classroom environment and student satisfaction with a sample of 1879 science students in 50 classes (Aldridge, Fraser, Taylor & Chen, 2000).

There is a strong tradition of past classroom environment research in Western countries. This research often included studies of associations among perceived psychosocial environment characteristics with the cognitive and affective learning outcomes of the classroom (Fraser, 1994; Fraser & Fisher, 1982; Haertel, Walberg, & Haertel, 1985; McRobbie & Fraser, 1993). Many research studies have shown that student perceptions of their classroom environment explain variance in learning outcomes, often beyond that explained by student background characteristics.

Associations among classroom environment and students' cognitive and affective outcomes have been established for classes in Australia using the SLEI (Fraser & McRobbie, 1995; McRobbie & Fraser, 1993). Using the QTI, associations were found between student outcomes and perceived patterns of teacher-student interactions for 489 senior high school biology students in Australia (Fisher, Henderson, & Fraser, 1995) and for 3994 high school science and mathematics students in Australia (Fisher, Fraser, & Rickards, 1997).

While many past learning environment studies have employed techniques such as multiple regression analysis, few have used multilevel analysis (Bock, 1989; Bryk & Raudenbush, 1992; Goldstein, 1987) which takes into account the hierarchical nature of school settings. Because classroom environment data are based on student responses in intact classes, the nested nature of students within classrooms is a strong influence. Researchers need to pay attention to the structure of the classes to avoid problems with aggregation bias (within-group homogeneity) and inaccuracy in interpretation of data. Two studies in Singapore compared the results of multiple regression analysis with those from analysis involving the hierarchical linear model. One study involving 1592 Grade 10 students in 56 chemistry classes (Wong, Young, & Fraser, 1997) investigated associations between three student attitude measures and modified scales from the SLEI. Using a modified version of the MCI, Goh, Young, and Fraser's (1995) study involving 1512 Grade 5 mathematics students in 39 classes indicated that environment scores were related to student achievement and attitudes.

Associations between student outcomes and the nature of the classroom environment were important in my study. Specifically, I investigated relationships between students' attitudes and their perceptions of the classroom learning environment.

2.4.2 Evaluation of Educational Methods

Classroom environment instruments can be used as a source of process criteria in the evaluation of educational innovations (Fraser, Williamson, & Tobin, 1987). An evaluation of the Australian Science Education Project (ASEP) revealed that, in comparison to a control group, ASEP students perceived their classrooms as being more satisfying and individualized, and having a better material environment (Fraser, 1979). The importance of this evaluation is that classroom environment variables differentiated significantly between curricula, even when various outcome measures showed negligible differences. Maor and Fraser (1996) showed that incorporating a classroom environment instrument as part of an evaluation of the use of a computerized database revealed that students perceived that their classes became more inquiry oriented while using the innovation. Also, evaluations of computer-assisted learning (Teh & Fraser, 1994) and computer application courses for adults (Khoo & Fraser, 1998) found similar results. In the USA, Dryden and Fraser's

(1996) evaluation of an urban systemic reform initiative using the CLES proved disappointing in that there was a lack of success in achieving constructivist-oriented reform. Mink and Fraser (2005) used the MCI in evaluating a Grade K–5 mathematics program in Florida.

In my study, educational methods were evaluated in terms of the learning environment and students' attitudes in science classes. By combining qualitative and quantitative data, I hoped to determine which educational method creates a more favorable learning environment.

2.4.3 Differences Between Student and Teacher Perceptions of Perceived and Preferred Environments

An investigation of differences between students and teachers in their perceptions of the same actual classroom environment and of differences between the actual environment and that preferred by students or teachers was reported by Fisher and Fraser (1983a). This study used the ICEQ with a sample of 116 classes for comparing student actual with student preferred scores, and a sample of 56 teachers and 56 classes of students for comparing teachers' and students' perceptions.

Generally teachers perceived their classrooms as more positive than the students. Also students preferred a more positive classroom learning environment than the perceived classroom environment, a pattern which has been replicated using the WIHIC and QTI with Singaporean high school students (Fraser & Chionh, 2000; Wong & Fraser, 1996) and using the WIHIC with 2498 university students in Indonesia (Margianti, Fraser, & Aldridge, 2004).

My study investigated differences in students' perceptions of actual and preferred environment.

2.4.4 Whether Students Achieve Better in Their Preferred Classroom Environment

Using both actual and preferred forms of learning environment instruments permits exploration of whether students achieve better when there is greater similarity between the actual classroom environment and that preferred by students (Fraser & Fisher, 1983a, 1983b; Fraser, 1998b). Fraser and Fisher (1983a, 1983b) used the ICEQ with a sample of 116 class means and predicted posttest achievement from pretest performance, general ability, the five actual individualization variables and five variables indicating actual-preferred interaction. These results suggested that actual-preferred agreement (or person-environment fit) could be as important as individualization in predicting student class achievement, thus suggesting the desirability of changing the actual classroom environment to make it more congruent with that preferred by the class.

2.4.5 Teachers' Practical Attempts to Improve Their Own Classroom Environments

Researchers have worked with teachers to help them to improve their classroom environments by providing feedback information about student and/or teacher perceptions of the classroom environment. This technique has been successfully used at the early childhood level (Fisher, Fraser, & Bassett, 1995), primary school level (Fraser & Deer, 1983), middle school level (Sinclair & Fraser, 2002), secondary school level (Thorp, Burden, & Fraser, 1994; Woods & Fraser, 1996), in Grades 4–9 (Sebela, Fraser & Aldridge, 2003) and at the higher education level (Yarrow & Millwater, 1995; Yarrow, Millwater, & Fraser, 1997). Teachers' attempts to change their classrooms involve these five steps:

1. Administering the preferred form of the classroom environment instrument and, one week later, the actual form.
2. Providing feedback information to the teacher. This feedback information contains results for both the preferred and actual forms of the learning environment instrument. Using these results, teachers identify the environment dimensions that they would like to change. These changes are intended to bring the actual environment and the preferred environment closer together.
3. Teachers reflecting on and discussing the feedback to decide if changes will be made. The criteria for deciding whether changes will be made include the amount of difference that there is between the actual and preferred environment.
4. The teacher initiating the changes for a period of approximately two months.
5. At the end of the two-month period, administering of the actual form of the classroom environment instrument to ascertain whether or not there is a change in students' perceptions of their class.

Woods and Fraser (1995) used this approach with 16 teachers who used the actual and preferred forms of the Classroom Interaction Patterns Questionnaire. Student perceptions of teacher behavior were assessed in six areas: Praise and Encouragement, Open Questioning, Lecture and Direction, Individual Work, Discipline and Management, and Group Work. In this study, the teachers were divided into two groups, with one group receiving feedback and the other group not receiving feedback. When the two months were concluded, the members of the group that received feedback were able to achieve more reductions in the differences between the actual and preferred environment than did the group that received no feedback.

Yarrow, Millwater, and Fraser (1997) described a study that involved 117 preservice teachers during their student teaching experience. The student teachers were introduced to the field of learning environments with the goal of improving their university education classes and their primary school classes during field experience. This study used the CUCEI at the university level and the MCI at the primary school level. After receiving feedback, improvement was observed in university and school classrooms, and the student teachers felt that the experience was beneficial.

2.4.6 Studies that Combine Qualitative and Quantitative Methods

Considerable progress has been made in the combining of quantitative and qualitative methods within the same research study (Fraser & Tobin, 1991; Tobin & Fraser, 1998). In one study, a team of 13 researchers spent over 500 hours investigating 22 exemplary teachers and another similar group of non-exemplary teachers. The researchers observed classrooms, interviewed students and teachers, and built case studies. In this study, the researchers found consistency between the qualitative information and the results from questionnaires assessing students' perceptions of the classroom environment. It was also found that exemplary teachers' classrooms were perceived by students to have more positive classroom environments than those of non-exemplary teachers (Fraser & Tobin, 1989).

In a study by Tobin, Kahle, and Fraser (1990), the Grade 10 science classes of two teachers (Peter and Sandra) were thoroughly studied by six researchers over a ten-week period to see if the goal of higher-level cognitive learning had been accomplished. Classes were observed, students and teachers were interviewed, and students' written work was examined on a daily basis. The study included quantitative information from questionnaires assessing students' perceptions of their classroom learning environment. Researchers concluded that the questionnaire results were supported by the qualitative data collected by the researchers.

Fraser (1996) conducted a multilevel study of the learning environment by combining a teacher-researcher view with six university-based researchers. The research began with an interpretive study of a Grade 10 teacher's classroom at a school where students came from various backgrounds and which included students with a troubled home life and English as a second language. Researchers attended the class each time it met for a period of five weeks. Student diaries were studied and interviews were conducted with the teacher-researcher, administrators and parents. The class was also videotaped for later study. The researchers kept field notes and met three times a week. A questionnaire was also used which linked three levels: the class that was studied; selected classes from within the school; and classes throughout the State. The purpose of the three levels was to decide if this teacher and school were typical. In the study, certain features were identified as prominent such as peer pressure and laboratory activities.

In my study, I combined quantitative data obtained from student questionnaires with qualitative data obtained from interviews and observations.

2.5 Textbooks, Science Kits and Teacher-Created Materials

This study compared the satisfaction and learning environments perceptions of science students in science classes using textbooks, science kits, and a combination of textbook, science kits, and teacher-created materials. Therefore, this section discusses research on textbook usage, science kits and teacher-created materials.

The first instructional treatment in my study was textbook instruction. The textbooks used were chosen from a list of state-approved textbooks and adopted by the school district. The textbook was accompanied by ancillary materials, including outlines for teaching each chapter, worksheets, and activities that support the chapter objectives and assessments. According to research done by Moulton (1997), teachers in the USA rely on the textbook for science education for themselves as well as for the students. Also, her research showed that 62.5% of class time was structured around print materials. Reasons for using the textbook include belief that, because the school board adopted the textbook, it must be used, beliefs about what school should be like, and ease of use. Moulton also stated that, because elementary teachers teach several subjects throughout the day, teachers rely heavily on the textbook organization for lesson plans. Teachers had little choice in selecting the teaching materials available for adoption other than letting the administration know which book they preferred.

There has been very little research on textbook usage in the classroom. Most of the research was done before 1988. Li (2000) reviews studies done in 1960 and determined that 75% of teachers found that the teacher's manual had helpful suggestions for improving students' problem-solving ability. Also, in the 1960s studies, 80% of the teachers found the teacher's manual helpful in planning lessons. Components of the teacher manual include a stated objective, an instructional activity directed by the teacher, and student exercises (Li, 2000).

Teacher knowledge is very important because many teachers rely on the textbook for pedagogical content and the subject matter. Shulman (1986) found that teachers' content knowledge includes three categories: subject matter content knowledge, pedagogical content knowledge, and curricular knowledge. Regarding pedagogical knowledge, the Professional Standards for Teaching Mathematics of the National Council of Teachers of Mathematics (NCTM, 1998) stress that "pedagogy focuses on the ways in which teachers help their students understand and be able to do and use mathematics" (p. 151). The teacher's manual provides pedagogical knowledge necessary to help the teacher who is without the background knowledge in the subject matter to teach the required lessons.

The second treatment was the use of science kits. Science kits are self-contained instructional modules that focus on a concept and provide all the laboratory materials that a teacher needs to teach the module. Laboratory equipment, reusable paper materials and a complete instructional guide explain the concept to the teacher. Also included was a videotape that covered every activity to be taught and how to teach it. Below is an overview of some research supporting the use of science kits:

- Allard and Robardy (1991) found that, using pretest and posttest scores, achievement was significantly higher after instruction using a Full Option Science System (FOSS) kit in third and fourth grades. Full Option means that there are many different ways to teach a concept contained in the kit and the teacher has the option to choose the materials for teaching the lessons.

- Klentschy, Garrison, and Amaral (2001) found that hands-on science has strong benefits for students from lower socio-economic and rural backgrounds and that it also leads to improved writing skills. This study also found that students who experienced more years of hands-on science scored better on the SAT (Scholastic Aptitude Test). The SAT was developed by the College Entrance Examination Board and is used by many colleges and universities as a measure of a student's ability to complete college-level classes successfully.
- Leach's (1992) study revealed that use of hands-on science significantly raised students' process skills (i.e. skills used to reason through a science question proposed by the teacher, textbook or another student). Another point was that students gained confidence in science and held more positive attitudes concerning their ability. Teachers using this treatment in my study had the option to adopt books or kits; also they chose the specific kits for their science instruction.

Many students have formed negative attitudes toward science sometime during their school experiences (Daiker, 2001). With the hands-on science approach, students can become active participants in the lesson rather than passive listener. Hands-on learning involves the student in a total learning experience, which can enhance the student's ability to think critically (Haury & Rillero, 1994).

The third treatment was a combination of textbooks, science kits and teacher-created materials. Teacher-created materials are developed by or modified by teachers for use in the classroom. These materials depend heavily on the teacher's knowledge of science and preference in presentation. Teacher-created materials include worksheets, vocabulary assignments, activities and hands-on lessons. The materials are available online and at many teacher workshops and seminars; they also could be available from colleagues.

2.6 Conclusion

Literature relevant to this study was reviewed in Chapter 2. This literature sets the stage for formulating as well as answering the research questions in my study. The studies carried out by previous researchers help to justify the selection of the MCI and the use of both qualitative and quantitative research methods in my study. The review of literature included a historical background of the field of learning environments.

Several learning environment instruments were reviewed, including information about the length of the instruments, scale names and the number of items that are contained in each learning environment instrument. The names of the instruments reviewed are the *Learning Environment Inventory* (LEI), *Classroom Environment Scale* (CES), *College and University Classroom Environment Inventory* (CUCEI), *Individualized Classroom Environment Questionnaire* (ICEQ), *Constructivist Learning Environment Survey* (CLES), *Questionnaire on Teacher Interaction* (QTI), *Science Laboratory Environment Inventory* (SLEI), *What Is Happening In this Class?* questionnaire (WIHIC), and the *My Class Inventory* (MCI).

Literature on the *My Class Inventory* was reviewed in detail because this questionnaire was used in my study. The MCI is a simplified version of the LEI and is suitable for use with 8–12 year-olds. However, it differs from the LEI in four major areas. First, the number of scales is reduced from 15 to 5. Second, the wording is simplified for younger students. Third, the number of response choices is reduced from four to two. Fourth, the students answer on the questionnaire itself to minimize transfer errors. With these modifications, the MCI was suitable for use in primary schools and middle schools because of the lower reading level (Fraser, 1989b). The modified MCI contains five items per scale and the five scales of Cohesiveness, Friction, Satisfaction, Difficulty, and Competitiveness (Fraser & O'Brien, 1985).

Lines of past research involving classroom environment instruments were reviewed, including associations between student outcomes and the nature of the classroom environment, differences between student and teacher perceptions of perceived and preferred environments, whether students achieve better in their preferred classroom environment, and teachers' practical attempts to improve the classroom environment. Past studies that used classroom environment dimensions in the evaluation of educational methods were reviewed because this was a central part of this study. Finally, I reviewed studies which combined qualitative and quantitative research methods. Also some background literature relevant to the use of textbooks, science kits, and/or teacher-created materials was given.

Chapter 3 discusses research methods used in this study in terms of the aims and objectives, research design, details of the learning environment instrument used (MCI), the sample, and data collection and analysis. It also discusses the interview procedures.

Chapter 4 reports the results in two major parts. The first half of the chapter contains analyses of quantitative data. Attention is given to findings regarding the validation of the learning environment questionnaire, effectiveness of using the science-kit based intervention, and associations between student satisfaction and classroom environment. The second half of Chapter 4 reports the qualitative data collected, including teacher and student case studies for each of the three schools and at each grade level studied.

Chapter 3

RESEARCH METHODS

3.1 Introduction

This chapter details the methods used to gather and analyse the data, including the aims and objectives of the study, the research design, and information about the samples, data-collection procedures, and data analysis. Section 3.2 discusses the methods of data analysis for each research question. Section 3.3 discusses the research design and includes sections elaborating the quantitative and qualitative methods employed, the MCI, the sample, data collection and interviews. Section 3.4 summarizes the chapter.

3.2 Methods of Data Analysis for Each Research Question

This section examines the methods of data analysis for each research question. The first research questions is:

1. *Can the learning environment be reliably and validly assessed among Grade 3–5 students in Texas?*

As discussed in more detail in Chapter 4, the first step was to validate the research instrument (namely, the *My Class Inventory*, MCI) using the following criteria: factor structure, internal consistency reliability, discriminant validity, and the ability to distinguish between different classes and groups. A definition of validity is the degree to which an instrument measures what it is supposed to measure (Gay & Airasian, 2000). The MCI has been found to be valid in past research for the particular purpose of investigating classroom environment in elementary schools, and for measuring changes in students' perceptions of the learning environment through the year (Fisher & Fraser, 1981; Fraser & O'Brien, 1985; Fraser & Walberg, 1981; Goh & Fraser, 1996; Goh, Young & Fraser, 1995).

Using factor analysis, a data-reduction technique, the set of MCI items was reduced to a smaller set of underlying factors, which were compared with the *a priori* structure of the questionnaire. Using the MCI questionnaire data obtained from the

588 students, factor and item analyses were conducted in order to identify ‘faulty’ items that could be removed to improve the internal consistency reliability and factorial validity of the MCI scales. Data were subjected to principal components factor analysis with varimax rotation. Varimax rotation is a factor analysis technique that keeps factor axes at right angles to each other, and it has been frequently used to validate learning environment instruments.

For each scale, an estimate of scale internal consistency (the extent to which items in the same scale measure a common construct) and discriminant validity (the extent to which a scale measures a unique dimension not assessed by another scale) was assessed. Internal consistency and discriminant validity were reported separately for the actual and preferred forms. As a convenient index of discriminant validity, use was made of the mean correlation of one scale with the other MCI scales. A one-way ANOVA was performed for each MCI scale using class membership as the main effect, to check whether the MCI can discriminate between the perceptions of students in different classes.

The second research question is:

2. *Is instruction using textbooks, science kits, or a combination of textbooks and science kits more effective in terms of changes in student attitudes and learning environment perceptions?*

For this phase of the research, I studied the students’ perceptions of the learning environment in the textbook-based classes and the science kit-based classes, using the actual and preferred forms of the *My Class Inventory*. I wanted to compare the effects of the different treatments on students’ perceptions during the course of the year. I also wanted to study the changes in student-perceived impressions of their own schools as a basis for helping teachers develop successful learning environments. Because students had not been receiving science instruction on a regular basis and they started the year not really sure what science was, the preferred form of the *My Class Inventory* (MCI) was administered in May at the end of the school year. Teachers planned to use information about these changes as a guide to improving their presentation in terms of student satisfaction with the course. Comparisons were made between the results of administration of the MCI in September, January, and May.

The method of data analysis used was the ANCOVA (analysis of covariance), which is a statistical method that can be used to equate groups on one or more variables (Gay & Airasian, 2000) before comparing the groups on the dependent variable. For each environment scale (namely, Friction, Competition and Cohesiveness) and for the Satisfaction scale, an ANCOVA was performed with delayed posttest scores as the dependent variable, the treatment group as the independent variable, and the corresponding pretest scores on that the covariate. The three treatment groups were compared in terms of satisfaction and environment scores on the delayed posttest. However, to accommodate any differences between the three groups at the time of pretesting, the corresponding pretest performance was taken into account in the analysis.

Qualitative data were also gathered and analysed to triangulate the quantitative results. Interviews were conducted during visits to the schools. The teacher and student interviews are reported as case studies found in Chapter 4.

The third research question is:

3. *Are there associations between student attitudes toward science classes and the classroom environment?*

The third research question involved associations between student Satisfaction and the three learning environment scales of Friction, Competition, and Cohesiveness. For these analyses, I followed the lead of Majeed, Fraser and Aldridge (2002) and employed the Satisfaction scale from the MCI as a dependent or outcome variable. Data were analyses using two methods of analysis (simple correlation and multiple regression analysis) for two units of analysis (the individual student and the class mean). Also all analyses were conducted for the three occasions when the actual classroom environment was assessed (pretest, posttest and delayed posttest).

There have been many studies into associations between student attitudes and the classroom environment. The learning environment has shown a strong and consistent link with student achievement and attitudes (Aldridge, Fraser, Fisher & Wood, 2002; Fraser, 1998a; Fraser & Walberg, 1991; Raaflaub & Fraser, 2002). These past studies are important to the present research because administrators and teachers are looking for ways to improve the learning environment and student attitudes in the classroom.

3.3 Research Design

This section discusses the research design. It includes:

- Section 3.3.1: Combining Quantitative and Qualitative Methods
- Section 3.3.2: Quantitative Methods: *My Class Inventory*
- Section 3.3.3: Sample
- Section 3.3.4: Qualitative Data Collection.

3.3.1 Combining Quantitative and Qualitative Methods

The present study was both quantitative and qualitative in nature as recommended by Tobin and Fraser (1998) and Punch (1998). For a number of years, researchers in various areas of educational research, especially the field of educational evaluation, have claimed that there are merits in moving beyond the customary practice of choosing either qualitative or quantitative methods and instead combining the two methods within the same study (Cook & Reichardt, 1979; Firestone, 1987; Fraser, Williamson & Lake, 1988; Howe, 1988). Recently, significant progress has been made toward this desirable goal of combining both methods in research on classroom learning environments (Fraser & Tobin, 1991; Tobin & Fraser, 1998). For quantitative data, the MCI questionnaire was used. Students' perceptions of the classroom environment were investigated through the questionnaire study because there is an advantage in engaging the students to report as milieu inhabitants.

While questionnaires can offer an economical way to gather information, they fail to provide some of the missing details. For my study, the qualitative data included interviews and observations, which were used for triangulation of patterns obtained with the quantitative data. Observations put the researcher into the actual learning environment, but are influenced by personal perceptions of the observer (Denzin & Lincoln, 1994). Also the presence of the observer in the classroom can affect teacher and student performance. Interviews can provide some of the missing details, but are time consuming. Even though interviews and observations have limitations, they can still provide important information about the students' perceptions of the classroom environment. Therefore, the research design chosen for this study combined questionnaires, interviews and observations.

Interview can be used as a basic mode of inquiry (Seidman, 1991). In this study, interviews were used to gain background information about the teachers, including their years teaching experience, amount of preparation for teaching science and their confidence in teaching science. This historical interview was a powerful way to gain insight through the experiences of the individuals (Seidman, 1991). Observations of the students in the individual classes indicated the extent to which the treatment, namely, textbooks, science kits or a combination of textbooks and science kits, were being implemented (Reichardt & Cook, 1979). Case studies were selected because they can reveal knowledge that we might otherwise not be able to access (Merriam, 1998). Sanders (1981) states that "case studies help us to understand processes of events, projects and programs and to discover context characteristics that will shed light on an issue or object" (p. 44).

By using multiple methods as data sources, the strengths of each method could be capitalized upon, their weaknesses could be partially overcome and a more complete picture of the learning environment could be provided (Aldridge & Fraser, 2000; Aldridge, Fraser & Huang, 1999; McGonigal, 1998; Seidman, 1991). Case studies have been used by researchers in various countries, such as Taiwan and Australia (Murray, Combs, Aldridge & Fraser, 2002; Proctor, Knapton, Aldridge & Fraser, 2002; Siragusa, 2002).

Through use of observations and interviews, details can be recorded. For the qualitative data, each teacher was interviewed at the beginning of the study. Teachers and selected students were interviewed each time that the MCI was administered. A summary of the interviews and case study information is located in Chapter 4. For the quantitative data, the actual form of the MCI was administered in September, January and May and the preferred form of the MCI was administered in May. This was done to measure changes in students' perceptions of their science class as the school year progressed.

Fieldwork in a research study requires the researcher/observer to be observing, talking with people and examining documentation to gather information. Interviewing can be used as an effective tool for gaining background information. In this study, a structured interview was conducted with each teacher participating in the study. Structured interviews are actually an oral form of a survey (Merriam, 1998). The questions were asked to obtain specific information, but also they allowed additional information to be gained during the interview. Teachers were encouraged to add any information that they thought of as a result of the questions, adding a more unstructured format to the process. According to Dexter (1970), the interview is the preferred method of data collection if it will add relevant information to the study. Guba and Lincoln (1985) state that the interview is valuable for tapping into the experiences of the interviewee. This information would be very difficult to obtain using only a survey. Dexter (1970) warns that interviewing should not be used solely as the basis of the study unless the interviewer is highly trained. He goes on to say that using interviews solely could sabotage the study by providing either uninformative or unreliable data. Guba and Lincoln (1985) support Dexter's opinion that the interview should not be a single-faceted approach. In my study, a combination of interviews, case studies and questionnaires was used.

Case studies are used in educational research to evaluate programs and provide sociological data that could affect the study (Merriam, 1998). The case study can provide a rich and holistic account of events or programs and advance the study's knowledge base. Case studies have been used extensively in educational research (Aldridge & Fraser, 2000; Murray, Combs, Aldridge & Fraser, 2002; Siragusa, 2002). By balancing the techniques of interviews, case studies and questionnaires, the researcher can gain a clearer understanding of what is happening in the classroom and with the individual students. When you combine qualitative and quantitative data, the strengths of each method can be realized and, hopefully, some of the shortcomings of the individual methods of data collection can be overcome (Patton, 1980). Further discussion of case studies can be found in Section 3.3.5.

3.3.2 Quantitative Methods: *My Class Inventory* (MCI)

Students participating in the present study completed the *My Class Inventory* (MCI) as a measure of classroom environment (Fraser & Fisher, 1983b). The MCI is a simplified version of the *Learning Environment Inventory* (LEI). As noted in Chapter 2, the LEI was developed as a part of the research and evaluation of the Harvard Project Physics (Anderson & Walberg, 1974; Fraser & Walberg, 1981). The LEI is an expansion and improvement on Walberg’s original instrument, the Classroom Climate Questionnaire (Fraser & Fisher, 1983a).

One of the first instruments developed was the Learning Environment Inventory (LEI). This instrument contains 15 scales, with 7 statements per scale and a total of 105 statements (Fraser & Walberg, 1981). The scales are Cohesiveness, Friction, Favoritism, Cliqueness, Satisfaction, Apathy, Speed, Difficulty, Competitiveness, Diversity, Formality, Material Environment, Goal Direction, Disorganization, and Democracy. The respondents have four choices of answers: Strongly Agree, Agree, Disagree, and Strongly Disagree. Examples of statements are "Pupils enjoy their schoolwork in my class" for Satisfaction and "Schoolwork is hard to do" for Difficulty (Fraser, 1989b, p. 3). The LEI was designed primarily for secondary school students.

The short form of the MCI differs from the LEI in four major areas. The number of scales was reduced from 15 to 5 and the number of questions was reduced from 105 to 25. Because the LEI was originally developed for use with senior high students, the wording was simplified to meet the reading capabilities of younger students. The number of responses was reduced from four to two and the students' answer of the form, itself. These modifications made the MCI highly suitable for use in elementary classrooms. Fraser and Walberg (1981) have discussed these advantages at length: economy in terms of time, economy in terms of expense because outside observers do not have to be trained to help with the research; more accurate representations could be obtained as "perceptual measures are based on students' experiences over many lessons…" (Fraser, 1994, p. 494) when compared to the small number of lessons observed by the researcher. There is a collective representation of the class by members of the class rather than the opinion of an outside observer. Research has shown that students' perceptual measures of classroom environments add more to the variance in student learning outcomes than do directly-observed variables.

The MCI form is set up for easy scoring with 25 questions divided into groups of 5 questions per section. Each section has one question from each scale. The scales are defined below:

- Satisfaction – Extent of enjoyment of the class (Yarrow, Millwater & Fraser, 1997).
- Difficulty – Children generally are comfortable with their learning activities and the difficulty level is close to ability levels (Yarrow, Millwater & Fraser, 1997).

- Friction – Nature of children's relationships with one another. It manifests itself in fighting, being mean towards one another or attempts to control other members (Yarrow, Millwater & Fraser, 1997).
- Competitiveness – Relating to, characterized by, or based on competition. It involves striving for the same objective (Merriam-Webster, 1993).
- Cohesiveness – Extent to which students know, help and are supportive of one another (Fraser, Giddings & McRobbie, 1993).

Scoring for the MCI involves allocating 3 for a Yes response and 1 for the No response. There are 5 items that require reverse scoring: Items 6, 9, 10, 16, and 24. For these questions, a No response would be scored 3 and a Yes response would be scored a 1. The total score for each scale is found by adding the scores of the 5 items belonging to that scale.

In addition to the actual form describing the students' perception of the actual classroom, the MCI also has a Preferred form measuring the perceptions of the classroom environment ideally wanted or preferred. Appendix 1 contains a copy of the Actual form and Appendix 2 contains a copy of the Preferred form. The Preferred form also has 25 items but the wording is changed. An example from the Actual form would be "The students enjoy their school work in my class" and the Preferred form would state "The students would enjoy their school work in my class" (Fraser, 1989).

The MCI has been used extensively in past research in various countries. Majeed, Aldridge and Fraser (2002) used the MCI in a study in Brunei Darussalam involving 1,565 secondary students. Fraser & O'Brien (1985) used the MCI in a study involving 758 Grade 3 elementary students in Sydney, Australia. Goh and Fraser (2000) used the MCI in a study involving 1512 primary school students in 13 government co-educational schools in Singapore. Mink and Fraser (2005) used the MCI in a study involving 120 fifth grade students in the United States. In each study, the MCI was found to be valid, reliable, convenient and useful. Because there were successful past studies using the MCI, I felt confident to use it in my study.

Another reason for choosing the MCI was that it has a low reading level, which was important for my study because I was working with young students. The MCI is an older environment instrument that has been used in several studies with success, but still it has limitations in that its dimensions might not be as salient as those in more recent instruments.

3.3.3 Sample

The sample consisted of Grade 3–5 students in three North Texas elementary schools. Each of the schools had roughly the same percentage of students in each of the subgroups determined by the Texas Education Agency (TEA). A subgroup exists if a particular population such as an ethnic group makes up 10% or more of the student body. Another separate subgroup is composed of economically-disadvantaged students. Still another subgroup would be the students who have English as their second language. Students receiving Special Services, students with learning disabilities, autism, emotionally disturbances, and/or handicaps, make up a special population and have their own subgroup.

The size of the classes in my sample ranged from 17 to 24 students. Texas has a rule that there should be no more that 22 students to one teacher in an elementary classroom, but waivers are granted if the school just has a few classes over the recommended 22:1 ratio and if the number of students over in a grade level does not necessitate hiring another teacher (Texas Education Agency Chapter 61, School Districts Subchapter CC). The total sample comprised 588 students in 28 classes: 115 students in the science kits school, 185 students in the textbook school and 288 students in the combination school. All of the students were included in the study. The groups consisted of approximately 50% males and 50% females. No students were eliminated due to disciplinary reasons or special education needs. The researcher assisted students needing extra help reading.

Teachers volunteered for the study after a brief inservice session about the importance of having a positive learning environment. Teachers understood that they could stop participating in the research study at any time without any penalty from the school district. Students were also informed that participation was voluntary and that they could quit at any time. Names of the teachers and students were kept anonymous and no-one in the school administration was allowed to look at the unscored data. Summaries of the research findings were submitted to the Science Consultant for the District after the study was completed.

There were some weaknesses in my sample. First, the teachers at the three schools might not have been comparable. Teachers' varying personal and professional experiences could account for the variations in the educational learning environment found in the classes. Teachers' background information, including preparation for teaching science, was included in the case studies. Also, there could have been differences in the students at the three schools. Even though the students were comparable demographically, there are always variations in the life experiences of the students. These differences could partly explain the differences found between the treatment groups.

3.3.4 Data Collection

When the questionnaires were ready for administration, I contacted the principals at the three schools in the study and received permission to go to their campuses to collect data. I then contacted the teachers involved and made arrangements for a time to visit their class and administer the questionnaire. All questionnaires were administered while the teachers were out of their rooms. Total completion time for students ranged from 20 to 40 minutes depending on students' reading abilities. After the questionnaires were completed, the teacher reentered the room and continued with the planned lessons.

To avoid conflicts in interpretation, I did all the observations and interviews personally. I met with each teacher at the beginning of the study during time set aside for planning lessons, and with a representative teacher from each grade level for the remaining visits. I also interviewed randomly-selected students during my visits to the campuses. The quantitative data were collected during four different visits to the campuses in September, January and May for the pretest and two posttests and in May for the preferred version of the MCI. During these four visits, I collected the qualitative data for each grade level and school.

All MCI data were entered into a database to allow for computer-generated statistics and graphics. In the MCI, the following items are reverse scored:

Some students are not happy in my class. (Satisfaction)

Most students can do their work without help. (Difficulty)

Some students in my class are not my friends. (Cohesiveness)

Some students don't like my class. (Satisfaction)

Most students in my class know how to do their work. (Difficulty)

For these items, a selected choice of Yes receives a score of 1 and the selected choice No receives a 3. For all other items in the questionnaire, the answer Yes receives 3 and an answer No receives 1. The average item mean was obtained for each scale by adding the scores for all items in a scale, and then dividing by the number of items in that scale.

3.3.5 Interviews

At the beginning of the study, I interviewed each teacher to gather socio-demographical information, such as the number of years that he/she had been teaching, the grade levels taught, the number of years that he/she had taught science, and the extent of each teacher's science training. I also inquired about his/her willingness to attend science training workshops and inservice courses if the school district made them available. The purpose of these structured questions was to obtain comparative information about each teacher to use in the case studies and to assist in the interpretation of the results of the questionnaire.

The key to obtaining good data from an interview is the questions asked (Guba & Lincoln, 1985; Merriam, 1998; Seidman, 1991). In this study, the questions started as highly structured and led to informal questions to clarify statements made by the interviewee. Specifically, I needed the socio-demographical information in order to identify differences in the teachers' background and training because this could influence the outcomes of the study.

Students' interviews consisted of questions about grade level, whether they enjoyed science classes, what they had been studying, and their general feeling about the class environment. I also asked what students' favorite part of science was and if they remembered a favorite lesson. In the student interviews, I was attempting to ascertain the quality of the science learned and how much information was retained. Students also volunteered information about the classes and teachers. This information was useful in clarifying results from the quantitative data. Because I was investigating the attitudes that students had toward science, events that occurred in the classroom or between the teacher and student were important to the interpretation of the data. If the student had a history of negative feelings towards a teacher, or if the student perceived the teacher having negative feelings toward him/her, this would certainly affect the student's attitude in the science class.

The analysis of qualitative data can be found in the case studies in Chapter 4. These case studies include the teacher background information and insights from teacher and student interviews.

3.4 Summary

This chapter began by recapitulating the objectives for the research study, together with identification of the methods of data analysis for each research question.

The first research question in this section is:

1. *Can the learning environment be reliably and validly assessed among Grade 3–5 students in Texas?*

For this research question, data were analyzed to investigate the reliability and validity of the MCI. Principal components factor analysis with varimax rotation, was used to check the structure of the questionnaire. For the actual and preferred forms of the MCI, the same two indices of internal consistency and discriminant validity were reported separately. The Cronbach alpha reliability coefficient was used as the index of internal consistency. As a convenient index of discriminant validity, the mean correlation of one scale to the other scales was used. For the actual form of each MCI scale, a one-way ANOVA was performed, with class membership as the main effect, to assess the ability to differentiate between classrooms.

The second research question is:

2. *Is instruction using textbooks, science kits, or a combination of textbooks and science kits more effective in terms of changes in student attitudes and learning environment perceptions?*

The goal of this phase of the research was to determine students' perceptions of their science class when each of the treatments was used. One school used science kits, one school used textbooks and one school used a combination of science kits, textbooks and teacher created materials. The questionnaires were administered three times during the year to determine changes in learning environment and attitudes in the three treatment groups.

This study combined qualitative and quantitative research methods to examine changes in students' perceptions of their learning environment. The investigation consisted of administering the actual form of the MCI in September, January and May. The preferred form of the *My Class Inventory* (MCI) was also administered in May. It is unusual to administer the preferred form at the end of a study but the students had not been receiving science instruction prior to the study. I felt that the students needed to experience science instruction to be able to form an opinion about their preferred classroom learning environment.

The method of data analysis for this question was ANCOVA (analysis of covariance). An ANCOVA was performed using the delayed posttest scores as the dependent variable, the treatment group as the independent variable, and the corresponding pretest scores on that covariate. The three treatment groups were compared in terms of satisfaction and environment scores on the delayed posttest, with the pretest performance being taken into account in the analysis to accommodate any differences between the three groups at the time of pretesting.

The third research question is:

3. *Are there associations between student attitudes toward science classes and the classroom environment?*

Data were analyzed using two methods of analysis, namely, simple correlation and multiple regression analysis for two units of analysis (the individual student and the class mean). These analyses were conducted for each of the occasions when the actual classroom environment was assessed. This included the pretest, posttest, and delayed posttest.

Section 3.3.2 contained a discussion about the *My Class Inventory* (MCI). In this section, background information was given about the development of various learning environment inventories and how the MCI was adapted from the Learning Environment Inventory (LEI). The MCI was originally developed to provide an instrument suitable for students aged 8 to 12 years. I chose the MCI as the measure of classroom environment because it has been found by other researchers to be valid, convenient and useful (Fraser & Fisher, 1983a; Goh, Young & Fraser, 1995; Majeed, Fraser & Aldridge, 2002), the vocabulary is appropriate for younger students, responses involve a simple Yes–No format, and the student answers the questions on the instrument itself to avoid errors in transferring answers to a separate answer document (Fraser, 1989).

The MCI is a one-page questionnaire that measures five scales, each containing five statements for a total of 25 questions (Fraser, 1989). The scales measured are Satisfaction, Friction, Competitiveness, Difficulty, and Cohesiveness. The MCI also has an actual and a preferred form. The actual form measures the students' perceptions of what is really happening in their classroom. The preferred form measures perceptions of the learning environment that are concerned with goals and value orientations. Both forms of the MCI were administered during this study.

Section 3.3.3 described the sample selection and the study population. The sample consisted of students and teachers in three North Texas elementary schools. It involved 588 students in Grades 3–5. The three schools had similar populations with approximately the same percentage of ethnic students and special education students. The schools were located in areas with similar demographics. Each school used a different instructional method.

In Section 3.3.4, data-collection techniques were elucidated and information was given about the use of qualitative and quantitative data. Scoring procedures were also considered and examples of items contained in the MCI were given.

In Section 3.3.5, an overview of the interview process was introduced, together with an explanation of the type of questions used and why those particular questions were chosen. During the teachers' interviews, I gathered background information, such as length of time and grade levels that they had taught, extent of science training and their willingness to attend science inservice courses. This background information was necessary in order to compare teacher experience at the different schools.

In Chapter 4, results of analyses of the quantitative and qualitative data are reported, including some case studies. Quantitative data collected using the MCI were subjected to statistical analyses to support the factorial validity, internal consistency reliability and discriminant validity of the MCI, as well as to investigate differences between the three instructional groups and explore attitude-environment associations. The study combined qualitative data in the form of interviews with students' perceptions of the classroom environment to determine if patterns exist.

Chapter 4

RESULTS

4.1 Introduction

This chapter reports differences between three instructional methods in three North Texas schools in terms of students' perceptions of classroom environments. It begins with an overview of my quantitative investigation and continues with a discussion of the reliability and validity of the learning environment instrument, changes in students' classroom environment perceptions, a comparison of actual and preferred learning environments, associations between students' attitudes and perceptions of the learning environment, and a summary of qualitative results.

As discussed in Chapter 3, the classroom environment instrument chosen for my study was the *My Class Inventory* (MCI). The MCI assesses the five scales of Satisfaction, Cohesiveness, Competition, Difficulty and Friction. It has 25 questions, five per scale, and is written for the elementary-level student. The students answer on the questionnaire, which helps to eliminate errors in transferring student responses to a separate answer document. The actual form of the MCI was administered three times, in September, January and May, to 588 students in 28 classes. The preferred form of the MCI was administered at the end of the study in May. This timing was used because students had not been receiving science instruction on a regular basis prior to this study and weren't sure what science classes actually involved.

In addition to collecting quantitative data using the *My Class Inventory* (MCI), qualitative information was gathered via interviews and classroom observations. Interviews and classroom observations were conducted to provide further evidence for the validity of the MCI and differences between the treatment groups (specifically the textbook only, science kits only, and a combination of textbooks, science kits and teacher-created materials).

Both qualitative and quantitative research methods were used in this study, as recommended by Tobin and Fraser (1998) and Punch (1998). My evaluation of an educational innovation, namely, use of science kits, the textbook or a combination of both, was based on three research questions are discussed in Section 4.2 of this chapter.

4.2 Validation of Learning Environment Questionnaire

The first step was to validate the research instrument (namely, the *My Class Inventory*, MCI) using the following criteria: factor structure, internal consistency reliability, discriminant validity, and the ability to distinguish between different classes and groups. My first research question is:

1. *Can the learning environment be reliably and validly assessed among Grade 3–5 students in Texas?*

The validation of the MCI involved data obtained from the administration of the actual form of the MCI as a pretest in September, as a posttest in December, and as a delayed posttest in May. The preferred form of the MCI also was administered in May. The MCI has 25 items and five scales: Friction, Competition, Difficulty, Cohesiveness and Satisfaction. Each scale has five questions. Further discussion of the MCI can be found in Section 2.2.9 and copies of the MCI questionnaire can be found in Appendixes A and B. The sample involved 588 students in 28 Grade 3–5 classes in three North Texas schools.

Using factor analysis, a data-reduction technique, the set of items in the MCI was reduced to a smaller set of underlying factors, which was compared with the *a priori* structure of the questionnaire. Using the MCI data obtained from the 588 students, factor and item analyses were conducted in order to identify 'faulty' items that could be removed to improve the internal consistency reliability and factorial validity of the MCI scales. Data were subjected to principal components factor analysis with varimax rotation. Varimax rotation is a factor analysis technique that keeps factor axes at right angles to each other (Bryant & Yarnold, 1998).

Table 2 reports the factor analysis results separately for the pretest and the two posttests. As a result of the factor analyses, the Difficulty scale was lost altogether. The criteria for the retention of an item were that as item must have a factor loading of at least 0.40 in its own scale and less than 0.40 on the three MCI scales. Also Item 17 from the Friction scale was removed to improve the internal consistency reliability and factor structure.

Table 2. **Factor Loadings for Four Refined MCI Scales for Actual Form**

Item No.	Factor Loading											
	Satisfaction			Friction			Competitiveness			Cohesiveness		
	Pretest	Post 1	Post 2	Pretest	Post 1	Post 2	Pretest	Post 1	Post 2	Pretest	Post 1	Post 2
1	0.61	0.55	0.57									
6	–	0.46	–									
11	0.75	0.78	0.56									
16	–	0.48	0.52							0.41		
21	0.76	0.64	0.75									
2				0.50	0.49	0.79						
7				–	–	–						-0.45
12				0.88	0.88	0.79						
22				0.88	0.88	0.78						
3							0.61	0.51	0.58			
8							0.69	0.64	0.63			
13							0.67	0.74	0.77			
18							0.62	0.69	0.75			
23							–	0.70	0.65			
5										0.77	0.83	0.82
10										0.80	0.76	0.75
15										0.64	0.64	0.75
20										0.68	0.76	0.75
25										0.49	0.46	0.50
% Variance	10.02	11.30	8.93	11.19	10.84	12.01	10.70	12.84	14.41	15.38	14.42	16.49
Eigen-value	1.27	1.80	1.22	1.81	1.34	1.63	1.53	2.07	1.93	4.37	4.18	5.07

N= 534 students in pretest, 550 in posttest and 588 for delayed posttest and 541 preferred all in 28 classes.
Factor loadings less than 0.40 have been omitted.

Table 2 shows that there are seven cases for which an item's factor loading on its own scale is less than 0.40: Item 6 for the pretest and second posttest; Item 16 for the pretest; Item 7 for each testing occasion; and Item 23 for the pretest. The only two cases for which an item has a factor loading of 0.40 or bigger on another scale are Item 6 for the pretest and Item 7 for the second posttest. Despite these inconsistent cases, overall the factor analysis results in Table 2 still provide a reasonable degree of support for the *a priori* structure of the MCI.

The percentage of variance and eigenvalue for each factor are shown at the bottom of this table. Table 2 shows that the total amount of variance accounted for by the 19 remaining items is 47.29% for the pretest, 49.40% for posttest, and 51.84% for the delayed posttest. Table 2 also shows the eigenvalues for the pretest range from 1.27 to 4.37, for the first posttest from 1.34 to 4.18, and for the delayed posttest from 1.22 to 5.07. These data provide support for the factorial validity of the four remaining scales, namely, Satisfaction, Friction, Competitiveness and Cohesiveness.

Internal consistency reliability is a measure of whether each item in a scale measures the same construct. The internal consistency reliability of each scale was determined using the Cronbach alpha coefficient for two units of analysis, namely, the individual student and the class mean. Table 3 reports the Cronbach alpha coefficient for the pretest, posttest, delayed posttest, and preferred versions for the four MCI scales that survived the factor analysis. Using the individual as the unit of analysis, scale reliability estimates range from 0.60 to 0.76 for the pretest, from 0.52 to 0.78 for the posttest, from 0.53 to 0.80 for the delayed posttest, and from 0.52 to 0.83 for the preferred form. As expected, reliability figures are higher with the class mean as a unit of analysis. Using the class as the unit of analysis, scale reliability estimates range from 0.72 to 0.88 for the pretest, from 0.63 to 0.91 for the posttest, from 0.77 to 0.93 for the delayed posttest, and from 0.78 to 0.96 for the preferred form. Overall, the reliability of MCI scales is satisfactory for short scales containing only four or five items each.

Discriminant validity is a measure of the extent to which scales are independent of each other. The discriminant validity for the four MCI scales is reported in Table 3 for two units of analysis (the student and the class mean) using the mean correlation of a scale with the other three scales as a convenient index. Using the individual as the unit of analysis, the discriminant validity results (mean correlation of a scale with other scales) for the three MCI scales in Table 3 range from 0.30 to 0.32 for the pretest, from 0.25 to 0.28 for the posttest, from 0.34 to 0.38 for the delayed posttest, and from 0.38 to 0.42 for the preferred form. Using the class mean as the unit of analysis, the discriminant validity indices for the three MCI scales range from 0.31 to 0.45 for the pretest, 0.51 to 0.56 for posttest, from 0.61 to 0.65 for the delayed posttest, and from 0.71 to 0.79 for the preferred form. The data suggest that raw scores on the MCI assess somewhat overlapping aspects of the learning environment, especially at the class level. However, the factor analysis results attest to the independence of factor scores. (The Satisfaction scale was excluded from the discriminant validity analyses because it was used as a dependent variable for Research Question 2 as discussed in Section 4.3.)

Another desirable characteristic of the actual form of any classroom environment scale is that students within the same class perceive the actual classroom environment relatively similarly, while mean class perceptions vary from class to class. An analysis of variance (ANOVA) was used to determine the ability of each MCI scale to differentiate between the perceptions of students in different classes. The scores on a particular scale were used as the dependent variable, and class membership was the independent variable. Table 3 reports the results in terms of the eta^2 statistic, which is the ratio of 'between' to 'total' sums of squares and represents the proportion of variance in scale scores which is attributable to class membership.

Table 3 also shows that each of the three MCI scales differentiates significantly ($p<0.01$) among classrooms for each of the three administrations. The eta^2 statistic (i.e. the proportion of variance) ranges from 0.12 to 0.18 for the pretest, from 0.09 to 0.15 for the first posttest and from 0.14 to 0.21 for the delayed posttest.

4.3 Effectiveness of Using Science Kit-Based Intervention

The second research question involved evaluating the effectiveness of using science kits in terms of impact on students' satisfaction and their perceptions of the classroom learning environment. This research question involved comparing three groups, namely, classes using kits only, classes using the textbook only, and classes using a combination of kits and the textbook. My second research question is:

Table 3. **Internal Consistency Reliability (Cronbach Alpha Coefficient), Discriminant Validity (Mean Correlation of a Scale with Other Scales) and ANOVA Results for Class Membership Differences (*Eta*^{2} Statistic) for Refined Three-Scale MCI and Satisfaction for Two Units of Analysis**

Scale	No of Items	Unit of Analysis	Alpha Reliability				Mean Correlation with Other Scales				ANOVA Results Eta^2		
			Pre	Post 1	Post 2	Prefer	Pre	Post 1	Post 2	Pref	Pre	Post 1	Post 2
Friction	4	Student	0.61	0.53	0.69	0.52	0.32	0.27	0.38	0.38	0.18**	0.09**	0.21**
		Class	0.81	0.78	0.92	0.78	0.31	0.55	0.65	0.71			
Competition	4	Student	0.61	0.65	0.71	0.76	0.30	0.25	0.35	0.42	0.12**	0.11**	0.15**
		Class	0.72	0.84	0.87	0.94	0.42	0.51	0.62	0.79			
Cohesiveness	5	Student	0.76	0.78	0.80	0.83	0.32	0.28	0.34	0.41	0.15**	0.15**	0.14**
		Class	0.88	0.91	0.93	0.96	0.45	0.56	0.61	0.76			
Satisfaction	5	Student	0.60	0.52	0.53								
		Class	0.74	0.63	0.77								

** $p<0.01$
N= 534 students for pretest, 550 students for posttest 1, 588 students for posttest 2 and 541 students for the preferred form in 28 classes.
Posttest 1 = first posttest; Posttest 2 = delayed posttest

2. *Is instruction using textbooks, science kits or a combination of textbooks and science kits more effective in terms of changes in student attitudes and learning environment perceptions?*

The three treatment groups consisted of three schools in North Texas, each using a different format for teaching science. The sample consisted of 588 students in Grades 3–5 and 16 teachers in 28 classes. One school adopted textbooks for instruction, the second school adopted science kits for instruction and the 3rd school adopted textbooks and used science kits along with teacher created materials for instruction. The purpose of the study was to compare students' perceptions of classroom environment towards their science class with each instructional method.

The three treatment groups were compared in terms of satisfaction and environment scores on the delayed posttest. However, to accommodate any differences between the three groups at the time of pretesting, the corresponding pretest performance was taken into account in the analysis. For each environment scale (namely, Friction, Competition and Cohesiveness) and for the Satisfaction scale, an analysis of covariance (ANCOVA) was performed with delayed posttest scores as the dependent variable, the treatment group as the independent variable, and the corresponding pretest scores on that the covariate. The class mean was used as the unit of analysis.

4.3.1 ANCOVA for Comparison of Three Schools

The ANCOVA results reported in Table 4 show that statistically significant differences exist between treatment groups ($p<0.05$) for Cohesiveness and Satisfaction, but not for either Friction and Competition. The sample size for the ANCOVA was 588 students in 28 classes.

The interpretation of the ANCOVA results is illustrated in Figure 1 which provides a graph of the changes between pretest and delayed posttest on each scale for each of the three treatment groups (kits only, textbooks only, and a combination of kits and the textbook). The average item mean (i.e. the scale mean divided by the number of items in that scale) is used to allow meaningful comparison between scales containing differing numbers of items.

Table 4. **ANCOVA Results (*F* and *Eta*^{2}) for Differences Between Three Treatment Groups on the Delayed Posttest on the MCI With the Pretest Controlled and for the Class Mean as the Unit of Analysis**

MCI Scale	*F*	Eta^2
Friction	0.57	0.05
Competition	2.50	0.17
Cohesiveness	5.01*	0.30
Satisfaction	6.76**	0.36

*p<0.05 **p<0.01
The sample size was 28 class means.
The eta^2 statistic represents the proportion of variance in MCI scores accounted for by the treatment.

Only the results for Cohesiveness and Satisfaction are interpreted here because the treatment groups were significantly different only for these two variables. For these two scales, the eta^2 statistic (or the proportion of variance explained by the treatment) is 0.30 and 0.36, respectively, for Cohesiveness and Satisfaction. For both Cohesiveness and Satisfaction, Figure 1, clearly shows that the group using the kits experienced considerably larger changes in scores than did either of the other two groups (textbook only or combination of kits and textbook). Also, for Cohesiveness, the group using a combination of kits and textbook had larger changes than the textbook-only group. Therefore, overall, the results support the effectiveness of using the kits.

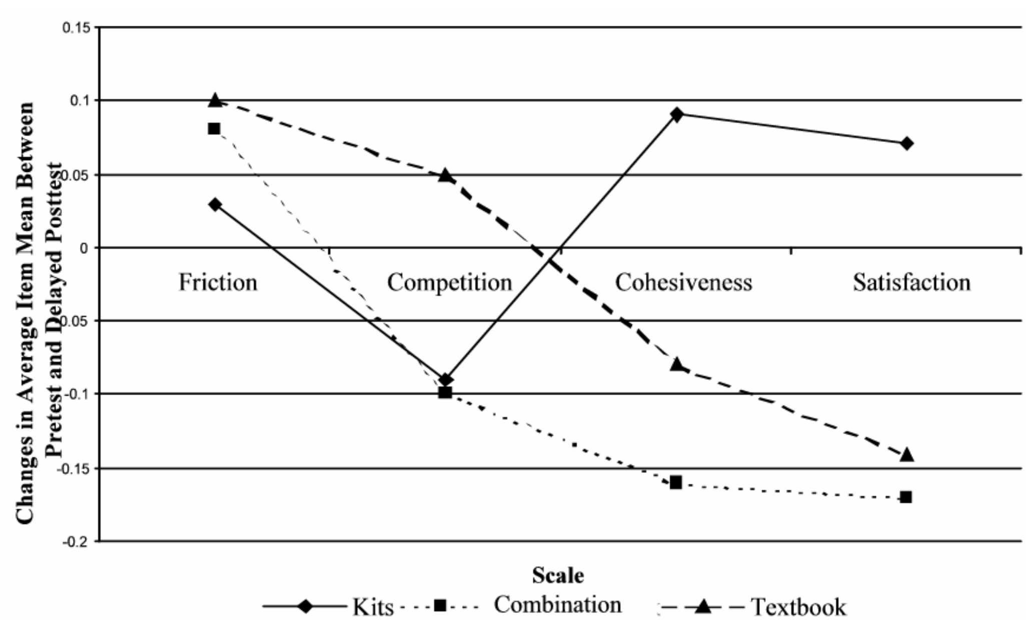

Figure 1. **Comparison of Three Treatment Groups' Changes in Classroom Environment and Satisfaction**

4.3.2 Descriptive Profiles of Environment Scores in Three Schools

This section discusses the results of the quantitative study in terms of the descriptive profiles of the environment scores in the three schools. Included in this section are a comparison of average item mean for pretest actual and preferred environments for the whole sample, a comparison of pretest actual environment scores in three schools, a comparison of posttest actual environment scores in three schools, and a comparison of the delayed posttest actual environment scores in three schools.

Table 5 gives descriptive statistics, namely, the average item mean and the average standard deviation, for three of the scales one the MCI for each school in the study. In this table, Friction and Competition are higher at the textbook school than at the science kits school or the combination school for the pretest, first posttest and delayed posttest. Cohesiveness and Satisfaction are greater at the science kits school and the combination school than at the textbook school also.

4.3.2.1 Comparison of Average Item Mean for Pretest Actual and Preferred Environment Scores for Whole Sample

The students in this study had not been receiving science instruction on a regular basis before the 2001–2002 school year. Because they had not had science instruction, the pretest was given in September to see what they perceived their science classroom environments to be like at the commencement of my study. Overall, the average item mean was 1.48 for Friction, 2.15 for Competition, and 1.93 for Cohesiveness (see Figure 2). This indicates that the students generally perceived low Friction, some Competition, and a reasonable level of Cohesiveness.

The preferred form was given at the end of the school year because the students had had an opportunity to experience science instruction during the year and could determine their preferences for classroom environment. The MCI scale means for the preferred form for the whole sample of three schools were 1.31 for Friction, 1.67 for Competition, and 2.35 for Cohesiveness. This indicates that the students preferred a more favorable classroom environment than was perceived to be actually present in terms of less Friction, less Competition, greater Cohesiveness and greater Satisfaction (see Figure 2). This pattern replicates the results of many past studies in different countries (Fisher & Fraser, 1983; Fraser, 1998a).

Table 5. **Descriptive Statistics (Average Item Mean and Average Item Standard Deviation) for each MCI Scale for Each Case Study School**

Scale	School	Average Item Mean				Average Item Standard Deviation			
		Pretest	Posttest 1	Posttest 2	Preferred	Pretest	Posttest 1	Posttest 2	Preferred
Friction	Science Kits	1.40	1.38	1.43	1.27	0.54	0.51	0.54	0.86
	Textbook	1.71	1.75	1.81	1.44	0.63	0.67	0.71	0.63
	Combination	1.32	1.48	1.44	1.24	0.44	0.96	0.52	0.46
Competition	Science Kits	2.13	2.12	2.05	1.63	0.64	0.65	0.72	0.74
	Textbook	2.23	2.27	2.28	1.72	0.65	0.64	0.69	0.77
	Combination	2.19	2.17	2.09	1.65	0.63	0.68	0.69	0.68
Cohesiveness	Science Kits	2.03	2.00	2.05	2.44	0.74	0.76	0.72	0.71
	Textbook	1.82	1.74	1.74	2.21	0.69	0.65	0.69	0.76
	Combination	1.98	1.90	1.82	2.36	0.70	0.70	0.70	0.71

N= 115 students in Science Kits school, 185 students in Textbook school and 288 students in Combination school

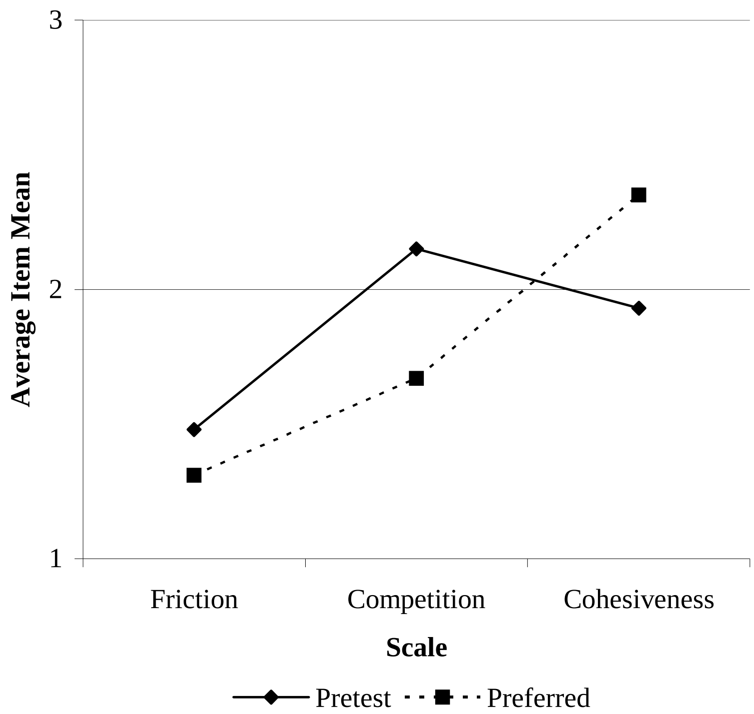

Figure 2. **Average Item Mean for Pretest Actual and Preferred Environment Scores for Whole Sample**

4.3.2.2 Comparison of Pretest Actual Environment Scores in Three Schools

The average item mean for each of the three schools on each pretest actual environment scale is tabulated in Table 5 and plotted as a graph in Figure 3. This figure clearly shows that the kits school and the combination school have similar means for all scales. Relative to the kits school and the combination school, however, the textbook school is perceived as having a less favorable classroom environment in terms of more Friction, less Cohesiveness and less Satisfaction. The level of Competitiveness is comparable in the kits school, the combination school and the textbook school.

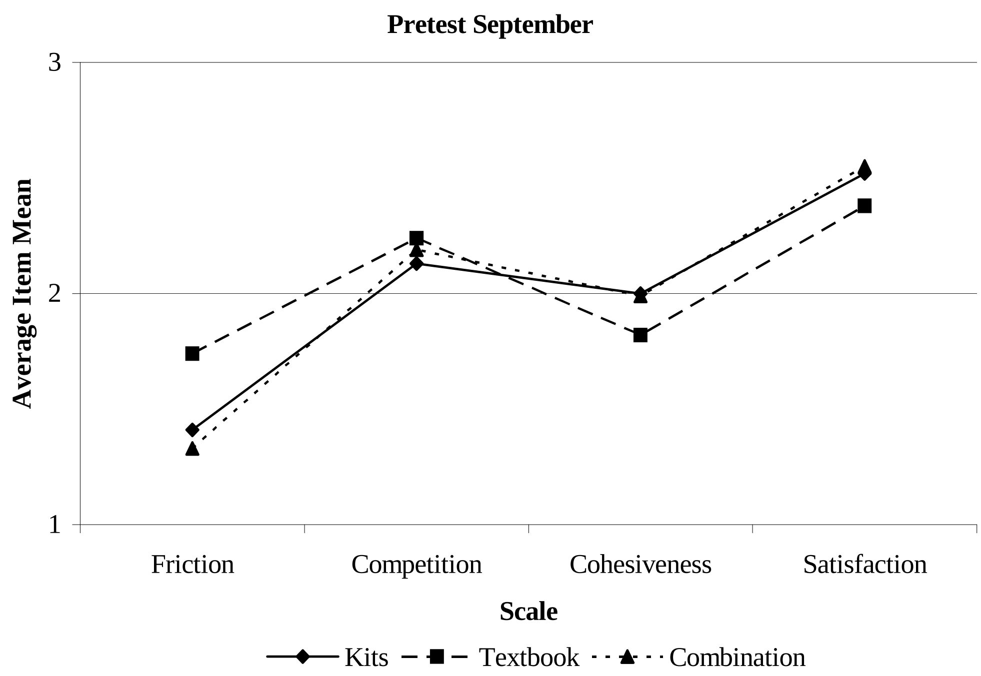

Figure 3. **Average Item Mean for Pretest Actual Environment Scores for Each School**

4.3.2.3 Comparison of First Posttest Actual Scores in Three Schools

The purpose of administering a posttest in January was to track changes in student perception after receiving science instruction for one semester. The average item mean for each MCI scales for each school at the time of the first posttest is shown in Table 5 and graphed in Figure 4. A comparison of Figure 3 and Figure 4 shows almost identical profiles of actual MCI scale scores for the first posttest as for the pretest in each of the schools.

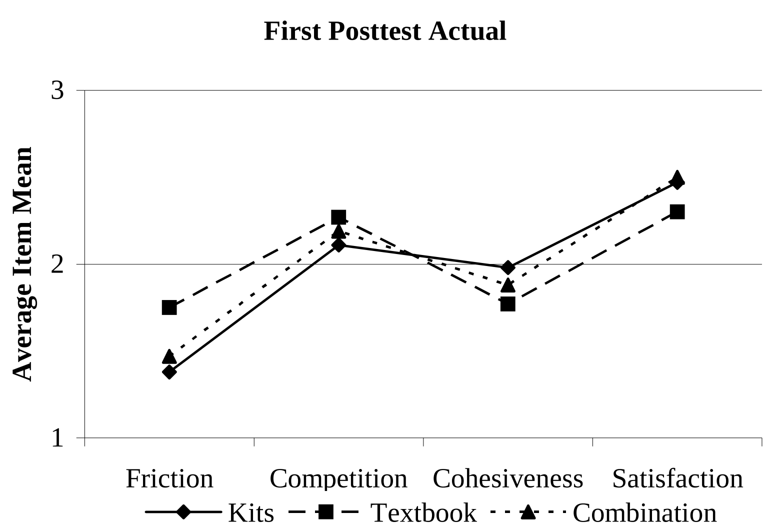

Figure 4. **Average Item Mean for First Posttest Actual Environment Scores for Each School**

4.3.2.4 Comparison of Delayed Posttest Actual Environment Scores in Three Schools

In May, the MCI was administered as a delayed posttest to identify changes throughout the year by comparing how students perceived their science class. Table 5 shows the average item mean for each school on each testing occasion. Figure 5 provides a profile of MCI means for each school at the time of the delayed posttest.

Figure 3 and Figure 5 and Table 5 enable comparison of the three schools in terms of relative changes on the four dimensions of the MCI between pretest and delayed posttest. A comparison of Figure 3 and Figure 5 shows that several similarities exist between the pretest and delayed posttest environment scores.

The analysis of covariance reported previously on Table 4 indicated that, when corresponding pretest scores were controlled, differences between the three schools were not statistically significant in terms of either Friction or Competition. Therefore these two scales are not discussed further here. On the other hand, the previous analyses of covariance did reveal statistically significant differences between the three schools on both Cohesiveness and Satisfaction. For Cohesiveness, the Kits school was more effective in that Cohesiveness stayed relatively constant while there was a decrease for both the textbook school and the combination school scores between pretest and delayed posttest (see Figure 5).

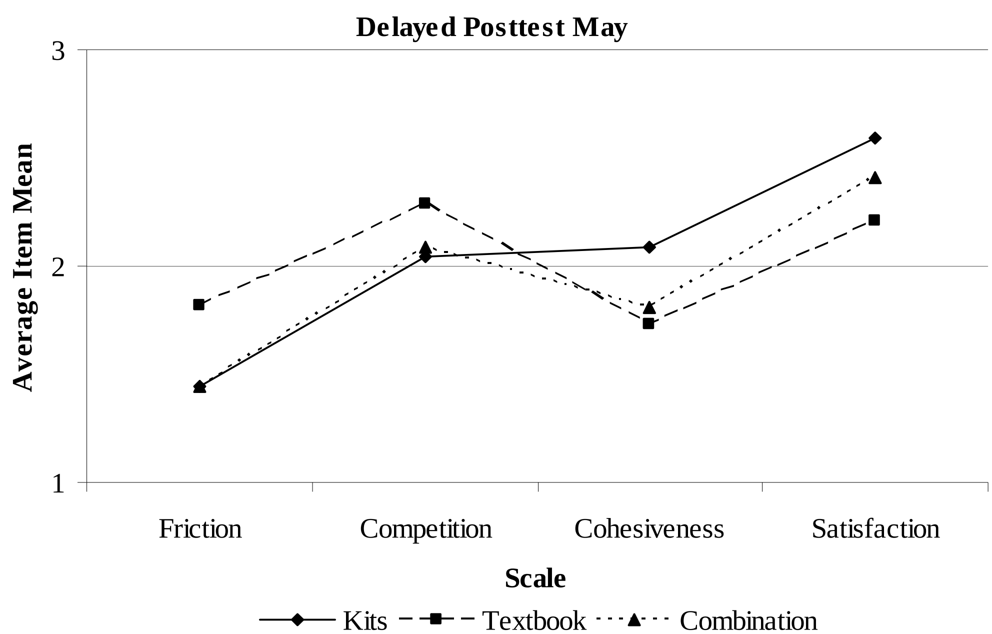

Figure 5. **Average Item Mean for Delayed Posttest Actual Environment Scores for Each School**

Figure 4 and Figure 5 show that larger changes between pretest and delayed posttest occurred for Satisfaction. Both the textbook school and the combination school declined in Satisfaction during the year. However, the kits school experienced a small increase in Satisfaction during the year.

4.3.2.5 Comparison of Preferred Scores in Three Schools

The average item mean for each preferred MCI scale is graphed separately for each of the three schools in Figure 6. This figure shows that students in the Kits school and the combination school have very similar preferred means on all four MCI scales. Also the average level of preferred Satisfaction is similar for all three schools. The textbook school preferred more Friction, more Competition and less Cohesiveness than did students in either the kits or combination school.

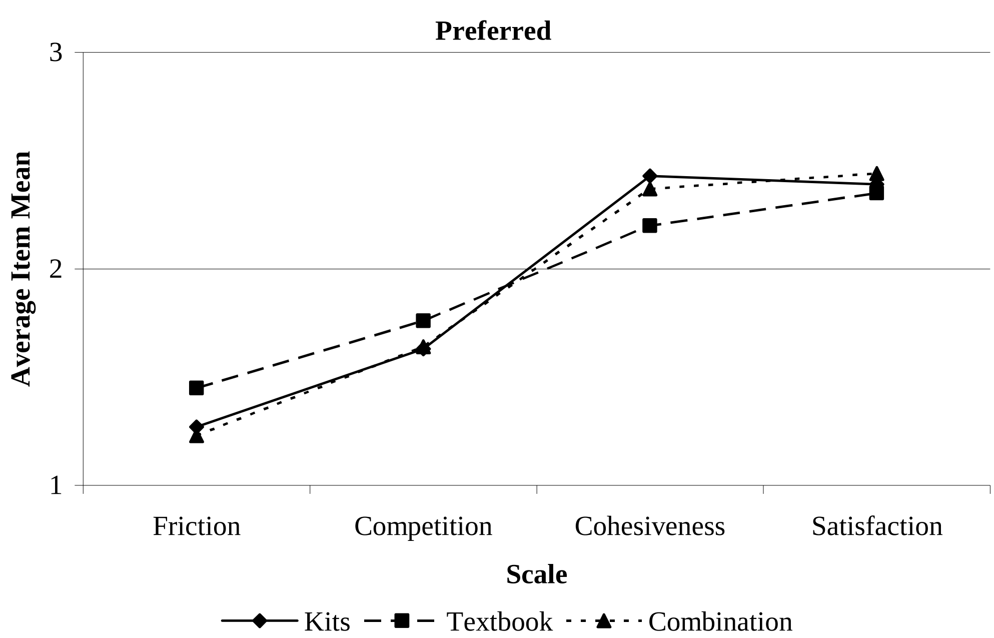

Figure 6. **Average Item Mean for Preferred Environment Scores for Each School**

4.4 Associations between Student Satisfaction and Classroom Environment

The third research question involved associations between student Satisfaction and the three learning environment scales of Friction, Competition, and Cohesiveness. For these analyses, I followed the lead of Majeed, Fraser and Aldridge, (2002) and employed the Satisfaction scale from the MCI as a dependent or outcome variable. Data were analyses using two methods of analysis (simple correlation and multiple regression analysis) for two units of analysis (the individual student and the class mean). Also all analyses were conducted for the three occasions when the actual classroom environment was assessed (pretest, posttest and delayed posttest). These results are reported in Table 6. My third research question was:

3. *Are there associations between student attitudes toward science classes and the classroom environment?*

The results in Table 6 generally are consistent with past research (Fraser, 1998b) in that statistically significant associations exist between students' satisfaction and their perceptions of classroom environment. The simple correlation between satisfaction and classroom environment is statistically significant (p<0.01) for each of the three environment scales, each testing occasion, and both units of analysis. All correlations are positive for Cohesiveness and negative for both Friction and Competition. That is, Satisfaction is higher in classes with a more favourable classroom environment in terms of less Friction, less Competition, and more Cohesiveness.

Table 6. **Simple Correlations (*r*), Multiple Correlations (*R*) and Standardised Regression Coefficients (*ß*) for Associations between Satisfaction and MCI Scales for Two Units of Analysis**

MCI Scale	Unit of Analysis	Simple Correlation (*r*)			Standardised Regression Coefficient (*ß*)		
		Pretest	Post 1	Post 2	Pretest	Post 1	Post 2
Friction	Individual	-0.41**	-0.28**	-0.40**	-0.27**	-0.18**	-0.22**
	Class Mean	-0.56**	-0.60**	-0.50**	-0.31*	-0.22	-0.02
Competition	Individual	-0.30**	-0.23**	-0.36**	-0.13**	-0.11**	-0.17**
	Class Mean	-0.52**	-0.57**	-0.61**	-0.10	-0.25	-0.34
Cohesiveness	Individual	0.42**	0.37**	0.41**	0.30**	0.29**	0.27**
	Class Mean	0.75**	0.69**	0.66**	0.58**	0.43*	0.48*
Multiple	Individual				0.52**	0.43**	0.51**
Correlation	Class Mean				0.81**	0.75**	0.71**

**p<0.01

Sample: 588 students in 28 classes

The magnitudes of the multiple correlations in Table 6 range, for the three testing occasions, from 0.43 to 0.52 with the individual as the unit of analysis and from 0.71 to 0.81 for class means. The multiple correlation is significantly greater than zero ($p<0.01$) for each of the three testing occasions and for each unit of analysis.

In order to identify which individual classroom environment variables are responsible for the significant multiple correlations, the standardized regression coefficients in Table 6 were examined. With the individual as the unit of analysis, each of the three environment scales is significantly related to Satisfaction for each testing occasion when the other two environment scales are mutually controlled. With the class mean as the unit of analysis, Cohesiveness is a significant independent predictor of Satisfaction for the pretest. All significant regression coefficients are in the expected direction in that Satisfaction is linked with greater Cohesiveness and less Friction and Competition. Overall, classroom Cohesiveness appears to be the strongest predictor of student Satisfaction for both the simple correlation and multiple regression analyses and for each unit for analysis. However, both classroom Friction and Competition also consistently linked with lower student Satisfaction.

4.5 Summary of Quantitative Investigation

This chapter, so far, has been devoted to reporting the results of the statistical analyses that were conducted to answer my study's research questions. First, the validation the MCI in was reported in Section 4.2. Using factor analysis, faulty items were identified and removed. The entire Difficulty scale and Item 7 from the Friction scale were removed. Internal consistency reliability was found to be sound using the Cronbach alpha coefficient for two units of analysis, namely, the student and the class mean. Discriminant validity, reported for two units of analysis, suggested that raw scores on the MCI were somewhat overlapping in terms of the learning environment, although the factor analyses supported the independence of factor scores. An ANOVA performed for each MCI scale confirmed the ability of each MCI scale to differentiate between the perceptions of students in different classes.

Section 4.3 reported results concerning the effectiveness of using a science kit-based intervention in terms of a comparison of the three treatment groups' satisfaction and class environment scores. An ANCOVA for each scale revealed statistically significant differences between the three groups in terms of changes in Cohesiveness and Satisfaction. The group using the kits experienced a larger pre-post change in scores than the other two groups (textbook and teacher-created materials) for both Satisfaction and Cohesiveness.

In Section 4.4, associations between student satisfaction and class environment were addressed. The Satisfaction scale was used as an outcome measure to be correlated with classroom environment scales. Statistically significant simple correlations with satisfaction were found for each of the three environment scales and both units of analysis. Correlations were positive for Cohesiveness and negative for both Friction and Competition. Again, using Satisfaction as an outcome, multiple regression analyses revealed that all significant regression coefficients are in the expected direction in that Satisfaction is linked with greater Cohesiveness and less Friction and Competition.

4.6 Qualitative Investigation

As introduced in Chapter 2 and discussed in Chapter 3, combining qualitative data-collection with a quantitative data-collection has been found to be useful in various studies (Tobin & Fraser, 1998; Tobin, Kahle, & Fraser, 1990). Qualitative data can provide details missed in the quantitative investigation. Researchers have found merits for combining qualitative and quantitative research in the field of educational evaluation (Cook & Reichardt, 1979; Firestone, 1987; Fraser, Williamson & Lake, 1988; Howe, 1988). The combination of qualitative methods and quantitative measures (Fraser & Tobin, 1991) has provided insight into the effect on the learning environment of different types of pedagogy.

In the quantitative investigation, the purpose of the research was to test the impact of using science kits, textbooks, and a combination of science kits, textbooks, and teacher-created materials on students' perceptions of their science classroom environment. The instrument chosen for the quantitative investigation was the *My Class Inventory* Questionnaire (MCI). In order to identify variables that could influence the outcomes of my research, a qualitative investigation was also conducted. The qualitative investigation consisted of teacher interviews, during which I collected background data on teacher preparation classes and/or inservice courses that teachers had attended, number of years of experience teaching, and number of years of teaching experience at the grade level at which they were teaching at the time of the research study. The purpose of collecting these data was to compare the teachers' experience and preparation for teaching science with other teachers in the same grade level at the three samples schools. This was necessary because it is a variable that could affect student perceptions of classroom environment.

Student interviews were conducted during the research timeline, namely, September, January and May. The purpose of the students' interviews was to see if the students' responses to the MCI were supported by their comments during the interviews. I also wanted to know why students' perceptions were different, if they were, when using science kits, textbooks, or a combination of science kits, textbooks, and teacher-created materials. I also used classroom observations to see how the science classes were organized and to observe student responses to the method of instruction. I observed one science class from each grade level at the three sample schools.

As a part of the triangulation of data, I observed classes to see the size of the class, the surroundings in the classroom, students' interactions with the teacher and other students, and the presentation of science lessons. Triangulation of data allows the researcher to determine if the information provided by one source can be supported by the other two data sources (Merriam, 1998; Punch, 1998; Tobin & Fraser, 1998). To this end, I compared the teacher interviews with their teaching behaviors during the observations. This information was then cross-checked with observations of students during the teaching of the lesson and the student interviews. Finally, these insights gained from interviews and observations were compared with the data collected from the MCI to develop a more complete picture of the classroom learning environment.

All of the teachers whom I observed volunteered to be a part of my study. I had a set list of questions to ask at each interview, but also I allowed extemporaneous questions to clarify the information gained as the interview progressed (Sideman, 1998). This was important because I wanted to be sure that I understood what the teachers and students were reporting. The purpose of the teachers' interviews was to obtain background information to see the effects of experience and amount of science training on lessons presented in the science classroom (Merriam, 1998). This was very important to the study because it introduces a variable that could influence the outcome of the observations. The amount of training and preparation for teaching science could have a strong influence on classroom management and presentation of the lessons.

A total of 16 teachers participated in the study. There were four teachers from the science kits school, four teachers from the textbook school, and eight teachers from the combination school. The teachers had various experience levels from novice to 30 years in the classroom. They also had various amounts of science training in preparation for teaching science.

The questions for the teacher interviews were as follows:

Interview Questions (Teacher)

1. How long have you been teaching? How long teaching science?
2. For how many years have you been teaching the grade level you are teaching now? What other grade levels have you taught?
3. Have you attended science workshops or seminars? Recently? What was the focus of the workshop or seminar?
4. How do you feel about adding science to the curriculum? Do you feel adequately prepared for teaching science?
5. How much time do you spend writing your science lesson plans?

Student interviews were also conducted as a part of my study. The purpose of the students' interviews was to discuss aspects of their science classes that students found satisfactory and areas in which they wanted change (Seidman, 1991). A total of 17 students was interviewed. The students were picked randomly to participate in the interview process. The questions for the student interviews are as follows:

Interview Questions (Students)

1. What was your favorite science activity this year? Why was it your favorite?
2. What do you like best about science class? Least?
3. Do you tell your parents about your science activities?
4. How do your classmates feel about science?
5. Do you work in groups? Do you like group work?
6. Finish this statement: If I could change my science class, I would......
7. Finish this statement: I wish my science teacher would.......

4.6.1 Science Kits School

The science kits school used only kits; by choice, the teachers received no textbooks. The kits that were used were from FOSS (Full Option Science System). The FOSS trainers came to their school and provided teachers with professional development on how to use the kits by using the activities from the kits as examples. The science kits school had two 3rd grade teachers, one 4th grade teacher and one 5th grade teacher for science instruction.

The science kits school is the oldest in the District and the smallest although the class sizes are comparable to the other two schools in the study. It is in an older neighborhood set away from main streets. The facilities have been upgraded and remodeled through the years. This school is scheduled to close after a new elementary school is built. The school has continually received high ratings from the Texas Education Agency, which determines the curriculum taught and the standardized tests administered, as well as rating schools according to their scores on state-developed standardized tests, student dropout rates, and the test scores of ethnic populations within the school. The school's rating is an indication of how well the school is performing.

4.6.1.1 Teacher Case Studies at the Science Kits School

Teacher case studies were conducted with the science teachers at the science kits school. There were four science teachers at the science kits school, two taught 3rd grade, one taught 4th grade and one taught 5th grade. The science kits school was departmentalized for 4th and 5th grades. This means that the students changed classes for instruction and that one teacher taught all the students in their grade level for a particular subject. A summary of the case studies of the teachers is included in this section:

> Cathi Jackson has taught for 17 years. She taught Special Education for the first six years of her career and then Kindergarten, and Grades 1 and 3. She has been teaching 3rd grade for five years. The science kits school is not departmentalized at the 3rd grade level in that both teachers teach all subjects to their respective classes. Cathi used the kits instruction manuals, equipment and reading lessons. She reported that the students responded enthusiastically to the lessons and looked forward to the science portion of the day. She attended a FOSS seminar and inservice meetings about using kits that were held before school started in August. She has not attended any other science-related seminars or workshops during her career. She feels that everything she needs is contained in the kits and

has no plans to attend seminars other than seminars taught by FOSS trainers. Her favorite lesson was weather and climate. The Weather and Climate kit had all the equipment necessary to perform several experiments. A reading supplement is also available in the kit. Cathi commented that not only were the students learning science, but they were also working on their reading skills.

Heather Harris was a first-year teacher. She had returned to the university after her children reached school age to complete her education and become certified in elementary education. Although she was a first year teacher, she brought experience in working with children to the classroom. She was very excited to work with 3rd graders and with the science kits. She attended science inservice courses before school started in August and had a FOSS representative come to her school to help her with the kits. Her favorite kit was the Weather and Climate kit. She stated that the students enjoyed building weather instruments and going outside to use them. She plans to attend a Conference on the Advancement of Science Teaching (CAST) and other science-related inservice programs offered by the Regional Education Service Center.

The science kits school was departmentalized for Grade 4. Cheryl Farr taught two classes of 4th graders. She had taught for eight years and had recently completed her Mid-Management degree, a degree required in order to hold administrative positions in public education in Texas. She was very enthusiastic about using the kits. She had attended the FOSS training and science inservice courses before school started. She was not sure she would attend any other seminars or workshops on science because she was planning on becoming an administrator at another elementary school. Her favorite kit was Magnetism and Electricity. The students worked with batteries, light bulbs and wire to make a simple circuit.

The science kits school was also departmentalized for Grade 5. Brittany Scott was an experienced teacher with 24 years of teaching experience. She had attended several workshops and seminars on science instruction. She stated that science was her favorite subject to teach. She was on the district committee that reviewed the kits before adoption. Her favorite kit was the Landforms kit. Students created their own river and delta system using equipment provided in the kit. The students also created a beach with waves to study beach erosion.

4.6.1.2 Student Case Studies at the Science Kits School

Interviews are “a powerful way to gain insight into educational issues through understanding the experience of the individuals whose lives constitute education” (Seidman, 1991, p. 7). For my study, I interviewed two randomly-chosen students for each grade level. The following are case studies of individual students based on interviews:

Sean is an outgoing, talkative 3rd grader. He has attended the science kits school for all of his school years. He likes school and likes being with his friends. I spoke with Sean at each of my visits to his class. He started the year being very active in class and said that he got into trouble a lot. When I asked how he liked science, he said that he didn't know for sure what science was but he knew that it would be fun. During each visit, I asked how he enjoyed science and, every time after the first visit, he answered that it was his favorite class. I asked what he liked most about science and he said that students could work with their friends and they didn't have to stay in their seats. He added that he doesn't get into trouble in science but still has trouble with some of the other classes. He loves his teacher and thinks she is "cool". When asked what he liked least about science he stated test days because students had to stay in their seats and answer questions. When asked if he would change anything about his class, he immediately said that he would not have test days. I asked about his classmates' feelings about science and he said everyone liked it except one girl who didn't like anything. When observed, he was an active participant and encouraged others to do activities as he did him. When asked what his favorite lesson was, he said it was about Water. He mentioned counting how many drops of water could be put on a penny. I asked why that happened and he said that it was because the water drops glued themselves together. Sean had difficulty staying in his seat and on task during bookwork and his attention wandered around the room. He seemed to stay focused during the activities and followed instructions well. Sean had difficulty during the testing phase of my study but he was easily redirected back to answering questions. When asked about his favorite lesson, he replied that is was volcanoes because they were messy! He told me that the mess was called an eruption and that not all volcanoes were erupting now.

The second 3rd grade student whom I interviewed was Michelle. Michelle was a quiet girl, a little bashful, and easily embarrassed. She had attended the science kits school since kindergarten and said that it was the best school. She started the year very quietly and was in class for approximately two weeks before she started participating. She was a quiet observer. She did all of her work but was not very outgoing. She relaxed in class after about two weeks and participated in quiet ways. She rarely raised her hand to answer questions but readily answered when called upon. She wasn't sure that she would like science because she had "never heard of it". When I returned for later visits I found Michelle participating and interacting with her group during science. When asked how she liked science, she said that it was fun. I asked about activities the students had performed in class and she explained what they did and told me what they had learned from it. She was more active during the activities. She wasn't the leader in her group but she participated in a cooperative manner. When asked what she would change about science, she said that she couldn't think of anything to change. She said that her favorite activity in science was when students planted the pea seeds and watched them grow. She told me that students put some seeds in the window, some in the room and some in the closet. She also said that students were very careful to give each plant the same amount of water. She said that it was fair to give all plants the same amount of water. She concluded that plants need light to grow because plants in the dark didn't grow.

Jose was a 4th grader at the science kits school. He was attending the science kits school for the first time. He was friendly and outgoing. He made friends easily. When I first interviewed him, I asked how he liked science. He said that science at his old school wasn't fun. He said that it was like mathematics with "lots of homework". He talked about his old school and how different the science kits school was from his old school. He said that he wasn't sure if the differences were good or bad but he missed his old friends. On subsequent visits, I asked how he liked science and he said that it was "okay". He said that he enjoyed working with everyone and that the activities were "fun". When I asked what he liked most about school, he said music but that he liked science too. I asked, if he could change anything in his science class, what it would be. He responded that he would have his teacher not walk around so much when they were working. It bothered him that she was "always" behind him. I asked about his classmates' feelings about science and he said that they all liked it. His favorite lesson in science was when the class made a magnet with wire and a battery. He said that it made a "feeling" (field) around his nail and that he could pick up paper clips with it. He was not really clear about what electricity is but he knew that magnets would attract metal objects.

Amy was in 4th grade and had attended the science kits school since kindergarten. She said that she liked it there because she could walk home with her friends. When asked how she liked science, she said that it was fun because you made things fizz. I inquired about this and she described making a volcano in 3rd grade and making the volcano fizz. I asked her more about volcanoes but she wasn't clear about anything other than that "stuff" bubbled out of them. When I asked about her opinion of science again on subsequent visits, her science vocabulary seemed to be increasing with each visit. She stated that she liked science because it was easy. I asked if students worked in groups in science and she replied that they did, but that the teacher picked the groups. She would have preferred to stay in a group with her friends. When asked what she liked least about science, she said that sometimes it was messy. When asked what she would change about her science class, she replied the students would be able to pick their own groups. I asked if students worked out of a book much. She said that they didn't have a science book but, with everything they studied, little books were included. When observed, she was an active participant in the science activities and answered the teacher's questions correctly.

Andrew was a 5th grader at the science kits school and had attended the science kits school since 3rd grade. He said science was "okay" but he that liked sports best. He participated in class and seemed comfortable with the teacher and other students. He was not an outgoing student but he participated in class. I asked throughout the year how he liked science and his answer remained the same. When asked if students worked in groups, he replied that they did for science and social studies but not for mathematics or reading. He said that working in groups was better because students could talk about the answers before they wrote them down. His favorite activity was when students made rivers and deltas. He talked about erosion and why it can be bad. He also explained how a delta was built up. He said that it was a little messy but that made it "better". I asked what he liked least about science and he said the teacher talked too much when they wanted to get started on the activity. He participated in the activities and volunteered to answer questions when the teacher asked. He said that he had good grades in science and that his parents were happy about that. When I asked if he talked to his parents about what they had done in science, he said that he did when students did the "neat stuff".

Charlotte was also a 5th grader at the science kits school and had attended the science kits school for five years. She said that, during her first year (kindergarten), she lived with her grandparents in another city in Texas. She had studied science in a summer program offered by her church and so she was looking forward to science classes. She was friendly with her classmates and seemed to get along with all the students in her class. She seemed to want everyone to get along with each other and worked to make it happen. She said that she enjoyed group work and that students did group work in science and social studies. Her teacher determined the grouping. When observed, she was an active participant in class and volunteered to answer questions. Her favorite lesson was about the environment. She said that they looked at the way in which "water can get acid in it (acid rain) and then dissolve statues and buildings". She said that they put vinegar in water, put it in a jar and put a rock in the jar. They observed changes for several days and then talked about what happened to the rock. When I asked if she talked to her parents at home about her science class, she said students did the same experiment at home and so her parents could see what happened. When asked what she liked least, she didn't have any comment. When asked what she would change about her class, she replied that sometimes the teacher spends too much time talking before students do their activity.

4.6.1.3 Observations at the Science Kit School

In order to triangulate data in my study, I observed one teacher from each grade level to see if the classroom environment observed coincided with the results of the quantitative part of this study. Included in the observations were the physical setting, the participants, and their activities and interactions.

I observed Heather Harris, one of the 3rd grade teachers at the science kit school. She was a first-year teacher but had experience with children at home. Her classroom was bright with primary colors accenting the walls. She had posters on the wall illustrating proper letter formation, number order, and phonics. She also had an aquarium with fish and several plants around the room. Heather was teaching a unit on weather using the Weather and Climate Kit. Today's project was to build weather instruments to take outside for the purpose of gathering data. The students were very excited and were working diligently on building their instruments. Heather circulated around the room, stopping to talk to each group, and to help when needed. All the students are actively engaged. I did not see any off-task behaviors.

The 4th grade was departmentalized, which means that the students changed rooms and that each teacher taught the entire 4th grade for a particular subject. Cheryl Farr was the science teacher for the entire 4th grade at the science kits school. She had taught for eight years and was hoping to become an administrator for the next school year. Cheryl's room was also painted in primary colors and had a large area where student work was displayed. She had several posters on the wall. Some of the posters were about grammar usage and mathematics but she also had a few motivational posters. Cheryl was teaching a unit on plants. The students were planting vegetable seeds to later transplant into a garden which the 4th grade was developing. After they had planted their seeds in their cups, students went outside to check on the plants that they had already planted outside. The students were measuring the height of the plants and counting the number of leaves. This information was being recorded into their data tables. I was told that the students would be developing graphs to display their data. All the students participated and some of the students took me to see the plants that they had planted personally. The students were all focused on the lesson and I observed no off-task behavior.

The 5th grade was also departmentalized. Brittany Scott taught the entire 5th grade science. She had 24 years of teaching experience. Brittany's classroom was also painted in primary colors. She had student work displayed as well as posters with cursive writing style as a border around the front of the classroom. She also had pictures and posters with historical events. She explained that the students had just finished a project in their history class and that the students had written stories about the events pictured around the room. The students were working on a Landforms unit from one of the kits. They had stream tables and were making rivers and deltas using the materials from the kit. They had to create the river system and then draw the results of their river system. The students were actively engaged. A couple of boys started to throw mud at each other but Cheryl quickly moved to their table and redirected the boys behavior. When the lesson was over, Cheryl asked questions about their river systems to check for understanding. Then she had the students clean their work area and return

4.6.2 Textbook School

The textbook school adopted only books and ancillary materials. A committee of teachers, parents and community leaders were instrumental in choosing the textbook for the science program. The choice was based on readability of the textbook, accuracy of the material presented and compliance with the Texas Education Agency's guidelines for science instruction at each grade level.

4.6.2.1 Teacher Case Studies at the Textbook School

The textbook school had two 3rd grade teachers teaching science. As with the science kit school, the textbook school was departmentalized for science in 4th grade and in 5th grade. The 4th grade students changed classes after their physical education class and the 5th grade students changed classes after their music class. They spent the morning with one teacher and the afternoon with another teacher. Half the students in the 4th and 5th grades had science instruction in the morning and the other half had science instruction in the afternoon. The following section reports the information gained through observations and interviews:

> The textbook school had three 3rd grade teachers but only two taught science. One teacher felt unqualified to teach science and traded classes with one of the other teachers. She taught a language arts block of classes and the other teacher taught a mathematics, science and social studies block. Suzanne Erickson taught one science class. She had 19 years of experience and had taught Grades K, 1, 2, 4, and 5. She had been teaching 3rd grade for eight years. She enjoyed reading to the class and read the science book to the students. She has attended workshops and seminars on teaching 3rd grade but no workshops or seminars concentrating on science. She had attended the science inservice courses before school started. She had no plans to attend any other science workshops or seminars because she had taught for so many years. She felt that there was no new information that would benefit her in the classroom. She stated that it took one to two hours to plan science lessons for the week. She had a general knowledge of science and said that it was more than enough to teach 3rd grade. She used the book for vocabulary, review questions and activities. She used ancillary materials for additional vocabulary and review worksheets. She also used the tests provided by the textbook company. Her favorite lesson was on Volcanoes. She felt that is was relevant to the present and that she could relate events to the students. She read stories

about volcanoes, showed videos, and had the students build a volcano as a homework project. She felt that students enjoyed the unit.

Robyn Allen was also an experienced teacher with 28 years of experience. She had taught all elementary grades and had been teaching 3rd grade for ten years. She stated that the principal at her school had told the teachers that he wanted them to use the textbook for instruction. She stated that she wrote her lesson plans in an hour or two. When asked about her favorite lesson or unit to teach, she said geology. She added that, if she went back to the university again, she would study to be a geologist. She had taken several science courses in college and felt that she was well prepared to teach science. She had attended CAST (Conference for the Advancement of Science Teaching) several years ago and said that she might go again if it was local. She enjoyed meeting with other teachers and sharing ideas.

James Russell was a first-year teacher and had taken several science courses in college. He felt that he was over-prepared and, at times, too advanced for his students. He stated that he was having some difficulty planning lessons at the appropriate level for 4th grade students. He had attended a few science workshops in Oklahoma, before moving to Texas, and some workshops in Texas. He would like to attend science workshops and seminars concentrating on elementary science. He attended the science inservice course at the beginning of the year. His favorite unit was Classification Systems and he had several activities planned for teaching it. He said that the students had trouble with the unit at first but that, after continued lessons, they began to understand the concept. He was very excited about teaching and worked very hard to prepare for his classes. When asked how much time he spent on lesson plans, he replied: "All weekend." James stated that he used the book for vocabulary, review activities and chapter summaries. He said that he depended on the book to help him adjust the classes to the appropriate level of instruction.

Benjamin Garcia, the 5th grate science teacher, taught two science classes. He was very experienced and had taught for 31 years. He stated that this would be his last year teaching. He had attended several workshops and seminars on science during his teaching career. His favorite unit to teach was displacement of a fluid. He said that the students enjoyed an activity in which they experimented with how many pennies they would float in their aluminum boat. He said that he was using the new book but relying on materials that he had collected through the years. He had no plans to attend workshops or seminars because he was retiring at the end of the school year. He did state that he had found workshops, seminars, and conferences very beneficial when he first began teaching.

4.6.2.2 Student Case Studies at the Textbook School

I interviewed six students at the textbook school. All of the students volunteered to be interviewed. I took the students to the library and asked them the questions that I had planned. At first, the students were hesitant about answering the questions and only gave brief answers. As the interviews progressed, the students became comfortable and added more detail in their answers. The following are the reports of student interviews and observations:

> Jason is a quiet 3rd grader at the textbook school. He has attended the textbook school since kindergarten. He likes school and says that he does very well. In September, I asked him how he liked science. He replied that he had not had science before and asked what is was. On subsequent visits, I asked how he liked science again and he said that it was "alright". When questioned further, he said that it was "okay" but no more special than his other classes. When I asked what his favorite class was, he said social studies because students colored maps. When I asked about his favorite science activity so far that year, he explained the students had made volcanoes and that was fun. I asked about how a volcano works and he wasn't sure, but he knew that they "spilled" over. When I asked what his favorite part of science was, he identified activities, but claimed that students didn't do them very much. When asked what they did do in science, he said papers, "worksheets" and questions out of the book. I asked what a typical science class was like and he said that students often read the chapter together and then do "papers" or questions out of the book. He said that sometimes students colored pictures and sometimes they did an activity but not very often. I asked what he would change about this science class if he could. He replied that there would be no books and no papers and that students would do a lot of different things. When I asked if he told his parents about his classes, he said not usually, except when students did activities. I asked if students worked in groups and he said that they did for part of the time. The teacher determined the group members. Students did group work in different classes. He said that he liked group work because you don't have to do it by yourself. If you need help, the other students in the group can help. I asked what he wished his science teacher would do and he stated that the class would be able to study volcanoes and hurricanes for a long time. When observed in class, Jason was quiet but attentive. He answered questions when asked but looked uncomfortable when called on. I observed the class on several occasions but never saw an activity. Lessons were concentrated on the textbook and ancillary worksheets that came with the textbook.

> Tina was a 3rd grader at the textbook school and had attended the same school since kindergarten. She was outgoing and active. She was reprimanded in class for being out of her seat and talking. She was very bright and answered questions that the teacher asked before being called on. I asked her about her favorite science activity and she identified rocks because they are what the Earth is made of. Her second choice was the human body. She liked cutting out the bones and putting a skeleton together. I asked what her science class was like most of the time and she replied that it involved the teacher reading the chapter, with students doing a vocabulary assignment, having a vocabulary test, and doing

questions from the book. She said that students have a chapter test every Tuesday. I asked what she would change if she could and she said students would never use the book and they would only do activities all of the time. When asked if she told her parents about her science class, she replied that she told them what grades she received but not much else. She added that her parents didn't ask what students were studying. She said that students worked in groups and that was better because she didn't get into trouble so much. She was very open and talkative when interviewed. When answering, she gave a complete response that required little or no clarification.

Sam was a 4th grader and had attended the textbook school since kindergarten. Sam volunteered the information that he lived with his older brother and his brother's wife and not with his parents. I asked how he liked science and he said that it was "okay". I asked what his favorite lesson had been that year and he replied the "gloop lab". I asked what the "gloop lab" was but all he could tell me was that students mixed different "stuff" together and made Silly Putty. When I asked what he had learned from the activity, he said nothing really but that it was fun. I asked what he would change if he could change his science class. He replied that he would do away with papers and only do "stuff" everyday. I asked what kind of "stuff" and he told me that they would do science "stuff" like his older brother did when he was in school. When I asked if he told his brother about his science class, he said that he told his brother about the "gloop lab" and brought his "gloop" home. He still had it on his table. I asked about group work and he said the students did group work. He said that his teacher usually picked the groups but sometimes she would let students pick their own group. When asked what he wished his science teacher would do, he replied that he would take away the worksheets, ask questions out loud to the class, and not talk so much. After observing his class, I noted that his teacher tended to talk quite a bit in class and often discussed material that was too advanced for the class.

Lisa was a quiet 4th grader who had attended the textbook school since kindergarten. She would answer questions in class, sometimes volunteering and sometimes when called upon. She told me that she didn't like answering when she had not raised her hand because she wasn't sure she had the right answer. I asked her about her science class and, in September, she said that it was like the other classes. She continued with that opinion on subsequent visits. I asked what her favorite activity was and she replied the "gloop lab". I asked what she learned from the activity and she said that, if you put too much food coloring in the "gloop", it gets on your hands and clothes. When I asked why students did that activity in science class, she didn't know. She also liked the mixtures activity because students separated things like dirt and rocks and salt and pepper. She said that the object of the lesson was to show the class that you could separate things without having to break them apart. When I asked if she told her parents about her science class, she said that she did because her dad was really smart in science. Her dad helped her with her lessons. When asked what she would change, she replied that she would have more activities, such as looking through microscopes and dissecting things. She added that she wished the teacher would not talk so much. The lesson became confusing because the teacher repeated himself, which is good if you didn't understand it the first time, but frustrating when you hear the same information repeated several times. She added that her teacher was always helping them with their work and wanted them to do well. She said that her science teacher was the best teacher she had that year.

Arthur was a 5th grader and had attended the textbook school for two years. He said that he liked this school better than his old school and that the teachers were nicer. I asked how much he liked science and, in September, he said not too much. By January, he said that science was his favorite class. I asked what activity was his favorite and he told me about building a boat out of aluminum foil and putting pennies in it. He said that they put pennies in it until it sank. I asked how he could apply the lesson to events in life and he explained buoyancy and how it was important for boats. I asked what he would change about his class and he said that students would do more activities and less bookwork. He enjoyed working in groups because students could talk about their disagreements in their group before reporting to the class. I observed his class and found that the teacher used the activities that came with the textbook and activities from his experiences in the past. The students were engaged and most of them were on task.

Dee was a quiet 5th grader who had attended the textbook school since kindergarten. She said that she knew what science was and really liked the class. When I asked what her favorite class was, she identified the class on chemical changes because students did a lot of activities. I asked what she liked least about her class and she identified using the book too much. She said that students do vocabulary and questions for every chapter. When I asked what she would change about her science class, she said that there would not be so many students in class at the same time. The teachers combined classes and there were many students in the class. I asked what her classmates thought about science and she said that they thought that it was boring. She said that students do group work and that the teacher determines the groups. Students work with different people all the time. I observed Dee in science class and she participated in everything, paid attention and was not off task during class. She continued to pay attention even when students around her were not. When I asked what she would change about her teacher if she could, she said that she would like him to be a little more patient.

4.6.2.3 Observations at the Textbook School

The textbook school was one of the older schools in the District and had a new hall with classrooms added. It also had portable classrooms located at the rear of the school. The 3rd grade was located in the older part of the building. The 3rd grade teachers' classrooms were colorful. The classrooms had several bulletin boards and the teachers used them to display a variety of information. The science kits school and the textbook schools were both older schools with several windows. At the science kits school, the windows faced a courtyard that was landscaped with trees, shrubs and flowering plants, whereas the textbook school's windows faced the playground.

Suzanne Erickson had decorated her classroom with a teddy bear theme. She had several teddy bear posters and used teddy bear-shaped number cards on her calendar to indicate the days. There were also posters with the alphabet written in cursive and grammar rules. She had a large rug in the center of her classroom. She had the students move their desks back so that they could sit around her on the rug. She had a rocking chair in the middle of the room and she read the science lesson from the textbook in this setting. She had a wall chart with each student's name and marks indicating if they had completed an assignment. The students could examine the chart to be sure they had turned in all their assignments.

Robyn Allen's room was decorated in blue and white. She had plants in her room and had bookshelves on two of the walls. She had several books that were suitable for 3rd grade readers and the students could get a book at any time. She also had knick-knacks on some of the shelves as decoration. The students sat in rows on each side of the room, facing toward the middle of the classroom. She had posters depicting history scenes and a large map of the United States. She had student artwork displayed on the wall outside her classroom and homework pages displayed on the bulletin board in her room. She had a red, white and blue poster with classroom duties and students responsible for do the tasks. For example, the tasks were collecting papers, cleaning the blackboard, and watering the plants.

For the science lesson that day, she had the students label and color parts of a flower, and then make a model of a flower with all the parts present. The students all seemed to be on task and actively engaged in the assignment. The teacher moved around the room and stopped to talk to groups of students.

James Russell's classroom was in a portable building located at the back of the school. The room seemed noisy in that sounds seemed to be amplified. He has posters of landscapes with motivational quotes on them. He also has bookshelves on one wall with age-appropriate books and magazines. The room is paneled and seems dark. One corner of the room is decorated with items from Mexico and he has a guitar hanging in this area. He plays the guitar for his students occasionally and has them sing along with him. The science lesson for the day was about the planets. The students took turns reading from their science book and then they moved to their groups and created a model of the solar system on poster board. Some of the students had to be redirected during the reading and, when he called on some of the students, they were not sure where they were to start reading.

Benjamin Garcia’s classroom was located in the new part of the building. It was bright and had many posters around the room. The posters were of airplanes, insects, grammar rules, historical scenes, various animals and rules for writing a composition. He had an aquarium in the room with several fish. He had the desks facing the front of the room where his desk was located. Behind him was a blackboard that had the objectives for the day and the due date for a history project that had been assigned for students. His lesson for the day was on weather and erosion. The students read the section of the science book that discussed weathering and erosion and then Mr Garcia asked them to give examples of weathering and erosion around the school and their homes.

4.6.3 Combination School

Teachers at the combination school adopted textbooks for use in the classroom. However, the Parent-Teacher Association (a support organization for the school) also purchased several science kits for teachers to use to supplement science instruction with textbooks. Teachers combined the use of the textbook, science kits, and teacher-created materials in their classrooms.

The combination school is located in a relatively new area with new housing developments around the school. The school was built approximately eight years ago and has experienced rapid growth. The hallways are wide and bright. There is an area on a wall in the main hall that is devoted to baseball teams consisting of classes from this school. Pictures of the teams for each grade level are displayed on this wall. Student work is displayed in the hallways outside the classrooms. The combination school was relatively new in comparison to the science kits school and the textbook school. The classrooms were a little smaller in size, which made movement in the classrooms difficult. The teachers taught their lessons in their rooms most of the time. There was a room designated as the science laboratory, but it was smaller than the regular classrooms and had no furniture in it. This room was seldom used due to lack of adequate facilities.

4.6.3.1 Teacher Case Studies at the Combination School

The combination school has three 3rd grade teachers, three 4th grade teachers, and two 5th grade teachers teaching science. The range of experience is from a first year teacher to 12 years of experience. The classrooms are grouped by grade level to make communication between classes easier. The combination school has one room set up for science laboratory classes, but it is hard to schedule a class in there because there are so many teachers at the combination school. As a result, most of the science classes are held in the teacher's classroom. The following are case studies involving students at the combination school:

> Sara Davis has had seven years experience teaching in elementary school. She has taught Grades 1, 3, 4, and 5. This was her first year teaching 3rd grade. She attended inservice training before the school year started to prepare for teaching science this year. She hasn't attended any conferences or seminars with a focus on teaching science because previously it was not relevant to state-mandated achievement tests. The state tests had been in the areas of reading, writing, and mathematics. A science test was to be given in 5th grade for the first time that year. She states that she would like to attend a conference like the Conference on the Advancement of Science Teaching (CAST) where she would have the opportunity to attend several different sessions covering several topics. She spends about five to six hours a week preparing for her classes across all subjects. She wasn't sure how much of that time was devoted to science. The amount of time depended on the unit that she was teaching. She used the lesson plans from the textbook to judge how much time to spend on the units. She used the book as a guide and used it in class. She incorporated some of the ancillary materials that came with the textbook with some teacher created-materials that she obtained from other teachers during planning time and during inservice courses courses. Her favorite class for the year was teaching classification systems. She used various activities to help students to understand how objects are classified and to help them to create their own classification system for a mixed group of objects.

> Esther Harper has been teaching 12 years. She has taught Grades 1, 3, and 4. She states she enjoys teaching 3rd grade because the students are so open to learning. She has taught 3rd grade for three years. She attended inservice courses before school began this semester to prepare for teaching science as part of the daily curriculum. She has no science background and wishes she had taken science classes in college. She is willing to attend seminars and workshops to increase her science background but wants to attend during regularly scheduled inservice courses. She states that she is very busy outside the class with her family and cannot attend summer or Saturday classes. Her favorite class to teach is geology. She enjoys teaching the mineral identification unit and has prepared a hands-on

unit to teach minerals. She says the students really enjoy the hands-on approach and are very enthusiastic participants in the lessons. She tries to have a hands-on activity at least once a week. She assigns vocabulary assignments and review questions in the book. She also uses activity ideas found in the ancillary materials that were purchased with the textbook and a computer test bank for test preparation.

Molly Hernandez has been teaching for four years. She has taught 3rd grade for all four years. She was concerned that adding science to the curriculum might take away from reading and mathematics classes. She is reluctant to teach science, feeling that she has no training to teach it. She attended the inservice courses offered before the school year began in August and has talked to other teachers to try to prepare for science classes. She is nervous about hands-on activities because of "chaos" in the classroom. She prefers to use only the book for assignments and for planning. She also stated that the lesson-planning section of the teacher edition has been very helpful when she is preparing her lesson plans. Her favorite class to teach is human body systems. She says that the students enjoy cutting out the bones and gluing them to a large sheet of colored paper. She would like the 3rd grade to be departmentalized so she would not have to teach science.

There are three fourth grade teachers, each teaching one class. In fourth grade, only some of the classes are departmentalized because two teachers preferred to keep their classes all day and teach all subjects. Gail Sanderson has been teaching six years. She has taught Grades 4 and 5. She has been teaching 4th grade since coming to this school district four years ago. She teaches science and reading to 4th grade students. She enjoys only having to prepare for two subjects. She states that she uses the book for vocabulary assignments and lessons when she has to be absent (illness or jury duty). She has developed units using the book sparingly, teacher-created materials and kits from FOSS. She prefers the teacher-created materials to other resources. She has only attended science training during inservice courses courses before the school year started in August. She has talked with other teachers and uses the Internet for ideas. She has no plans to attend science seminars or conferences. She stated that she depends on the District to provide training. Her favorite unit is geology. She has a model of a volcano that she made and enjoys using to teach about structure and eruption of volcanoes. She states that the students really enjoy it when the volcano erupts in class. Students ask to see it again and again.

Diane Willoughby is a first-year teacher who relies on Gail to help her to prepare for science class. She has attended the inservice courses training provided by the District before school started in August. She has not attended any seminars focusing on teaching using kits. She is overwhelmed by all the preparations necessary for each day and uses lesson plans from the teacher edition as her guide. She is not planning to attend any seminars or workshops focusing on teaching science at this time. Her favorite class to teach has been body systems. She said the students were actively engaged in cutting out the bones and gluing them onto a large sheet of colored paper. She prefers a very structured class and feels that the class is out of control when students are doing activities. She realizes she needs to do more hands-on activities in her lessons.

Maggie French has had four years of teaching experience, with three years in kindergarten and one year in 4th grade. She prefers to keep her students all day because they are hard to settle down after changing classes. She attended the inservice courses training before the school year started, but has not attended any other science-related seminars or workshops. She relies on Gail for ideas to use in her class. She also uses the Internet for lessons and ideas. She states that she uses the textbook about 50% of the time and uses teacher-created materials for the remaining 50%. She has used one kit but feels she doesn't have time to study the materials included with the kit. She stated that she would use the kits more if she had training on them. Her favorite unit to teach is ecology. She has stories and posters to use when teaching ecology and the students prepare a report discussing an aspect of ecology. They create a "trash pizza" using trash they collected from home in order to become aware of the amount of trash generated by each person daily.

There were five 5th grade classes, three taught by Amber Bailey and two taught by Eric Lawson. Both Amber Bailey and Eric Lawson believe that hands-on lessons are the best way for students to learn. Their classrooms reflect this in that they had science-related objects around the room. The students were excited when they arrived and participated in the class. Amber and Eric use the textbook rarely. They depend on teacher-created materials for most of their instruction. They have attended workshops and seminars focusing on hands-on science instruction. They enjoy meeting with other science teachers and exchanging activities and ideas. One of their favorite lessons was on mixtures and solutions. They had several activities prepared for the students to do.

4.6.3.2 Student Case Studies at the Combination School

Students at the combination school were chosen randomly to answer the interview questions. I allowed time after each question for the student to elaborate on his/her answers. As with the other schools, the students were hesitant and reserved at first, but then they became comfortable and talked more when answering questions. I interviewed the students outside the classrooms while the classroom doors were closed. The students knew that their comments would not be repeated to the teacher. A summary of the student interviews is found in the following case studies:

Joe is a 3rd grader at the combination school and has attended the combination school since kindergarten. He is outgoing in the halls and in the lunchroom but quiet in the classroom. He participates and stays on task most of the time. When asked how he liked science in September, he asked: “What is science?” On subsequent visits, he began defining science as learning about plants and animals. He concluded the year by stating that science was studying everything. When I asked what everything included, he listed plants, animals, zoos, growing things and dead things. I asked what he liked most about science and he said that it was different all the time. Students learned about different things. When asked what he liked least, he identified having too much bookwork. He preferred days when students did activities. I asked what his favorite lesson was and he said bones and skeletons. Students cut out the bones and put the skeleton together. When observed in class, he participated in the lessons. He was a good reader and so he finished his reading assignments before the rest of the class and helped some of the slower students with their reading assignment. He was a leader in his group work.

Marcy was a 3rd grader at the combination school where he had attended for two years. She came at the beginning of her first grade year. She said that she had studied some science in second grade and enjoyed coloring the pictures. Her favorite class was mathematics. Marcy participated in class most of the time but, at times, she seemed preoccupied with her thoughts. She said that her favorite science lesson was volcanoes. She said that students built them in class and her teacher had one that bubbled up white “stuff”. When I asked about another favorite lesson, she identified the class when they planted seeds and they grew. I asked if they did any other experiments with the plants and she said they just watched them grow and then took them home. When asked what she would change about her science class, she said that she would play games and make it fun.

Rosemary was a 4th grader at combination school and had just been released from the English as a Second Language program. She was a charming student, who was quiet in class but talkative at lunch and during Physical Education. She said that she enjoyed science and achieved good grades in it. She said that she liked the science lesson on adaptation of animals in their environment. She said that students made animals in class and told how hers had adapted to the school classroom environment. She said that she would like to have more activities like the adaptation activity if she could change her science class. She also mentioned that there were too many worksheets and that she didn’t like using the textbook. When asked if she told her parents about her science class, she said that she did some of the time.

Charles was a 5th grader at the combination school and had attended the combination school for all his school experience. He was friendly and eager to please. He said that he liked helping people. When I asked how he felt about science, he said that it was the best class. He said the students did lots of activities and were able to be loud without getting into trouble. When observing the class, I noticed that the teacher was very animated and kept the class moving. There were many science-related activities around the room and science posters on the wall. When asked about his favorite science lesson, he had difficulty choosing. He finally said electricity because that was what students were studying then. He said that students made a circuit and made a flash light bulb light up. He started explaining how you wire the circuit correctly. He said that science class was the best subject because students undertook different activities most of the time. He also added that he told his parents about science every day when they picked him up at school. He told me about going to the store with his dad to buy the things that they had used in class so that he could do the activity at home too.

Elisa was a 5th grader at combination school. She had attended combination school since 3rd grade. She was quiet but became very animated when science class started. When asked what science was, she said: “Everything.” I asked for more detail and she told me that science was how the world works. She said that science was her favorite subject. When asked about her favorite science lesson, she talked about electricity because that was what they were studying at the time. She also talked about landforms and how they are made. She said that the only thing that she would change about science is to have longer classes. She said that she told her parents about science class most of the time. She said that her mother asked if she had any classes other than science because she talked about it so much. When observed in class, Elisa was an active participant. She worked in a group and had said that the teacher determined the groups but he wanted everyone to work together.

4.6.3.3 Observations at the Combination School

Sara Davis’s classroom was the first one that I visited at the combination school. The classroom was bright and desks were arranged into groups of four. She said that she prefers group activities because they teach the students how to get along with other people. She had cabinets along one wall, windows along another one and a large blackboard on the 3rd wall. The wall behind her desk had the door to the classroom and a bulletin board. She used bright primary colors for borders around her bulletin board. Above her blackboard, she had posters demonstrating the correct way to write in cursive. She also had a poster with classroom rules and procedures listed.

Sara was teaching a lesson about classification. She had small bags with buttons of different shapes and colors. The students were to separate the buttons into groups and be able to discuss the reason why they had sorted them in the way that they did. The students were very busy determining different ways to identify the buttons. Sara walked around the room, stopping to ask questions of each group. At the end of the lesson, she had the groups report how they had classified their buttons.

Esther Harper's room was set up just like Sara's with a wall of cabinets, a wall of windows and a wall with a large black board extending almost the entire length of the wall. The wall behind Esther's desk had a bulletin board and the entrance door. She had used a zoo theme in her classroom with jungle bird posters hanging from her ceiling. She also had other zoo animals' pictures on the front of the cabinets and a border of zoo animals around the bulletin board. She had the alphabet in cursive letters above her black board and a jungle scene below the black board. On the day I observed her class, she had the students playing a matching game with vocabulary words from the science book. All of the cards were turned upside down and the students had to turn two cards over, one from the word side and one from the definition side. Most of the students were engaged but some were talking and playing while the other students played the game. The teacher redirected the off-task students several times.

Molly Hernandez's room was set up just like the other rooms with cabinets along one wall, windows and a black board along two walls, and the door and bulletin board behind the teacher's desk. She had used a Winnie the Pooh (a popular children's book) theme and had posters of the characters from the book. She also had a bookcase under the windows where she had stuffed animal characters from the book. Molly had the desks arranged with half of the desks on each side facing the middle of the room. She had a rocking chair at the end of the classroom in the middle. On the day I observed her, the students were working on questions at the end of the chapter in the science book. She walked around the room and answered questions for students. The room was very quiet and she spoke softly to the students. Most of the students were working on the assignment but there were a few students who seemed to be daydreaming. She redirected them back to the textbook as she walked around.

Gail Sanderson's room's design was exactly like the other classrooms. She had chosen rainbows for decoration and had a rainbow border around the bulletin board. She had also covered the bulletin board with fabric with a rainbow design. She had a valance made from rainbow-designed fabric like her bulletin board over her windows and had a rainbow mobile in the corner. The lesson that she had prepared for the day involved showing videotape explaining how species are chosen to be on the endangered species list and what precautions could be taken to preserve the species. She had to wake up two students when the videotape was finished.

After the videotape, she had the students color pictures of different animals and write a story about the animal. She had checked out books from the library to use for research. She planned to put the pictures and stories together in book form. Students were engaged in the lesson and no off-task behaviors were observed during the activity.

Diane Willoughby's classroom was designed just like the other classrooms. She had used rainbows as a theme just as Gail Sanderson had done. Her classroom was almost identical to Gail's. She seemed very nervous on the day when I observed her. She had the students read aloud, taking turns as she called on them, and then the students answered questions from a worksheet that was in the ancillary materials that came with the textbook. She sat at her desk working on the computer and had students come to her desk if they had a question. Several students in the back of the room were giggling and she told them repeatedly to continue with their work. She finally went to the back of the room where the students were off task and spoke to them. After she spoke to them, they appeared to start to work. As soon as she started working on the computer, they started their off-task behavior again.

Maggie French's room was designed like the other classrooms. She had plants in her room and had posters depicting ecosystems and recycling. She said that her goal for the year was to make the students more aware of their surroundings and ways in which they could help the environment. The lesson that she had planned for the day involved a game about dinosaurs on the computer. The class moved to a computer classroom and the teacher and the computer assistant helped the students to begin the game. The students were involved in the game and I saw no off-task behavior. The teacher said that she tries to bring them to the computer classroom two times a month. She also said that it was hard to schedule times in the computer classroom because they only had two computer classrooms for the entire school. When their time was over, the students seemed disappointed that the class had to leave the computer classroom.

Amber Bailey's room had the same arrangement of cabinets, black boards, and windows. In front of her windows, she had several plants, an aquarium, a cage with two white mice, a cage with a hamster and a cage with a guinea pig. She had different students caring for the pets and the plants and they rotated so everyone had an opportunity to take care of the plants and animals. Amber had several examples of student artwork displayed in the room. Her room was bright and crowded with all the pets and plants. She also had large boxes stored on top of the cabinet. She said that she had prepared laboratory equipment for several of her activities and that, when she taught the activity, she was able to retrieve the materials needed from the boxes. She was very organized and helped the students to be organized also. Her lesson was on magnetism. For each group of students, she had prepared a box with different shaped magnets and a box with different items for students to experiment with. After the students had experimented with the items in their box, she let the students try to find all the items in the classroom that would attract a magnet. She brought the students back to their groups and discussed the items that were attracted to the magnets and discussed the properties of these items.

Eric Lawson's room was designed like the other classrooms at the combination school. He had posters depicting different simple machines like the pulley, inclined plane, lever, and wheel and axle. He also had student projects around the room. He had made a table that was the length of the black board and that just fitted under the tray of the black board. On the table, he had wooded puzzles, electric toys, a cross section of a flower made of puzzle pieces, a cross section of a frog made of puzzle pieces, and various card games about animals, dinosaurs, sea creatures, and simple machines. His lesson that day was on electricity. He had batteries, wire and a flashlight bulb. He had the students make a simple battery and light up the light bulb. After they had completed that, he had circuit boards for each group. He talked about direct circuits and the necessity for the electricity from their battery (a D cell size battery that he had brought for each group to use) to flow without interruption in order to illuminate their light. The students worked hard at the lesson and helped each other when they had problems. Eric walked around the room and answered questions and praised the students' work. The students were very excited and there were moans when he said that it was time to put everything away and have their mathematics lesson.

4.7 Summary of Qualitative Investigation

The purpose of conducting the case studies was to determine if information from interviews would support the findings of the quantitative part of the study. A historical case study was performed with the teachers to determine differences among the teachers at the sample schools. Historical case studies include descriptions of institutions, programs and practices as they have evolved in time

(Merriam, 1998) Data, such as number of years teaching experience, number of years of teaching at the current grade level, and extent of preparation for teaching science classes, were garnered from the interviews. All teachers participating in the study volunteered to participate and understood that they could drop out of the study at any time. Teachers' classrooms were described and science lessons were observed. During these observations, I paid particular attention to student involvement in the lesson and the behaviors of the students during the lesson. I used this information along with the quantitative findings to better understand why students felt the way that they did toward their science class.

Students were interviewed about their perceptions of their science classes using the different educational methods and what they would prefer in their science classes. This relates to the second research question:

2. Is instruction using textbooks, science kits, or a combination of textbooks and science kits materials more effective in terms of changes in student attitudes and learning environment perceptions?

I also asked questions about science concepts that had already been addressed in their science classes to determine whether or not they had understood the concepts. Two questions that were asked about students' attitudes and perceptions towards their science classes were:

If I could change my science class, I would…
I wish my science teacher would…

The purpose of these questions was to assess students' level of satisfaction in their classes. Using responses to the interview questions, observations and quantitative data, I was able to conclude that the students preferred a more hands-on approach to their science lessons, and that this method of instruction often leads to more on-task behaviors and more retention of the concepts taught in their science class. The next two sections provide a summary for teacher interviews and student interviews.

4.7.1 Summary of Teacher Case Studies

The experience level of teachers participating in this study ranged from being a novice teacher to having taught for 31 years. Their backgrounds varied from having no science training to having considerable science preparation. A variety of experience levels and backgrounds was evident in the way in which teachers approached their science teaching. Most of the teachers with little or no science training felt uneasy with performing laboratory activities. They were concerned that having students out of their seats could create chaos in the classroom and make it difficult to have students calm for other classes.

Most teachers had participated in seminars, inservice courses and/or other training opportunities to prepare for the implementation of science in their curriculum on a regular basis. Teachers who did not like setting up the laboratory lessons and teachers who felt unprepared for teaching science more frequently relied on the textbook and ancillary materials for their lessons. Teachers who relied on the textbook found that they had the same discipline problems in science as they experienced in other subject areas. Students in teacher-directed classrooms had more students with off-task behaviors such as playing, talking and sleeping. Teachers at the science kits school who had participated in the inservice courses specifically addressing use of the science kits reported that students in classes that used a hands-on instruction were more actively involved in the lesson and that very little off-task behavior was observed.

All teachers agreed that using the science kits required extra time for setting up the laboratory experience and putting away materials after the experience. Teachers with an interest in science said that they did not mind the additional time because the experience was so beneficial to the students. Teachers using science kits also reported fewer discipline problems and less off-task behaviors.

Teachers at the science kits school reported that typically students looked forward to science and participated in class discussions and activities. These teachers felt that many students retained more information through the hands-on activities and reading supplements found in the kits. The teachers agreed that, at first, setting up for science took a lot of time but that, after they became familiar with the kits' contents, less time was required to prepare for class. They added that the students' behavior was positive and they attributed this to all the students being actively involved and on-task for the lessons.

Teachers at the textbook school used the textbook and ancillary materials for instruction. These teachers spent the least amount of time preparing lessons. Teachers said that some of the students did not retain the information for an extended period of time, but felt that this was typical for elementary school students. Some of the teachers had focused the class lessons around mathematics and language arts (reading and grammar) to prepare for the Texas Assessment of Knowledge and Skills (TAKS) test and felt that it was too much to teach science and be tested in that area also.

Teachers at the combination school used the textbook, ancillary materials, science kits and teacher-created hands-on materials. Teachers with limited science background tended to rely on the textbook for lesson planning. They used the lesson plan guides that came with the textbook. Teachers with more science training used the science kits and teacher-created materials to provide more hands-on experiences. These teachers reported that discipline typically was not a problem for their students in the hands-on activities and that the students were actively engaged in the lessons.

To summarize, teachers with more science background seemed more likely to try to use the science kits. There were a few cases of experienced teachers not wanting to devote the time needed for preparation, but most of them used the science kits. Some teachers with limited background used the science kits because of the training they had received before the school year started. Other teachers with limited background in science relied heavily on the textbook for lesson planning and assignments.

4.7.2 Summary of Student Case Studies

All of the students interviewed agreed that they would prefer science to be taught using a lot of activities. The students remembered activities that they had done in science class and most were able to describe the steps that they followed and to discuss the science concept being taught. Students also agreed that they prefer not using the textbook as the sole source of science information. Several students also mentioned that they would prefer less paperwork and less emphasis on reading assignments. The science kits school had the most satisfied students based on the interviews. At this school, only science kits had been adopted and the curriculum is taught using a series of activities designed to guide the student through a process to understanding the concept.

The third and fourth graders at the combination school and all the students at textbook school said there was too much emphasis on textbooks, but the fifth graders at the combination school expressed great satisfaction with their classes. The combination school used the textbook, science kits and teacher-created materials to present the lessons. Of all of the students, the fifth graders at the combination school were the most satisfied with their science classes and were best able to discuss science concepts based on activities that they had undertaken in the past as well as at the present time. Teachers in 5th grade at the combination school used teacher-created materials and science kits focusing on hands-on lessons.

Students from the textbook school reported the most dissatisfaction with the method used for teaching science. The textbook school adopted only textbooks and used only the textbook and ancillary material for most of the instruction. Textbooks were used for reading assignments, vocabulary, and worksheets. The teachers also found that the ancillary materials were very helpful for planning lessons and for teaching science concepts. Students mentioned that they completed many worksheets but had very little hands-on experience.

The combination school's 3rd and 4th graders were not satisfied with their instruction because they preferred more hands-on lessons and less work from the textbook. Students in 3rd and 4th grades remembered activities that they had performed, but did not always remember the science concept that was represented. The two fifth grade teachers used many hands-on activities. The 5th grade students remembered the activities and the concepts that they had studied and were able to relate all the steps of the activity with an explanation of the reason why events were happening during the process. The science kits school had the most satisfied students based on the interviews from all three grade levels. The 5th grade students at the combination school and the students at the science kits school expressed a high level of satisfaction in their science classes.

4.8 Summary of Chapter 4

Chapter 4 was devoted to reporting the results of the quantitative and qualitative data collected at three elementary schools in North Texas using three different educational methods. Section 4.2 reported results regarding validation of the learning environment instrument, which constituted Research Question 1:

1. *Can the learning environment be reliably and validly assessed among Grade 3–5 students in Texas?*

The first method used to determine reliability and validity of the *My Class Inventory* (MCI) was a factor analysis to identify 'faulty' items that could be removed to improve the internal consistency reliability and factorial validity. As a result of the factor analysis, the Difficulty scale and Item 7 from the Friction scale were lost. In most instances, the remaining 19 items loaded at 0.40 or higher on their *a priori* scale and no other scale for each of three different administrations.

Internal consistency reliability, a measure of whether each item in a scale measures the same construct, was reported in Table 3 using the Cronbach alpha coefficient for two units of analysis (student and class mean). Using the class mean as a unit, reliability figures were higher than when the using the individual as a unit. MCI scales were found to be reliable for short scales containing only four or five items.

Discriminant validity measures the extent to which scales are independent of each other. Using the mean correlation of a scale with the remaining scales as a convenient index, the results suggest that raw scores on the MCI assess somewhat overlapping aspects of the learning environment, although the factor analysis results attest to the independence of factor scores. The Satisfaction scale was excluded from the discriminant validity analyses because it was used as a dependent variable for Research Question 2.

An analysis of variance (ANOVA) was used to determine the ability of each MCI scale to differentiate between the perceptions of students in different classes. As reported in Table 3, the three MCI scales differentiate significantly among classrooms for each of the three administrations.

The second research question asks:

2. *Is instruction using textbook-based, science kits or a combination of textbooks and science kits materials more effective in terms of changes in student attitudes and learning environment perceptions?*

An analysis of covariance (ANCOVA) was performed for the MCI with delayed posttest scores as the dependent variable, the corresponding pretest scores as the covariate, and the method of instruction as the independent variable. Table 4 shows that statistically significant differences exist between the treatment groups in terms of changes in Cohesiveness and Satisfaction. Larger changes were seen in the science kits school than in either the textbook or combination schools. Overall, the results support the effectiveness of using kits over textbook-based instruction and a combination of science kits, textbook and teacher-created materials instruction in terms of changes in student perceptions and learning environment perceptions.

Section 4.4 reported the associations between student satisfaction and class environment to answer the third research question:

3. *Are there associations between student perceptions toward science classes and the classroom environment?*

For these analyses, I followed the lead of Majeed, Fraser, and Aldridge (2002) and used the Satisfaction scale from the MCI as a dependent or outcome variable. The results in Table 5 indicate that statistically significant associations exist between students' satisfaction and their perceptions of classroom environment. The simple correlation between satisfaction and classroom environment was statistically significant for each of the three environment scales, on each testing occasion, and for both units of analysis. All correlations are positive for Cohesiveness and negative for Friction and Competition. That is, Satisfaction is higher in classes with a more favorable classroom environment in terms of less Friction, less Competition and more Cohesiveness.

Multiple regression analyses with the individual as the unit of analysis revealed that each environment scale was significantly related to Satisfaction for each testing occasion when the other two environment scales were mutually controlled. Cohesiveness appeared to be the strongest independent predictor of student Satisfaction, but both classroom Friction and Competition are linked consistently with lower student Satisfaction. Overall these analyses suggest that there are associations between student attitudes toward science classes and the classroom environment; this replicates considerable prior research (Fraser, 1998b; Majeed, Fraser, & Aldridge, 2002).

Section 4.6 reported the qualitative investigation in terms of case studies. Sixteen teachers and 17 students were interviewed for this study. The teachers were asked about their background experience in teaching, number of years teaching the present grade level, and preparation for teaching science. This historical type of interview was conducted in order to ascertain differences in the experiences of the teachers participating in the study.

Students were interviewed for the purpose of determining their attitudes toward their science classes. I asked students about what they liked about their class and to describe what would they change in their science class. The students at the science kits school and the 5th graders from the combination school expressed a higher level of satisfaction with their science classes. The 3rd and 4th graders at the combination school and the students at the textbook school expressed less satisfaction with their science classes.

As a result of the teacher case studies, I concluded that teachers with more science background seemed to be more willing to try using hands-on lessons. The teachers with less science background seemed to depend more on the textbook and ancillary materials as their planning resources.

Based on the student case studies, it seemed that students prefer more activities in their science instruction. It was also found that students at the science kit school who received hands-on activities as a part of their science instruction were better able to remember science concepts with more accuracy. All students expressed that they would appreciate less worksheet lessons. The science kits school had the most satisfied students in terms of students' perceptions.

Chapter 5 follows this chapter and includes a summary of previous chapters, research methods, and quantitative and qualitative results. As well, Chapter 5 discusses limitations of the study and proposes suggestions for future research.

Chapter 5

CONCLUSION

5.1 Introduction

The purpose of this study was to evaluate the relative effectiveness of instruction using science kits, textbook, and a combination of science kits and textbook instruction in terms of the classroom learning environment and student attitudes in their classes. The three main questions guiding the research were:

1. *Can the learning environment be reliably and validly assessed among Grade 3–5 students in Texas?*
2. *Is instruction using textbooks, science kits, or a combination of textbooks and science kits more effective in terms of changes in student attitudes and learning environment perceptions?*
3. *Are there associations between student attitudes toward science classes and the classroom environment?*

This chapter focuses on conclusions, discussion and implications of the present study. Also, consideration is given to limitations of my study and suggestions for future research are offered. These topics are discussed in five sections:

- Section 5.2: Synopsis of the Chapters
- Section 5.3: Summary of the Research Methods
- Section 5.4: Summary of the Quantitative Results
- Section 5.5: Summary of the Qualitative Results
- Section 5.6: Limitations of the Study
- Section 5.7: Suggestions for Future Study
- Section 5.8: Conclusion.

5.2 Synopsis of the Chapters

Chapter 1 introduced the study and gave background information explaining why the study was undertaken. The rationale for this study is based on the implementation of high-stakes testing by the state and other entities. Because schools are rated on student performance on these tests and because the learning environment is directly tied to achievement (Fraser, 1994), I decided to look at science teaching methods and their possible impact on the learning environment. I wanted to explore whether instruction using science kits would be superior because students were experiencing hands-on science which could make the subject easier to learn.

Chapter 2 provided a review of pertinent literature in the field of learning environments. The historical background of educational environments research was reviewed and methods for studying learning environments were discussed. A brief synopsis of learning environment instruments was given and an overview of the scales contained in nine classroom environment instruments was listed. A section discussing perceived versus preferred forms was included because part of my research involved the difference between students' perceptions of their actual and preferred learning environment.

Twelve lines of learning environment research were reviewed in Chapter 2, including associations between student outcomes and the nature of the classroom environment. Students' perceptions of their classroom environment can be used as a source of process criteria in the evaluation of educational innovations and this was relevant to my study. Because my study involved the use of qualitative and quantitative data, a section was included that discussed previous studies that used both methods of data collection. Also, as my study involved the use of textbooks, science kits and combination of teacher-created materials as methods of classroom instruction, I included background information on these three types of educational methods.

The study's research methods were outlined in Chapter 3. Also included in this chapter were descriptions of the sample, the data-collection methods, the instrument used for data collection, and the statistical procedures for analyzing the data. Section 5.3 is devoted to a more detailed summary of my research methods.

Chapter 4 reported the results of the study. This chapter included information about the reliability and validity of the learning environment instrument. In addition, associations between students' attitudes towards their science class and their preferred learning environment perceptions were reported. In particular, instruction using textbook-based, science kit-based, or a combination of textbook, science kit and teacher-created materials was evaluated in terms of and students' perceptions of classroom environment. Summaries of the results based on quantitative data and qualitative data were provided. Sections 5.4 and 5.5 below summarize these findings.

5.3 Summary of Research Methods

The main purpose of my study was to determine whether using science kits, textbooks or a combination of science kits and textbooks resulted in greater student satisfaction and a more positive learning environment. I combined qualitative and quantitative research methods in examining changes in student attitudes and learning environments among 588 Grade 3–5 students in 28 classes.

The investigation was divided into four implementation steps. Using the actual form of the *My Class Inventory* (MCI), the students were first given a pretest to determine their perceptions of their science classroom learning environment. The second step in the implementation, in January, consisted of posttesting to determine if there had been any changes in perceptions of the learning environment; and the third stage involved delayed posttesting (early May). Finally, the preferred version of the MCI was administered in late May to provide insight into students' science learning environment preferences.

As recommended by Tobin and Fraser (1998) and Punch (1998), both qualitative and quantitative research methods were used. Quantitative data were used to measure and investigate student perceptions of their science classroom environments. The qualitative data were collected through interviews and classroom observations and were also used to support the analysis of student perceptions of classroom environment based on data gathered using the MCI.

I chose the My Class Inventory as a measure of classroom environment (Fraser & Fisher, 1983b) because the vocabulary is suitable for use with elementary school students. Another reason for choosing the MCI is that the responses are in a simple Yes–No format and the answers are recorded on the questionnaire itself to avoid errors in transferring information from one place to another (Fraser, 1989b).

For my first research question, data were analyzed to investigate the reliability and validity of the MCI. Principal components factor analysis with varimax rotation was used to check the structure of the questionnaire. For the actual and preferred forms of the MCI, the same two indices of internal concistency and discriminant validity were reported separately. The Cronbach alpha reliability coefficient was used as the index of internal consistency. As a convenient index of discriminant validity, the mean correlation of one scale to the other scales was used. For the actual form of each MCI scale, a one-way ANOVA was performed, with class membership as the main effect, to assess the ability to differentiate between classrooms.

The method of data analysis for my research question about differences between instructional groups was ANCOVA (analysis of covariance). An ANCOVA was performed using the delayed posttest scores as the dependent variable, the treatment group as the independent variable, and the corresponding pretest scores as the covariate. The three treatment groups were compared in terms of satisfaction and environment scores on the delayed posttest, with pretest performance being taken into account in the analysis to accommodate any differences between the three groups at the time of pretesting.

For my research question about attitude-environment associations, data were analyzed using two methods of analysis, namely, simple correlation and multiple regression analysis for two units of analysis (the individual student and the class mean). These analyses were conducted for each of the occasions when the actual classroom environment was assessed (pretest, posttest, and delayed posttest).

I visited the three elementary schools three times (September, January, and May) to conduct interviews and to administer the actual version of the MCI. On each of these occasions, the students answered the MCI with the teacher out of the room. I made a fourth visit to the elementary schools to administer the preferred version of the MCI. I read questions to students who were having difficulty with wording. The students and teachers understood that they could stop participating in the study at any time.

To collect qualitative data, I interviewed students and teachers and I observed their science classes. Selected students and teachers responded to a set of predetermined questions and were given an opportunity to elaborate on their answers. They were also allowed to bring in information not solicited in the set of questions. Teacher interviews consisted of background information relevant to the study in order to determine the experience levels of the teachers at each of the schools. The collection of data from the teachers followed the historical case study method as explained by Merriam (1998). The collection of student data followed interpretive methods adopted by Erickson (1986). Data were compiled into written field notes after the interviews and classroom observations as recommended by Tobin, Kahle and Fraser (1990).

Three schools with similar demographics were chosen to participate in the study. A total of 588 students and 16 teachers in 28 classes participated in the study. The study was conducted from September to May.

Two of the schools, the science kits school and the textbook school, were older schools that were located in established neighborhoods. The administrators and teachers from the two older schools were friendly and the atmosphere in the schools was inviting. The combination school was newer and located in newer subdivisions in the District. The administrators and teachers at the combination school were open to participate in the study but they did not demonstrate the same level of friendly interactions between the administration and teachers as was noticed at the science kits school and the textbook school. Both the science kits school and the textbook school had administrators who had been at the schools for many years. The combination school's principal had only been at the school for two years. The sizes of the classrooms were comparable at the three schools.

5.4 Summary of Quantitative Results

The results from the analyses of the quantitative data were used to answer the three research questions. These results added knowledge to learning environments research in that the goal of this research was to compare students' perceptions of science learning environments among classes using three different instructional techniques. One group used only science kits, one group used only the textbook, and one group used a combination of science kits, textbook and teacher-created materials. These results are summarized in the following subsections:

- Section 5.4.1: Summary of Findings for Research Question 1 – Reliability and Validity of the Learning Environment Questionnaire
- Section 5.4.2: Summary of Findings for Research Question 2 – Effectiveness of Using Science Kit-Based Intervention
- Section 5.4.3: Summary of Findings for Research Question 3 – Associations between Student Satisfaction and Classroom Environment.

5.4.1 Summary of Findings for Research Question 1 – Reliability and Validity of the Learning Environment Questionnaire

Section 4.2 and Tables 2 and 3 discussed the validation of the research instrument (namely, the My Class Inventory, MCI) using the following criteria: factor structure, internal consistency reliability, discriminant validity, and the ability to distinguish between different classes and groups. My first research question is:

1. *Can the learning environment be reliably and validly assessed among Grade 3–5 students in Texas?*

The actual version of the MCI was administered as a pretest in September, posttest in January and delayed posttest in May. The preferred version of the MCI was administered in May. The first method used to determine validity was factor analysis. As a result of the factor analysis, the Difficulty scale and Item 7 from the Friction scale were removed. This improved the factor structure and internal consistency reliability. There were seven cases for which an item's factor loading on its own scale is less that 0.40 and two cases for which there is a factor loading greater than 0.40 on another scale. Even with these inconsistencies, results of the factor analysis provided a reasonable degree of support for the *a priori* structure of the MCI..

The percentage of variance accounted for was 47.29% for the pretest, 49.40% for posttest, and 51.84% for the delayed posttest. The eigenvalues ranged from 1.27 to 4.37 for the pretest, 1.34 to 4.18 for the first posttest, and 1.22 to 5.07 for the delayed posttest. The results of these data supported the factorial validity of a version of the MCI with the scales of Satisfaction, Friction, Competitiveness and Cohesiveness.

For the MCI scales of Friction, Competition, Cohesiveness and Satisfaction, Cronbach's alpha reliability coefficient was used to assess internal consistency. Data were analyzed separately for the pretest, posttest, delayed posttest and preferred versions of the MCI. Internal consistency was found to be satisfactory for each MCI scale, and for two units of statistical analysis (the student and the class mean). For example, for the delayed posttest and with the class as the unit of analysis, the alpha reliability was 0.92 for Friction, 0.87 for Competition, 0.93 for Cohesiveness and 0.77 for Satisfaction for both the actual and preferred forms.

The discriminant validity of the MCI was assessed using the mean correlation of a scale with the other scales as a convenient index. Analyses were reported separately for the pretest, posttest, delayed posttest and preferred administrations and for two units of analysis (the student and the class mean). Discriminant validity results suggested that the raw scores on the MCI assessed somewhat overlapping aspects of the learning environment, although the factor analysis results attested to the independence of factor scores.

Students within the same class should perceive their environment similarly but perceptions should vary from class to class. This was explored for the actual form of each MCI scale by performing a one-way ANOVA with class membership as the main effect. The findings show that all scales except Difficulty were able to significantly differentiate between classes.

5.4.2 Summary of Findings for Research Question 2 – Effectiveness of Using Science Kit-Based Intervention

The second research question involved the effectiveness of using science kits in terms of students' satisfaction and their perceptions of the classroom learning environment. This research question involved comparing three groups, namely, classes using kits only, classes using the textbook only, and classes using a combination of kits and the textbook. Analyses were guided by the following research question:

2. *Is instruction using textbooks, science kits, or a combination of textbooks and science kits more effective in terms of changes in student attitudes and learning environment perceptions?*

The three treatment groups were compared in terms of satisfaction and environment scores on the delayed posttest. However, to accommodate any differences among the three groups at the time of pretesting, the corresponding pretest performance was taken into account in the analysis. For each environment scale (namely, Friction, Competition and Cohesiveness) and for the Satisfaction scale, an analysis of covariance (ANCOVA) was performed with delayed posttest scores as the dependent variable, the treatment group as the independent variable, and the corresponding pretest scores on that the covariate. The class mean was used as the unit of analysis. The ANCOVA results shown on Table 4 indicate that statistically significant and large differences exist between treatment groups for Cohesiveness and Satisfaction. In terms of Satisfaction and Cohesiveness, the science kits school had the highest changes between the pretest and the delayed posttest for both Satisfaction and Cohesiveness, while the textbook school and combination school had negative changes. The textbook school had a greater decrease for Cohesiveness and the combination school had the greatest decrease for Satisfaction. Using the eta^2 statistic (i.e. the proportion of variance accounted for), the effect size for the between-group differences is large for Cohesiveness (0.30) and Satisfaction (0.36). These results are important in determining what method of instruction could lead to the most success in terms of fostering more positive student perceptions of the learning environment in the science classroom.

5.4.3 Summary of Findings for Research Question 3 – Associations between Student Satisfaction and Classroom Environment

The third research question involved associations between student Satisfaction and the three learning environment scales of Friction, Competition and Cohesiveness. Using Majeed, Fraser and Aldridge's (2002) lead, I employed the Satisfaction scale from the MCI as a dependent or outcome variable. As reported in Table 6 in Section 4.3, data were analyzed using two methods of analysis (simple correlation and multiple regression analysis) and two units of analysis (the individual student and the class mean). Also all analyses were conducted for the three occasions when the actual classroom environment was assessed (pretest, posttest, and delayed posttest). The relevant research question is:

3. *Are there associations between student attitudes toward science classes and the classroom environment?*

The results for associations between student satisfaction and classroom environment are consistent with past research (Fraser, 1998b) in that statistically significant associations exist between student satisfaction and their perceptions of classroom environment. All associations are positive for Cohesiveness and negative for both Friction and Competition. That is, Satisfaction is higher in classes with a more favorable classroom environment in terms of less Friction, less Competition and more Cohesiveness. This is important because, while teachers and administrators are striving to increase students' achievement scores, they are also trying to create the most satisfying classroom environment for the students.

5.5 Summary of Qualitative Results

Collecting qualitative data involved teacher and student interviews and classroom observation (Erickson, 1986). Teachers and students answered a predetermined set of questions during each visit and were allowed to share other information during the interview phase. All data were compiled into written field notes following each observation or interview.

The qualitative information supported the use of science kits as a positive means of instruction in that students seemed more satisfied with their class and felt less competition or friction than did students in other treatment groups. Teachers using the science kits reported that their students experienced fewer discipline problems and it appeared that students retained information longer. The teachers at the combination school that used the science kits along with the textbook also reported higher student retention of science concepts, whereas the teachers at the textbook school reported the least amount of student retention and the greatest amount of student misbehavior. This was supported by interviews with students participating in the three treatment groups and observations of the class interactions.

Both quantitative and qualitative data supported the effectiveness of science kits in terms of student attitudes and satisfaction. This is important because student attention and participation in the class are necessary for learning to occur. In atmospheres with a lack of attention or participation, students were not able to accurately explain the science concepts that they had been taught. It was also observed that the more actively involved the student was in the lesson, the better that he/she remembered what was learned.

5.6 Limitations of the Study

There were several limitations associated with my study. The single most important limitation is that each treatment involved only one school for each treatment group. The schools were similar in demographics and had achieved similar ratings from the State on prior standardized achievement tests. Nevertheless, the possibility that differences in classroom environment found between schools in my study might be attributable to unknown factors within these schools cannot be dismissed.

Another limitation was the proportions of the ethnic groups for each school in the study. The ethnic groups were representative of the general population in the District but not necessarily representative for the state of Texas. Therefore, it is uncertain that my findings would apply to a more diverse group of students.

The third limitation of my study is that some students in the sample were not proficient in English and so there might have been some misinterpreted questionnaire items. I read the questionnaire to students who expressed a problem with the words contained in the questionnaire, but there still could have been other students who did not feel comfortable with admitting their difficulty with reading in spite of the low reading level of the MCI.

The fourth limitation of the study was that I was not able to have access to student achievement scores on standardized tests. It would have been beneficial to have the results of the students' TAKS (Texas Assessment of Knowledge and Skills) scores. Although I had originally planned to evaluate the instructional methods in terms of student test scores, District policy prevented this. I had to rely on teachers sharing information about student success with the material covered in their classes and my questioning of students to test their recollection of the lessons.

The fifth limitation of the study could be associated with the use of case studies. Guba and Lincoln (1985) note that case studies can oversimplify a situation, which could lead to erroneous conclusions. This could be due to the limited number of interviews that might not represent the views of the whole sample involved in my study. Merriam (1998) states that another limitation of case studies involves issues of reliability, validity, and generalizability.

The final limitation involves the instrument chosen. The MCI is somewhat outdated. Nevertheless, the MCI still contains scales in which I was interested for my study. Also the low readability level led to my choosing the MCI rather than one of the newer questionnaires that assess other dimensions that are of more contemporary relevance, but are more difficult to read.

5.7 Suggestions for Future Research

An important suggestion for future research is to conduct a more comprehensive study with a much larger sample of students and schools that more closely reflects the various ethnic and socio-economic groups commonly found in Texas. It could also include schools with a variety of achievement levels. As school districts continue to become more diverse ethnically and socio-economically, the MCI, or a newer instrument, could be used to investigate how these changes are affecting teaching practices and, in turn, the learning environment.

Also, including achievement as a dependent variable would be desirable to furnish needed information about the impact of instruction using science kits on students' science achievement. This could be accomplished through a longitudinal study of the learning environments encountered by students moving from their third through fifth grade classes. If associations between achievement, teaching techniques, and learning environments could be established, this might provide a basis for policy decisions concerning methods for the teaching of science.

It would also be desirable to use a different learning environment instrument that has some new scales of contemporary relevance. An example would be the *What is Happening In this Class* (WIHIC; Aldridge, Fraser & Huang, 1999). This instrument has seven scales: Student Cohesiveness, Teacher Support, Involvement, Investigation, Task Orientation, Cooperation and Equity. It has a Class form to assess students' perceptions of the class as a whole and a Personal form to assess a students' perception of his/her own role in the classroom. The reading level would have to be adapted for younger children and its length might need to be shortened to accommodate younger students' attention spans and abilities.

5.8 Conclusion

The purpose of the research was to compare students' classroom environment perceptions and attitudes toward science when experiencing teaching techniques using science kits, textbooks or a combination of science kits, textbooks and teacher-created materials. The *My Class Inventory* (MCI) was the main questionnaire used. Three research questions were investigated: the validity and reliability of the MCI for use among Grade 3–5 students in Texas; the evaluation of the three treatment groups in terms of changes in student attitudes and learning environment perceptions; and associations between student attitudes toward science classes and the classroom environment.

Schools selected for this study were similar in socioecnonmic and ethnic makeup. Across the three schools, more than 500 students in 28 classrooms participated in the study. The research was conducted over a period of one year and involved using the actual and preferred forms of the MCI. The MCI was administered in September as a pretest because students had not been receiving science instruction, in January as a posttest, and in May as a delayed posttest. The preferred form was administered in May after the delayed posttest. Along with the MCI, I conducted interviews and observations of teachers and students. This was to allow for triangulation of quantitative and qualitative data.

Results from analyses of both qualitative and quantitative data revealed some differences between teaching methods. Specifically, four general outcomes can be reported:

- The MCI scales of Satisfaction, Friction, Competitveness, and Cohesiveness were shown to be valid and reliable when used with students in Grades 3–5 in Texas.
- Statistically significant differences existed between the instructional groups in terms of changes from pretest to posttest to delayed posttest for Satisfaction and Cohesiveness, with the science kits school experiencing the largest improvements.
- The Satisfaction was higher in classrooms with a more favorable classroom environment in terms of less Friction, less Competition and more Cohesiveness.

There are advantages in using the MCI with young students. One advantage is the readability of the MCI. It is written at a level that is suitable for Grade 3–5 students. Another advantage of the MCI is that the students answer on the questionnaire document rather than on a separate answer sheet. The MCI is also easy to hand-score, which is advantageous to administrators and teachers wanting an instrument to assess the learning environment in their school or classroom.

In the research reviewed by Fraser (1994), a consistent association has been found between the learning environment and student achievement. This is important to administrators and teachers because a positive learning environment could lead to better scores on standardized tests and other outcomes. Results from my study showed that students were found to be more satisfied in classroom learning environments with greater Cohesiveness and less Friction. Therefore, it might be reasonable to believe that these more positive environments will promote greater student achievement. These findings were consistent with the results of both quantitative and qualitative investigation.

This is significant because administrators and teachers are searching for ways to improve student perceptions in science. Past research supports that students' achievement scores are more favourable when students have a more positive learning environment. With the emphasis on standardized test scores, administrators and teachers are searching for ways to improve student achievement. This study suggests that using science kits for instruction created a more positive learning environment in terms of student satisfaction and cohesiveness. This information is likely to prove valuable in future decisions about teaching materials and methods and, hopefully, raise scores on the standardized tests required by the state.

The goal of this research was to find which type of instruction created the most favorable learning environment in terms of Satisfaction, Cohesiveness, Friction and Competitiveness. Regarding the day-to-day life in the classroom, my study provides information about positive learning environments to administrators and teachers so that changes can be implemented in the classroom.

Administrators and teachers are seeking ways to improve the learning environment in their classrooms. Therefore this research is important because of the necessity of retaining students in science classes. At the District level, science is important because it is an area that is assessed using standardized tests. The state level is concerned because of the attrition of students in science classes and the national level is concerned because of a shortage of qualified students pursuing a career in science-related fields. This is important to me because students have a better chance of having a career that will provide benefits necessary for a comfortable life style if they have an education. Having students stay in the science field is especially important because there is a need for scientists in the United States. We have students dropping out of school, which makes it difficult to find well-paying jobs, and educators are falling behind in technology because we do not have enough students taking advanced courses in order to fill vacant positions in science-related fields. It is my responsibility to try to instil a desire for students to stay in school and achieve high goals. This is important to parents who want their students to have a better life, and to students so that they have a feeling of success in a classroom learning environment that is positive.

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Appendix I

MY CLASS INVENTORY

STUDENT ACTUAL SHORT FORM

DIRECTIONS: This is not a test. The questions are to find out what your class actual classroom looks like. Each sentence is meant to describe what your actual classroom is like. Draw a circle around

YES — if you AGREE with the sentence
NO — if you DON'T AGREE with the sentence

EXAMPLE
27. Most students in our class are good friends.
If you agree that most students in the class are good friends, circle the Yes like this:

(Yes) No

If you don't agree that most students in the class actually are good friends, circle the No like this:

Yes (No)

Please answer all questions. If you change your mind about an answer, just cross it out and circle the new answer.
Don't forget to write your name and other details below:

NAME ______________________________ CLASS_________________

Remember you are describing your actual classroom.

1. The students enjoy their schoolwork in my class	YES	NO	______
2. Students are always fighting with each other.	YES	NO	______
3. Students often race to see who can finish first.	YES	NO	______
4. In my class the work is hard to do.	YES	NO	______
5. In my class everybody is be my friend.	YES	NO	______
6. Some students are not happy in my class.	YES	NO	R____
7. Some students in my class are mean.	YES	NO	______
8. Most students want their work to be better than their friend's work.	YES	NO	______
9. Most students can do their schoolwork without help.	YES	NO	R_____
10. Some students in my class are not be my friends.	YES	NO	R_____
11. Students seem to like my class.	YES	NO	______
12. Many students in my class like to fight.	YES	NO	______
13. Some students feel bad when they didn't do as well as the others.	YES	NO	______
14. Only the smart students can do their work.	YES	NO	______
15. All students in my class are close friends.	YES	NO	______
16. Some students don't like my class.	YES	NO	R_____
17. Certain students always want to have their own way.	YES	NO	______
18. Some students always try to do their work better than others.	YES	NO	______
19. Schoolwork is hard to do.	YES	NO	______
20. All students in my class like one another.	YES	NO	______
21. My class is fun.	YES	NO	______
22. Students in my class fight a lot.	YES	NO	______
23. A few students in my class want to be first all of the time.	YES	NO	______
24. Most students in my class know how to do their homework.	YES	NO	R_____
25. Students in my class like each other as friends.	YES	NO	______

For Teacher's Use Only: S _____ F _____ Cm _____D _____Ch _____

Appendix II

MY CLASS INVENTORY

STUDENT PREFERRED SHORT FORM

DIRECTIONS: This is not a test. The questions are to find out what your class actual classroom looks like. Each sentence is meant to describe what your actual classroom is like. Draw a circle around

YES if you AGREE with the sentence
NO if you DON'T AGREE with the sentence

EXAMPLE
28. Most students in our class are good friends.
If you agree that most students in the class are good friends, circle the Yes like this:

(Yes) No

If you don't agree that most students in the class actually are good friends, circle the No like this:

Yes (No)

Please answer all questions. If you change your mind about an answer, just cross it out and circle the new answer.
Don't forget to write your name and other details below:

NAME ______________________________ CLASS__________________

Remember you are describing your actual classroom.

1. The students would enjoy their schoolwork in my class	YES	NO	______
2. Students would be always fighting with each other.	YES	NO	______
3. Students often would race to see who can finish first.	YES	NO	______
4. In my class the work would be hard to do.	YES	NO	______
5. In my class everybody would be my friend.	YES	NO	______
6. Some students wouldn't be happy in my class.	YES	NO	R____
7. Some students in my class would be mean.	YES	NO	______
8. Most students would want their work to be better than their friend's work.	YES	NO	______
9. Most students would be able to do their schoolwork without help.	YES	NO	R_____
10. Some students in my class would not be my friends.	YES	NO	R_____
11. Students would seem to like my class.	YES	NO	______
12. Many students in my class would like to fight.	YES	NO	______
13. Some students would feel bad when they didn't do as well as the others.	YES	NO	______
14. Only the smart students would be able to do their work.	YES	NO	______
15. All students in my class would be close friends.	YES	NO	______
16. Some students wouldn't like my class.	YES	NO	R_____
17. Certain students always would want to have their own way.	YES	NO	______
18. Some students always would try to do their work better than others.	YES	NO	______
19. Schoolwork is hard to do.	YES	NO	______
20. All students in my class would like one another.	YES	NO	______
21. My class would be fun.	YES	NO	______
22. Students in my class would fight a lot.	YES	NO	______
23. A few students in my class would want to be first all of the time.	YES	NO	______
24. Most students in my class would know how to do their homework.	YES	NO	R_____
25. Students in my class would like each other as friends.	YES	NO	_______