Science and Mathematics Education Centre

Gender Differences in Teacher-Student Interactions, Attitudes and Achievement in Middle School Science

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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 acknowledgement has been made.

Signature:

Date:

ABSTRACT

Research has shown that interest in science often decreases in the middle-school grades for both boys and girls, but that more boys continue on the science track in high school and college, leading to males dominating the fields of science and engineering in the work place. The interpersonal interaction between teachers and students, as both individuals and as a group, comprises a large part of the classroom learning environment. Though these interactions last only a school year, they can influence student attitudes and achievement in the long term. Past research has suggested that a key factor in improving student achievement and attitudes is to create learning environments which emphasize characteristics that have been found to be linked empirically with achievement and attitudes.

The purpose of this study was to use quantitative methods to validate a learning environment questionnaire (Questionnaire on Teacher Interaction, QTI), to investigate outcome-environment associations, and to compare male and female students in terms of their attitudes, classroom environment perceptions and achievement.

An attitude scale, based on items from the Test of Science Related Attitudes (TOSRA), and a 48-item eight-scale version of the QTI were administered to 1228 science students in Grades 6, 7 and 8 at one middle school in South Florida. Student achievement was measured using the students' quarterly (nine-week) science grade.

The results revealed satisfactory internal consistency reliability for the QTI, with alpha reliability coefficients ranging from 0.51 to 0.83 for different scales with the student as the unit of analysis and from 0.54 to 0.96 for class means. For the 10-item

attitude scale, the alpha coefficient was above 0.80 for both the student and the class mean as the unit of analysis, demonstrating high internal consistency reliability. Overall, the results of the statistical analyses supported that the QTI questionnaire and the attitude scale are valid and reliable instruments for use with secondary science students in South Florida

A strong relationship was found between student outcomes (attitudes and achievement) and many of the eight QTI scales with either the individual or the class mean as the unit of analysis. For example, students' attitudes towards science were more positive when teachers exhibited more leadership and understanding behaviors and science achievement was higher when teachers were friendlier and less uncertain.

The use of MANOVA tentatively revealed gender differences in students' perceptions of teacher interpersonal behavior, attitudes towards science, and science achievement. However, the differences between males and females were statistically significant only for the Helping/Friendly, Dissatisfied, and Admonishing scales of the QTI and for achievement. In general, relative to males, female students had more positive perceptions of teacher interpersonal behavior and higher academic achievement.

DEDICATION

This thesis is dedicated to my son, Keith, and daughter, Kamini, who gave me moral support and encouragement, especially at times when I thought I would never complete this task.

I also dedicate this thesis to all teachers who are forever trying to find ways to improve student achievement. This study, along with the myriad before it, shows that improving student achievement can be accomplished by modifying teachers' interactions with their students. The findings of this study should serve as a powerful tool that can be easily implemented in the classroom and whose results can empower teachers to attain some of the goals pertaining to student achievement set by American middle schools.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

Chapter 1

RATIONALE AND BACKGROUND

Academic achievement is dependent on more than individual abilities and aspirations. The social environment in which learning takes place can enhance or diminish the behaviors that lead to achievement. Scott-Jones and Clark

1.1 Context of the Study

In recent years, there has been an increased emphasis on student achievement especially on standardized tests such as the FCAT (Florida Comprehensive Assessment Test), which is the state-mandated test that all Florida students must take and pass. In addition, there have been reports on the gap in achievement in science between American students and those in other countries. In an attempt to narrow this gap, science has been added to the FCAT (in addition to mathematics and language arts) as a subject to be tested. Finally, to encourage teachers to have a greater influence in their students' learning, there is a proposal to financially reward the 'best' teachers – that is, teachers with students having the highest scores on quarterly assessment tests and the FCAT.

With these educational goals in mind, it now is imperative that both students and teachers work in an atmosphere that maximizes teaching techniques, skills and practices and is conducive to student learning. In other words, teachers and students have now become shareholders in the educational process and both have a role to play in making this process viable, enjoyable and productive in the context of education.

On a more personal level, during my years of teaching, I have often heard students say that “I don’t like science”, “I’m not good in science” or “My teacher doesn’t like me”. I began wondering why these comments were being made, thinking that they could have been a reflection of my teaching skills, my methodology or possibly my personality. I also wondered "Is it them or is it me?” I know that I perceive my students in a certain way, but how did they perceive me? Were they scared of me? Did they enjoy being in my class? Because I had studied gender differences while working on my specialist degree, I began to think about whether boys and girls differed in their attitudes to science and in their perceptions of their science teacher.

There are many studies that have focused on teacher-student interpersonal relationships and student achievement (Goh & Fraser, 1998; Lee, Fraser & Fisher, 2003; Quek, Wong & Fraser, 2005a), but this study attempted to inject a more personal perspective on the subject. I would like to better understand the dynamics between myself and the students in my science classes. Doing this might help me to implement the strategies needed to improve student participation in and enjoyment of science and subsequently lead to improved student achievement.

The present study examined student perceptions of teacher-student interactions in the learning environment in science classes in South Florida. I investigated associations between the nature of interpersonal teacher behavior and students’ attitudes toward science and science achievement. The results were further analyzed by gender to determine whether there were gender differences in student perceptions of teacher interpersonal behavior, attitudes and achievement.

1.2 Background to the Study and Learning Environments

1.2.1 Background to the Study

The interpersonal interaction between teachers and students, as both individuals and as a group, comprises a large part of what happens in the classroom learning environment (Arowosafe & Irwin, 1992; Ferguson & Fraser, 1998; Kramer, 1992; Rickards, 1998). Though these interactions last only a year, they can have lasting effects, both positive and negative, on the students' perceptions of learning and teaching. NeSmith (1997) found that pre-adolescents not only have definite opinions about effective teaching and learning practices, but they also have several issues of dissonance and contradiction regarding this 'transitional period' from the elementary to the secondary stage of schooling. Associations between learning environments, the role of the teacher and student attitudes have been previously noted by Arowosafe and Irwin (1992), Callahan, Clark and Kellough (2002), Delisio (2002), Ferguson and Fraser (1998), Midgley and Urdan (1992) and the joint report of the National Middle School Association and the National Association of School Principals entitled *Supporting Students in their Transition to Middle School* (n.d.).

Hargraves (1972) suggests that the behavior of the student is a product of the perceived role and teaching style of the teacher. He has also suggested that the nature of teacher-student interpersonal behavior becomes more skewed toward the teacher's behavior. But the systems theory of communication (Créton, Wubbels & Hooymayers, 1993) suggests that the teaching style in turn is a product of, and responds to, the interactions that teachers have with their students.

It has been shown that a key factor in improving student achievement and attitudes is to create learning environments which emphasize characteristics that have been found to be linked empirically with achievement and attitude (Brekelmans, Wubbels & Créton, 1990; Germann, 1994; Henderson, Fisher & Fraser, 1995b; Rawnsley, 1997; Wubbels, Brekelmans & Hooymayers, 1991). Wubbels (1993) found that teachers who were perceived as less strict were more likely to promote more positive attitudes, while those who were perceived as more strict were likely to promote better achievement. It has also been reported that student motivation, which can translate into positive attitudes, is influenced by the teacher’s ability to make the subject interesting (Kounin, 1970). In the past two decades, it has been shown that teachers have expectations for student performance and that teacher expectations influence student performance (Baron, Tom & Cooper, 1985; Dusek, 1985)

1.2.2 Background to Field of Learning Environments

Most of the instruments used in learning environment studies are related to the theoretical frameworks for human environments proposed by Moos (1968) and/or the work of Walberg (1968). Walberg, while working on Harvard Project Physics, began using the classroom environment assessment when evaluating curriculum innovations (Anderson & Walberg, 1968; Walberg, 1968; Walberg & Anderson, 1968a). Walberg’s endeavors led to the development of the Learning Environment Instrument (LEI). At about the same time, Moos, working in a variety of environments such as hospital wards, school classrooms and correctional institutions, developed and validated the Classroom Environment Scale (CES) (Moos & Trickett, 1974, 1987). Since then, several different instruments have been devised for assessing the classroom environment, including the My Class Inventory (Fraser, 1989), the Science Laboratory Environment Inventory (McRobbie & Fraser, 1993), the Constructivist Learning Environment Survey (Taylor, Fraser & Fisher, 1997), the

What Is Happening In this Class? (Fraser, Fisher & McRobbie, 1996) and the Individualized Classroom Environment Questionnaire (Rentoul & Fraser, 1979). Chapter 2 reviews literature relevant to these learning environment instruments in greater detail.

Leary (1957) developed a two-dimensional model for representing and measuring specific relationship dimensions. Wubbels and his colleagues later adapted Leary's model into an eight-sector model from which an instrument named the Questionnaire of Teacher Interaction (QTI) was developed by Wubbels, Créton and Hooymayers (1985) to measure students' and teachers' perceptions of teacher interpersonal behavior. The QTI is based on a two-dimensional model in which Cooperation and Opposition are at the ends of a Proximity dimension and Dominance and Submission are at opposite ends of an Influence dimension. Dominance is considered the opposite of Submission and Opposition is considered the opposite of Cooperation. Within these two dimensions of the QTI are eight sectors which are called Leadership, Helpful/Friendly, Understanding, Student Responsibility and Freedom, Uncertain, Dissatisfied, Admonishing and Strict behavior. This questionnaire has been used in the Netherlands (Wubbels, Brekelmans & Hooymayers, 1991), Singapore (Goh & Fraser, 1995) and Australia (Fisher, Henderson & Fraser, 1995; Henderson, Fisher & Fraser, 1995a) and elsewhere (see Section 2.6). In each of the previously-mentioned studies, it was found that the quality of the interaction between the teacher and students is an important determinant of students' attitudes and achievement. The QTI was the instrument used in this study to assess teacher-student interpersonal interaction and it is discussed in greater depth in Chapter 2.

1.2.3 Learning Environments and Gender Differences

In the past, the opportunities for women to study science and subsequently to pursue careers in science have been limited (Baker, 1998). There has been stereotyping of the roles played by the sexes and gender inequality has existed in various forms over the years. These gender gaps still exist in schools, academic fields and science-related careers (Baker, 1998; Sonnert, 1996; Teese, Davies, Charlton & Polesel, 1995). Baker (1998) observed that girls were barred from academic high schools in most European countries before the 1920s and few universities in the United States admitted women in the 1800s.

In science education, this gender inequality is observed at all levels of schooling, especially at the primary and secondary levels. Studies show that females avoid additional science courses (Archer & McDonald, 1991; Maple & Stage, 1991) and, as they progress through the secondary grades, females become less confident of their academic skills, thus narrowing their career aspirations (AAUW, 1992; Linn & Hyde, 1989). Osborn (1994) notes that, although females comprise 40–50% of university students in Europe and the United States of America, a much higher proportion of males than females choose to study science at this level. This gender gap continues into the workplace, with Bojesen (2000) reporting that females make up more than half the American population but that only 22% of scientists and engineers are females. This means that, for whatever reasons, females are choosing not to pursue careers in science.

Weiss (1987) showed that student attitudes toward science declined especially from the middle school to high school. In a study of students in Grades 4 to 12 in three

Midwestern American cities, James and Smith (1985) showed that positive attitudes toward science decreased sharply during the seventh grade. Morrell and Lederman (1998) found that students at this age had less positive attitudes toward science irrespective of their gender. Dimitrov (1999) also showed that interest in science drops between the seventh and tenth grades for both boys and girls. But something encourages boys to continue taking high school course, which leads to a higher percentage of males pursuing careers in science-related fields.

Previous research has revealed differences in the cognitive achievement of different sexes (Husen, Fagerlind & Liljefors, 1974; Keeves & Kotte, 1995; Rickards, 1998) and student attitudes (Friedler & Tamir, 1990; Rickards, 1998; Schibeci & Riley, 1986; Wareing, 1990). Gender differences in student perceptions of the learning environment in science classes have also been reported (Fisher, Fraser & Rickards, 1997; Fraser, Giddings & McRobbie, 1991, 1992; Lawrenz, 1987).

Past research has suggested that, in order to improve student attitudes and achievement, it is advantageous to create learning environments that emphasize the characteristics found to be positively associated with attitudes and achievement. Studies have shown that teachers play an important role in influencing student achievement and decisions to continue in science. Leach (1995) found that teacher contact is the main influence for students, especially girls, on remaining in science. A student's perceptions and memories of a class determine how and if she will continue in science. Debacker and Nelson (2000) studied motivational influences on twelfth graders to take science and found that three factors affected enrollment in twelfth grade science: gender, the class being offered, and the student's ability level. Because twelfth grade is the level just before college enrollment, it would seem that this is a crucial time in terms of the decision to pursue a career in science. However, as previous studies have shown, interest in and attitude toward science start to decline at a much earlier age. Farenga and Joyce (1998) found that, while science-related attitudes have an impact on female students' course selections, creating positive feelings for and perceptions of science will keep girls enrolling in advanced science classes. Barton (as cited in Taylor and Sweetnam, 1999) has shown that the nature of teacher-student interpersonal behavior is a factor that is associated with student attitudes and achievement in science.

Teacher behavior has been shown to have an appreciable influence on the learning environment (Wubbels, Brekelmans & Hermans, 1987) and Fraser (1998a, 1998b) has confirmed the contribution that teachers make to the classroom environment. Wubbels and Levy (1993) found that teacher interpersonal behavior is a very important aspect of the learning environment, while other studies found that teachers need to create learning environments which emphasize helpful, friendly, understanding and leadership behaviors that have been positively linked to student outcomes.

Studies have shown that teacher perceptions of the learning environment usually differ from those of students and tend to be more positive than those of the students (Wubbels & Brekelmans, 1998; Wubbels, Brekelmans & Hooymayers, 1991). Therefore, student perceptions of the learning environment have been more suitable, and probably more reliable and accurate, in assessing the quality of the classroom learning environment than the perceptions of teachers or classroom observers. Using student perceptions could be more appropriate because, according to Wubbels et al. (1987), student perceptions are related to their cognitive and affective performance.

1.2.4 Middle Schooling

In Florida, there are two levels of education – elementary and secondary. Elementary school consists of Grades 1–5, with student ages ranging from 5 to 10 years. Secondary school is made up of middle school, which includes Grades 6–8 (with ages ranging from approximately 11 to 13 years), and high school, which includes Grades 9–12. Because this study was conducted at a middle school in South Florida, a brief introduction to the middle-school concept is now presented.

In Miami-Dade County, where the school involved in the study is located, the school day is generally divided into six class periods of approximately 55 minutes each. Some schools have implemented a block schedule in which there are only three periods per day with the concomitant increase in class time and these periods alternate with the other three during the week. All students must study four ‘core’ subjects – Science, Mathematics, Language Arts and Social Studies – for three years. The other two class periods are engaged in elective studies which, as the name suggests, are subjects the students choose such as Computers, Woodshop and Photography.

The school year is split into two semesters. The first semester consists of two quarters and a mid-term examination and the second semester of two quarters and a final examination. At each grade level, students must get 10 points per semester in the core subjects to be promoted to the next grade. Each quarter accounts for 20% of the final grade and the mid-term and final examinations each contribute 10% toward the final grade. Points are based on letter grades where A = 4 points, B = 3 points, C = 2 points, D = 1 point and F = 0 points. The quarterly grades are multiplied by 2 to obtain the number of points. So A = 4x2 = 8 points, B = 3x2 = 6 points and so on. The mid-term and final examinations are only weighted once so A on a final or mid-term examination is only four points.

If a student fails to obtain the required 10 points to graduate to the next grade, there are a few options available. If there is summer school, the student can attend and 'make up' the subject that he/she failed. Alternatively, the student can move to the next grade but will also have to repeat the failed subject in the lower grade. So, for example, a student can be taking both Grade 7 and 8 Science and, in this case, he/she will be only allowed to take one elective subject. Finally, if the student fails two or more core subjects, he/she might be required to repeat the entire grade the following school year. To graduate from middle school to high school, students at present must pass the FCAT (Florida Comprehensive Achievement Test) in Mathematics and Reading/Language Arts and, beginning in 2007, Science.

1.3 Purpose of the Study

The objectives of this study were to answer the following questions:

Research Question #1

Is the Questionnaire on Teacher Interaction (QTI) valid and reliable when used in science classrooms in South Florida?

This study provides information about the validity and reliability of the QTI in a South Florida classroom setting.

Research Question #2

Is an attitude scale modeled on the Test Of Science-Related Attitudes (TOSRA) reliable when used in science classrooms in South Florida?

The reliability of the TOSRA as an attitude scale will be validated for use in South Florida science classrooms.

Research Question #3

Are there associations between the nature of interpersonal teacher behavior and students':

a) attitudes towards science

b) science achievement?

Associations between teacher interpersonal behavior and students' attitudes to and achievement in science in several other countries have been demonstrated (see Chapter 2). This study will examine these associations in a South Florida middle school.

Research Question #4

Are there gender differences in student perceptions of teacher interpersonal behavior, attitudes, and achievement?

Previous studies have shown that there are gender differences in student perceptions of teacher interpersonal behavior, attitudes and achievement. This study will examine gender differences in a South Florida middle school setting.

1.4 Significance of the Study

There are several reasons why this study is important. First, because the QTI has not been extensively used in South Florida, this study will provide further validation for this instrument when used among middle-school science teachers and students in South Florida. This is important as there is increasing evidence that student achievement is influenced by the classroom learning environment, especially teacher-student interpersonal interaction. The logical extension is that the QTI could be used more frequently as a learning environment instrument, especially as it assesses the perceptions of the classroom environment of both teachers and students.

Second, because it has been consistently shown that more males than females pursue careers in science in the United States, it would be useful to undertake a study to assess whether there are differences in perceptions of the classroom environment, attitudes and academic achievement between male and female students in South Florida. Again, these results would provide useful information for teachers so that they could provide conditions that could eliminate differences in the perceptions of the learning environment and achievement that could be attributed to gender.

Third, this study uses a combination of a learning environment instrument, the QTI, and the TOSRA (Test of Science-Related Attitudes) to examine whether there are associations between interpersonal teacher behavior and students' attitudes towards and achievement in science. This could suggest ways of improving student attitudes by making teachers aware of classroom learning environment factors that affect student attitudes and achievement.

1.5 Overview of Thesis Chapters

This thesis consists of five chapters. Chapter 1 is the introduction to the study and summarizes the background to, significance of and objectives of the study. It also briefly discusses the methodology and the concept of middle schooling in South Florida. This chapter also provides a short description of the development of the field of learning environments. Finally, the research questions to be answered are outlined.

Chapter 2 reviews relevant literature concerning learning environments teacher-student interpersonal behavior and on the development and use various questionnaires, especially of the Questionnaire on Teacher Interaction (QTI). As well, some literature on the assessment of student attitudes to science is considered.

Chapter 3 outlines the methodology used in the study. It describes the background and selection of the sample, instrument selection, and data collection and analysis.

Chapter 4 reports the data analyses and findings for the present study, including findings for the validity and reliability of the QTI and the reliability of the TOSRA. It also includes results regarding associations between QTI scores and student attitudes and achievement as well as gender differences in teacher-student interactions and student attitudes and achievement.

Chapter 5 is the conclusion and gives an overview of the entire thesis including the major findings in relation to the research questions. It also identifies practical implications of the study, its significance and limitations, and ways of improving and/or enhancing the present study in future research.

Chapter 2

LITERATURE REVIEW

2.1 Introduction

This study examined associations between teacher-student interpersonal behavior and student attitudes and achievement in middle-school science classes, as well as gender differences in each of these variables.

This chapter reviews literature relevant to the present study. Section 2.2 presents a conceptual framework for research on learning environments. In Section 2.3, the historical background of various research approaches used in classroom learning environment research is explored. Section 2.4 reviews research in the area of student-teacher interpersonal behavior. Past studies on associations between learning environment and student outcomes are reviewed in Section 2.5. The history and development of the QTI are examined in Section 2.6. Section 2.7 reviews studies into gender-related differences. Section 2.8 reviews literature devoted to student attitudes and the TOSRA (Test of Science-Related Attitudes), which is the instrument from which items were selected to measure student attitudes to science in this study. Finally, Section 2.9 summarizes the literature reviewed in the previous sections.

2.2 Conceptual Framework

Lewin (1936) and Murray (1938) could be considered the forerunners in the field of classroom environment research. Lewin formulated the equation, $B = f(P, E)$, which is also known as the person-environment paradigm (Hunt, 1975), where B stands for behavior, P for person, E for environment with f being the interactive function. In the classroom setting, behavior (learning) would be determined by both the person (learner) and the environment (way of teaching). Murray (1938) developed a needs-press theory to describe an individual's personal needs and environmental press. He used the term *alpha press* to describe the environment as viewed by an observer and the term *beta press* to describe the environment as perceived by members of the environment under observation.

Building on Murray's distinction between *alpha press* and *beta press,* Stern, Stein and Bloom (1956) suggested that beta press can be further differentiated by the individual view and experience of the environment versus the shared view that the students have as a group of participants in the learning environment. They used *private beta press* to represent the view that an individual student might have of the classroom environment and *consensual beta press* for the shared view of the perceptions of all students in a group (for example, the students in a class). Withall (1949) was one of the first researchers to attempt to categorize and observe interactions in the classroom using trained observers who recorded verbal elements of interaction in the classroom.

Before the development of learning environment instruments, classroom research methods typically focused on observation techniques involving trained observers categorizing classroom activities and interactions between members of the class. Later, with improvements in observation procedures and techniques (Brophy & Good, 1986), observations were categorized as either high- or low-inference measures, which were defined as the specific items that were recorded during classroom observations.

High-inference measures require the observer to make an inference about the teacher's behavior in terms of aspects such as warmth, clarity or overall effectiveness. High-inference observations can be made by either an outside observer or a member of the classroom.

In the late 1960s, Walberg's research and evaluation related to Harvard Project Physics included a focus on classroom environment (Walberg & Anderson 1968a, 1968b). Later on in the 1970s, Moos (1973, 1979a, 1979b) developed social climate scales for use in various clinical and family therapy situations, as well as in school classrooms. After this, there were many studies of students' perceptions of the classroom environment (Anderson & Walberg, 1974; Chavez, 1984; Fisher & Khine, 2006; Fraser, 1989, 1994, 1998a, 2002; Fraser & Walberg, 1991; Goh & Khine, 2002; MacAuley, 1990; Khine & Fisher, 2003a; von Saldern, 1992; Walberg, 1976; Walberg & Haertel, 1980).

2.3 Development of Learning Environment Instruments

Research on classroom environment shows that three main methodologies have been used (Fraser, 1991). These are the use of trained observers to record observations made of classroom events and practices, the use of case studies, and the assessment of the perceptions of students and teachers. However, in the past, the dominant approach has been the assessment of students and teachers, though there are advantages in combining two or more methods within the same study.

Moos and Walberg pioneered the study of classroom environment, using the perceptions of students and teachers within the environments. Their work used the concept of Murray's (1938) beta press and involved the subjective perceptions of teachers and students in the classroom environment instead of the perceptions of external, objective observers.

Moos (1974) proposed the theoretical framework for human environments which was the basis for the development of many of the learning environment instruments. Based on his research on human environments in hospitals, school classrooms, prisons, university residences and military establishments, Moos (1979) proposed that there were three dimensions that characterize learning environments:

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

Using Moos' three dimensions, Table 2.1 summarizes eight classroom environment instruments which are briefly discussed below.

Table 2.1 Overview of Scales Contained in Eight Classroom Environment Instruments

Instrument	Level		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 Differentiation
Individualized Classroom Environment Questionnaire (ICEQ)	Secondary	10	Personalization Participation	Independence Investigation	
My Class Inventory (MCI)	Elementary	6-9	Cohesiveness Friction Satisfaction	Difficulty Competitiveness	
Questionnaire on Teacher Interaction (QTI)	Secondary/ Primary	8-10	Leadership Helpful/Friendly Understanding Student Responsibility and Freedom Uncertain Dissatisfied Admonishing Strict		
Science Laboratory Environment Inventory (SLEI)	Upper Secondary/ Higher Education	7	Student Cohesiveness	Open-Endedness Integration	Rule Clarity Material Enviroment
Constructivist Learning Environment Survey (CES)	Secondary	7	Personal Relevance Uncertainty	Critical Voice Shared Control	Student Negotiation
What Is Happening In This Classroom (WIHIC)	Secondary	8	Student Cohesiveness Teacher Support Involvement	Investigation Task Orientation Cooperation	Equity

Based on Fraser (1998b)

2.3.1 Learning Environment Inventory (LEI)

The Learning Environment Inventory (LEI) was developed in relation to the evaluation and research on Harvard Project Physics (Fraser, Anderson & Walberg, 1982; Walberg & Anderson, 1968). The LEI evolved from the 18-scale Classroom Climate Questionnaire developed by Walberg (1968). The LEI has 15 dimensions of climate which had been identified as good predictors of learning and were relevant to social psychological theory of the time. This instrument measures student perception of 15 classroom climate scales with seven items per scale for a total of 105 items. There are four possible responses on a Likert-type scale: Strongly Disagree, Disagree, Agree and Strongly Agree.

2.3.2 My Class Inventory (MCI)

The MCI (My Class Inventory) is a simplified version of the LEI that has 38 items instead of the original 105 items (Fraser, Anderson & Walberg, 1982). The number of scales has been reduced from 15 in the LEI to 5 in the MCI, which makes it more suitable for younger children. The LEI was modified to improve comprehension by 8 to 12 year-old children (Fisher & Fraser, 1981; Fraser, Anderson & Walberg, 1982; Fraser & O'Brien, 1985). In addition, the MCI has a Yes–No response format and is answered directly on the questionnaire. The original MCI had 45 items which were reduced by Fisher and Fraser (1981) to 38 items. In Singapore, Goh et al. (1995) have successfully used a three-point response format (Seldom, Sometimes, Most of the Time) with a modified version of the MCI. Majeed et al. (2002) also used the MCI in Brunei Darussalam for assessing perceptions of classroom learning environments among lower secondary school school mathematics students. The MCI, together with the QTI, has also been used by Goh and Fraser (1998) in Singapore in a study involving achievement and attitudes of primary mathematics students and

Mink and Fraser (2005) in Miami in a study evaluating a primary school mathematics program.

2.3.3 Classroom Environment Scale (CES)

The Classroom Environment Scale (CES) was developed by Moos (Moos, 1974, 1979a, 1979b; Moos & Trickett, 1987; Trickett & Moos, 1973) at Stanford University and was a result of Moos' research in several workplaces including psychiatric hospital wards, school classrooms, correctional institutions and work place environments. The version in current use in secondary schoolrooms contains nine scales with ten items per scale. The scale names are shown in Table 2.1. The scales are scored using a True/False response format. The CES was developed to examine the psychosocial environment of school classrooms from the perspective of interaction between participants including teacher-student and student-student interactions and behavior exhibited by the teacher (Moos & Trickett, 1974, 1987).

2.3.4 Individualised Classroom Environment Questionnaire (ICEQ)

The ICEQ (The Individualised Classroom Environment Questionnaire) assesses dimensions, such as participation and personalization (Fraser 1990), which distinguish individualized classrooms from conventional ones. This questionnaire was developed by Rentoul and Fraser (1979) and originally had five scales each with 15 items. The revised version of the ICEQ reduced the 15 items per scale to ten items per scale to give a total of 50 items. There is also a short form of the questionnaire (Fraser, 1990) that has five items for each of the five scales to give a total of 25 items.

2.3.5 Science Laboratory Environment Inventory (SLEI)

The Science Laboratory Environment Inventory (SLEI) was developed to assess the learning environments of laboratory classes at the secondary and tertiary levels (Fraser, Giddings & McRobbie, 1991). In order to economize in terms of time needed for answering and scoring, the SLEI was designed to have a relatively small number of scales, each containing a fairly small number of items. Therefore, the SLEI consists of five scales with a total of 34 items. Responses are scored on a five-point frequency scale with responses ranging from Almost Never, Seldom, Sometimes, Often and Very Often. Information about the reliability of the SLEI scales was reported by Fraser, Giddings and McRobbie (1991) for a sample consisting of 1875 senior high school students and 298 university students in Australia. Reliability has also been reported for a sample of 3727 senior high school students and 1720 university students in Australia, USA, Canada, England, Israel and Nigeria. The SLEI has been used successfully in Korea (Lee & Fraser, 2001), Singapore (Quek, Wong & Fraser, 2005a; Wong & Fraser, 1995), Brunei (Riah & Fraser, 1998) and the USA (Lightburn & Fraser, 2007).

2.3.6 Constructivist Learning Environment Survey (CLES)

The Constructivist Learning Environment Survey (CLES) helps researchers and teachers assess the extent to which a classroom's environment is consistent with a constructivist epistemology (Taylor, Fraser & Fisher, 1997). In the constructivist view of learning, students use previous experiences or knowledge and incorporate these into new information to which they might be exposed (O'Loughlin, 1992).

The original version of the CLES comprised four scales that ranged from 9 to 29 items, giving a total of 58 items. After further validation, the CLES was reduced to five scales each with six items, giving a total of 30 items. Taylor and others (Taylor, Fraser & White, 1994) arranged the items in groups that were alike, which resulted in all the items for a particular scale being in the same group unlike the more traditional random or cyclic arrangement of scale items in other learning environment questionnaires.

The CLES uses a five-point frequency response scale of Almost Always, Often, Sometimes, Seldom and Almost Never. The CLES has been used in many countries including Korea (Kim, Fisher & Fraser, 1999; Lee & Fraser, 2003), Taiwan (Aldridge, Fraser, Taylor & Chen, 2000), the USA (Dryden & Fraser, 1998; Nix, Fraser & Ledbetter, 2005), and South Africa (Aldridge, Fraser & Sebela, 2004).

2.3.7 What Is Happening In this Class? (WIHIC)

The WIHIC (What Is Happening In this Class?) was developed by Fraser, Fisher and McRobbie (1996) and has both a class and personal form. The class form assesses student perceptions of the class as a whole and the personal form assesses the student's perceptions of his or her role in the classroom. The original version of the WIHIC contained 90 items in nine scales but this was refined to contain 56 items in seven scales. The WIHIC uses a five-point frequency response format of Almost Always, Often, Sometimes, Seldom and Almost Never.

The WIHIC is one of the most-used questionnaires in learning environment research and has been used world-wide in many studies. This learning instrument has been used in the USA by Allen and Fraser (2007), in Canada by Zandvliet and Fraser

(2005), in Singapore by Chionh and Fraser (1998) and Khoo and Fraser (in press), in Australia by Fraser et al. (1996) and in Brunei by Riah and Fraser (1998). In addition, a Chinese version has been field tested with a sample of 1800 students from Taiwan (Aldridge & Fraser, 2000; Aldridge, Fraser & Huang, 1999). A Korean version (Kim, Fisher & Fraser, 2000) and Indonesian version (Margianti, Fraser & Aldridge, 2004) have also been used.

Dorman (2003) validated the WIHIC cross-nationally using a sample of 3980 high school mathematics students from Australia (1433 students), the UK (1596 students) and Canada (951 students). All the scales had good internal consistency ranging from 0.76 to 0.85. The eta^2 statistic (the strength of association between class membership and the dependent variable) ranged from 0.06 to 0.12 and each WIHIC scale differentiated significantly between different classes in each country. The confirmatory factor analysis results, based on conventional model fit standards, indicated a good model fit with the data and provided support for the postulated model for the WIHIC. This study also supported the wide international applicability of the WIHIC as a valid measure of classroom psychosocial environment.

2.3.8 Questionnaire on Teacher Interaction (QTI)

The Questionnaire on Teacher Interaction (QTI) is the instrument that was used in this study. It is briefly mentioned here and is discussed in more detail in Section 2.6. The QTI was originally developed in the Netherlands and examines students' perceptions of eight aspects of teacher interpersonal behavior, namely, Leadership, Helpful/Friendly, Understanding, Student Responsibility/Freedom, Uncertain, Dissatisfied, Admonishing and Strict behavior (Créton, Hermans & Wubbels, 1990;

Wubbels, Brekelmans & Hooymayers, 1991; Wubbels & Levy, 1993). The original QTI was in Dutch and was later translated into English by Wubbels and Levy (1991) for an American study.

The QTI has been used in various countries including Australia (Fisher, Henderson & Fraser, 1997; Henderson, Fisher & Fraser, 1995), Singapore (Goh & Fraser, 1995, 1998; Quek, Wong & Fraser, 2005a), Brunei Darussalam (Khine & Fisher, 2002; Scott & Fisher, 2004) and Korea (Lee, Fraser & Fisher, 2003; Kim, Fisher & Fraser, 2000). More detailed information about these studies can be found in Section 2.6.

Of the eight classroom learning environment instruments listed in Table 2.1 and reviewed in Sections 2.3.1 to 2.3.8, only the QTI has a specific focus on teacher-student interactions. Therefore, the QTI was a natural choice for my study of gender differences in teacher-student interactions in the classroom.

2.4 Teacher-Student Interaction

This section addresses the importance of interpersonal teacher behavior in the classroom. Learning environments are components of the educational experience and are constructed by individuals and groups of individuals in a given setting. According to Wubbels, Créton & Hooymayers, 1992), communication is reciprocal so that the behavior of the teacher and students influence each other mutually. According to Wenglinsky (2003), student learning is a part of the interaction between students and teachers and both partners contribute to this interaction. Combs (1982) emphasized the affective domain as being a vital part of the educational process which involves both the cognitive and affective domains.

Because one of the goals of the National Science Education Standards (1996) is to educate students who are able to experience the richness and excitement of knowing about and understanding the natural world, development of positive attitudes toward science is a critical component of science instruction (Gardner, 1991; NAEP, 1987). Kahle (1993) reports that teachers' behaviors and instructional strategies affect students' skills, interests and retention in science.

The need for determining students' perspectives in education was established in the theories and works of Fullan (1999), Hargreaves (1972), Dunn (1988), Sizer (1992) and Glasser (1986). One early study by Stayrook, Corno and Winne (1978) found that teacher behavior positively influenced student perceptions and that student perceptions positively influenced student achievement. Other past research indicates a strong link between student perceptions of their teachers' interpersonal behavior and students' achievement and subject-related attitudes (Brekelmans, Wubbels & den Brok, 2002; den Brok, Brekelmans & Wubbels, 2004; Wubbels & Brekelmans, 2006). Marchant, Paulson and Rothlisberg (2001) found that students' perceptions are predictors of academic achievement.

Wigfield and Harold (1992) noted that "it is not just what teachers do but how students view teachers' behavior that relate both to students' own sense of efficacy and their school performance" (p. 192). It has also been reported that teacher behavior is a key factor in the discipline problems experienced by teachers, especially beginning teachers (Wubbels, Créton & Hooymayers, 1992). This is significant because the interactive behavior of a teacher plays a major role in directing the flow of teaching and learning in the classroom.

Many science educators are recommending that learning experience can be improved by focusing more on the teacher-student relationship and, more importantly, the learning environment (Fisher, Rickards & Fraser, 1996; Rickards, 1998; Schunk, 1995; Wubbels, 1993). Researchers believe that the creation of a positive classroom environment is conducive to student learning (Brophy & Good, 1986; Doyle, 1986; Emmer, Evertson & Anderson, 1980; Fraser, 1998a).

There is considerable evidence suggesting a decline in student motivation and achievement for students moving from elementary to middle school (Anderman & Midgley, 1998; Bishop, 1989; Daniels, Kalkman & McCombs, 2001; Eccles et al. 1993; Ferguson & Fraser, 1998; Forbes, 1996; Kramer, 1992; Maeroff, 1982, 1996; Robison, 2001; Thomason & Thompson, 1992). Misiti, Shrigley and Hanson (1991) note that "during the middle school years attitudes are formed that influence science course selections in the high school and college" (p. 525). Consequently, if this is true and if student attitudes to science are negative, then it is unlikely that career choices would include the sciences and engineering.

2.5 Past Studies on Learning Environment-Outcome Associations

Past classroom environment research has shown that student perceptions of the learning environment account for appreciable amounts of variance in both cognitive and affective outcomes (Fraser, 1986; Haertel, Walberg & Haertel, 1981; McRobbie & Fraser, 1993). Because one of the research questions in my study focused on associations between student outcomes and teacher-student interactions, past studies of outcome-environment associations are reviewed in this section.

In one study in the USA, Meece (2003) studied 377 students in 22 introductory science classrooms. He found that the students' perceptions of the classroom climate played a significant role in both student science achievement and satisfaction with learning science.

She and Fisher (2002) used the Teacher Communication Behavior Questionnaire (TCBQ) in the Chinese language to assess teacher communication behaviors and associations with student cognitive and attitudinal outcomes in secondary science classes in Taiwan. It was found that there was a positive relationship between student perceptions of their teacher's communication behaviors and their attitudes toward science.

In Australia, Henderson, Fisher and Fraser (2000) used the SLEI to study associations between student perceptions of their laboratory learning environment and their attitudinal outcomes including attitudes toward their class and attitudes toward laboratory work. All the scales, except the Open-Endedness scale, were associated with attitudinal outcomes.

Wong and Fraser (1996) found positive associations between student attitudes and learning environment among 1592 final-year secondary chemistry students from 56 classes in 28 schools in Singapore. Quek et al. (2005a, 2005b) reported relationships between the chemistry laboratory classroom environment and teacher-student interaction and student attitudes toward chemistry for 200 gifted secondary-school students. Two questionnaires, Chemistry Laboratory Environment Inventory (CLEI) and Questionnaire on Chemistry-Related Attitudes (QOCRA), were used in these two studies.

Fisher and Rickards (1996) studied relationships between teacher and student interpersonal behavior and effects on student attitudes in mathematics using the QTI. A similar study, also using the QTI, investigated associations between secondary school science and mathematics students' perceptions of the classroom learning environment and attitudes and achievement (Fisher, Rickards & Fraser, 1996). The findings of these studies indicated a strong correlation between student attitudes and interpersonal teacher behavior and a weaker correlation between cognitive achievement and interpersonal teacher behavior.

Rickards and Fisher (1996) surveyed science and mathematics students in Western Australia and Tasmania using the QTI. Once again, a significant correlation between student attitudes and teacher behaviors was obtained. However, when the data were analyzed for cognitive outcomes, the correlations were not as strong.

In Brunei, Majeed, Fraser and Aldridge (2002) found correlations between student satisfaction and scales of the MCI among 1565 Form 2 mathematics students in Brunei Darussalam. In Brunei Darussalam, Khine (2001) and Khine and Fisher (2001) found correlations between science attitudes and scales of the WIHIC and QTI with 1188 Form 5 science students. Riah and Fraser (1998) established outcome-environment relationships for achievement and attitudes and scales of the WIHIC, QTI and SLEI with a sample of 644 chemistry students in 35 classes in Brunei Darussalam.

Koul and Fisher (2005) used the QTI to study 1021 students from 31 science classes from Years 9 and 10 in India. All the QTI scales showed significant associations with students' attitudes. Using the QTI, Fisher and Rickards (1997) reported associations between teacher-student interpersonal behavior and students' attitudinal outcomes. Seven of the 8 scales were significantly correlated with student attitudes to class and achievement scores.

Goh and Fraser (1998), using a sample of 1512 primary school students in Singapore, reported relationships between a variety of student outcomes and students' classroom environment perceptions as assessed by the MCI and QTI. In Brunei, a sample of 1188 Form 5 students in 54 science classes (Khine, 2001; Khine & Fisher, 2001, 2002) was used to establish outcome-environment associations for science attitudes and scales of both the WIHIC and QTI.

Scott and Fisher (2004) found associations between enjoyment of science lessons when a primary school version of the QTI, translated into standard Malay, was used with 3104 students in Brunei.

In Korea, Lee and Fraser (2001a, 2003) found associations between attitudes to science using Korean versions of the SLEI, CLES and QTI with 440 Grade 10 and 11 science students. Kim et al. (2000) also used the Korean-language version of the CLES and established associations for student attitudes and scales of the learning environment instrument. Lee et al. (2003) used a translated version of the QTI with 439 high school students in Korea and found associations between teacher-student interactions and classroom environment.

In addition to the research reviewed above, various other studies also have explored associations between students' perceptions of their learning environment and students' outcomes (attitudes and performance) in Taiwan and Australia (Aldridge & Fraser, 2000), Australia (Fisher, Henderson & Fraser, 1995; Henderson, Fisher, Fraser, 1998), five different countries (Fraser, Giddings & McRobbie, 1995; Fraser, McRobbie & Giddings, 1993), the USA (Germann, 1988), Korea (Lee & Fraser, 2002) and Singapore (Wong & Fraser, 1996). These studies have replicated positive associations between better student outcomes and a more favorable classroom environment.

2.6 History, Development and Validity of the QTI

Because the learning environment has been identified as one of the leading factors in student attitudes and achievement, different instruments have been developed to assess student perceptions of the learning environment (see Section 2.3). Because one of these instruments, the QTI, was used in this study, this section outlines the history and development of this instrument

2.6.1 History of the QTI

In 1985, Wubbels, Créton and Hooymayers (1985), working in the Netherlands, developed a model to map interpersonal teacher behavior using an adaptation of the work of Leary (1957). The Leary model for interpersonal behavior originates from research carried out by Leary and his colleagues, working on a Kaiser Foundation research project (Leary, 1957). The Leary model provided a graphic representation for human interactions (Wubbels, Créton, Levy & Hooymayers, 1993). According to Wubbels, Créton and Hooymayers (1992), this model also presents researchers with a means of mapping and describing interpersonal teacher behavior in addition to providing the basis of a method to measure these teacher behaviors. This model, shown in Figure 2.1, conceptualizes the behavior of teachers along two-dimensional axes, consisting of an Influence dimension (Dominance – Submission, DS) and a Proximity dimension (Cooperation – Opposition, CO).

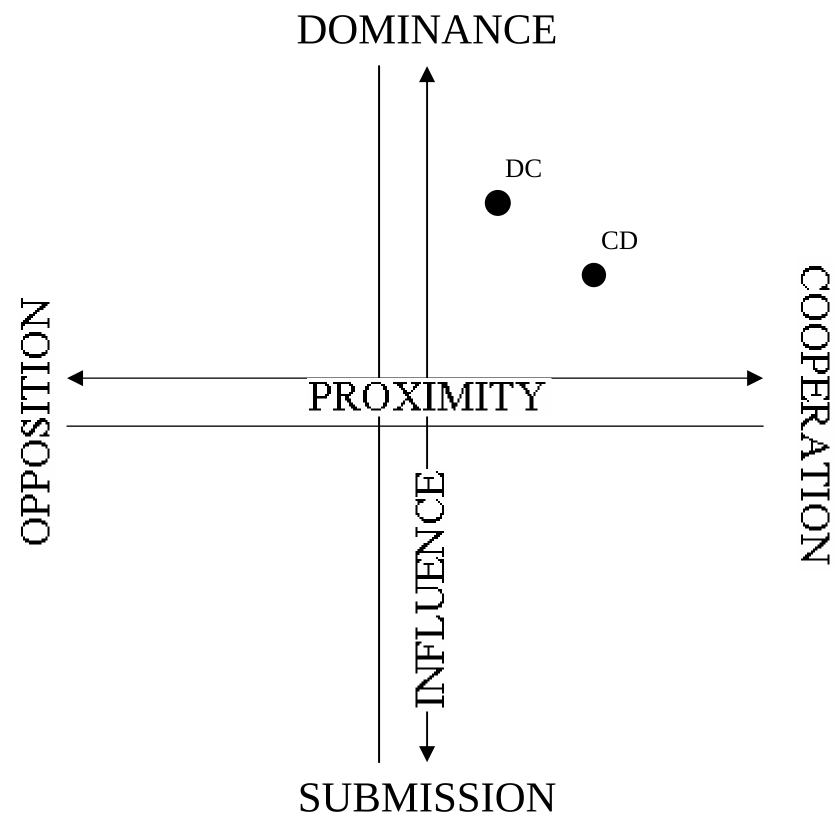

Figure 2.1 Two-Dimensional Coordinate System of the Leary Model
(Source: Wubbels, Créton, Levy & Hooymayers, 1993, p. 15)

According to Wubbels and others (1993), the Influence dimension shows who is controlling or directing the communication process and how often. The Proximity dimension indicates the degrees of cooperation or closeness among the participants involved in the communication process. These two dimensions are independent and reminiscent of effective teacher behaviors that could influence classroom interactions. According to Dunkin and Biddle (1974), directivity and warmth are two aspects of effective teacher behaviors which strongly resemble Influence and Proximity. The axes DS and CO represent opposite behaviors with DS representing dominance and submission and CO cooperation and opposition.

This two-dimensional diagram leads to the circumplex shown in Figure 2.2 in which eight sectors, representing different types of teacher behavior, are developed. These eight sectors or scales are Leadership, Helpful/Friendly, Understanding, Student Responsibility/Freedom, Uncertain, Dissatisfied, Admonishing and Strict behavior. These are labeled DC, CD, CS, SC, SO, OS, OD and DO corresponding to their position in the circular model.

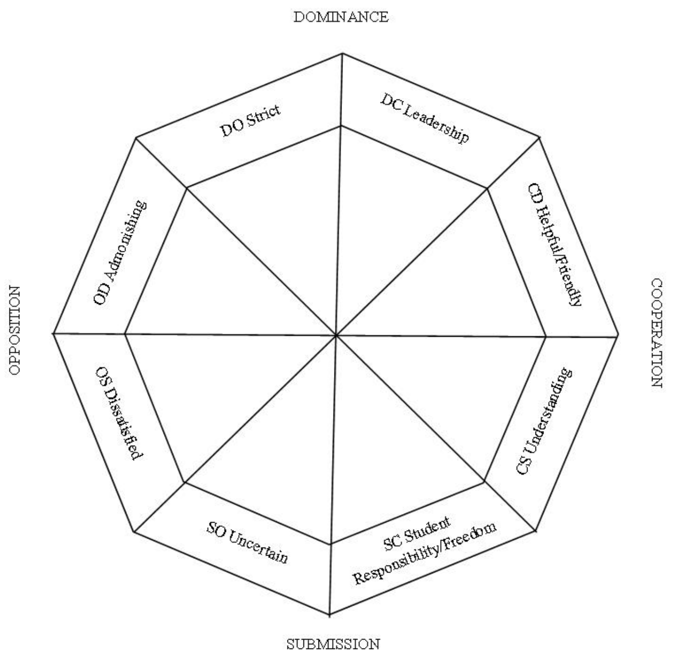

Figure 2.2 Model for Interpersonal Teacher Behavior
(Source: Fisher, Fraser & Wubbels, 1993)

One predominant characteristic of a circumplex is the rotation of factors (Becker & Krug, 1964; Kent, 1992). Looking at the circumplex, one can see that adjacent scales have at least one letter in common and in some there are the same two letters in a different order. So, for example, the sectors OS and SO both include Submission and Opposition. However, in the sector OS, teacher opposition is a stronger trait than teacher submission whereas, in the SO sector, teacher submission is a stronger trait than teacher opposition.

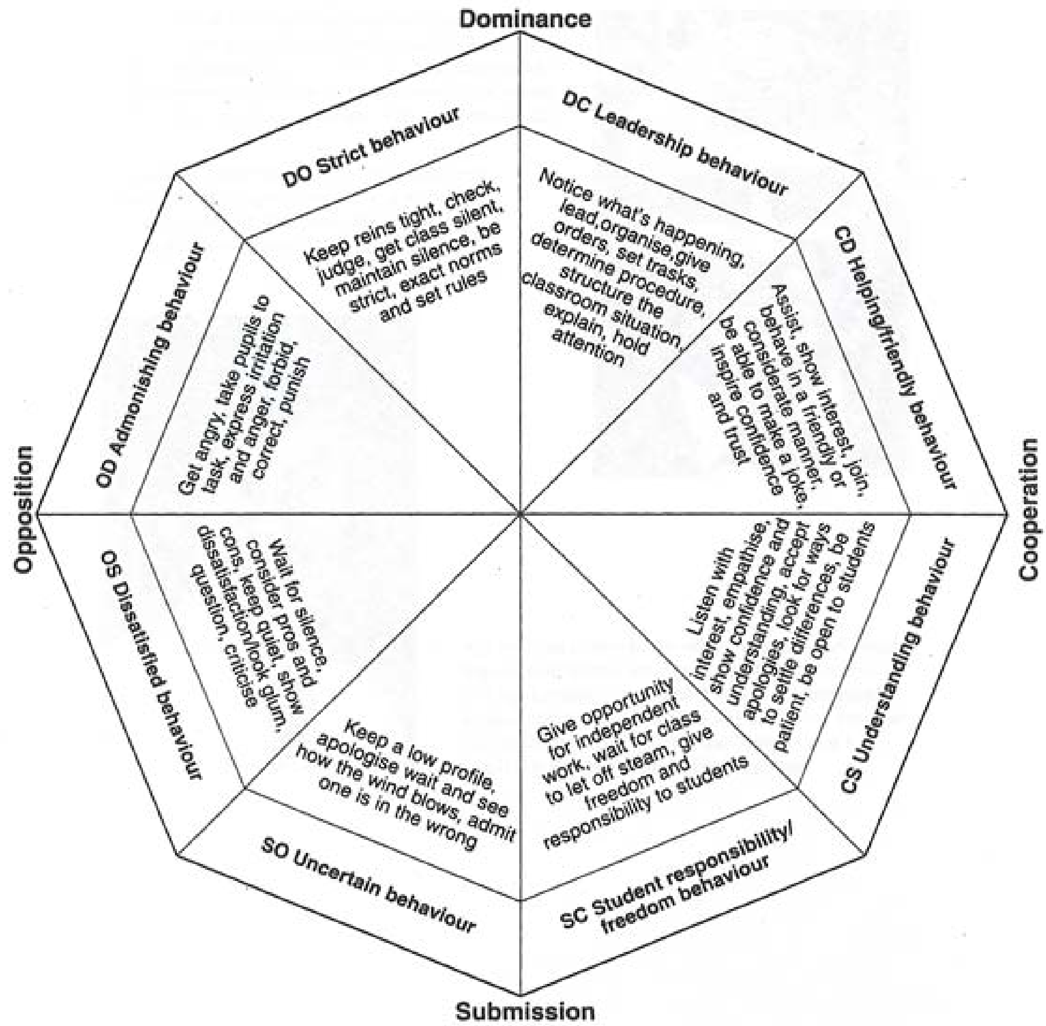

Figure 2.3 Typical Behaviors Associated with the Model for Interpersonal Teacher Behavior
(Source: Wubbels, 1993)

Wubbels (1993) added a description of typical teacher behavior to each of the eight sectors as shown in Figure 2.3. It can be seen that two adjacent sectors, for example Leadership (DC) and Helping/Friendly (CD) show closely – related types of teacher behavior. Based on this observation, the closer the scales are in the diagram, the more the types of teacher behavior in those scales would resemble each other (Wubbels, Créton, & Hooymayers, 1993). So adjacent scales should have the highest correlation with each other. In contrast, as the distance between the scales increases, they become more different until they are diametrically opposite to each other. So, for example, (DO) Strict behavior in which the teacher keeps reins tight, is strict and sets rules is the opposite of (SC) Student Responsibility in which students are given freedom and responsibility and the opportunity for individual work.

2.6.2 Development of the QTI

The model discussed in Section 2.6.1 was used to develop the QTI (Questionnaire on Teacher Interaction), which assesses students' and teachers' perceptions of interpersonal teacher behavior (Wubbels, Créton, Levy & Hooymayers, 1993). The QTI (Wubbels & Levy, 1991, 1993) was designed to assess teacher-student interpersonal behavior in lower secondary classrooms and was developed to measure student and teacher perception of teacher behavior. The original version was developed in the Netherlands in the early 1980s, was in Dutch and had 77 items arranged into eight scales. The items were answered on a five-point frequency scale.

In the late 1980s, Wubbels and Levy (1991) developed an American version of the QTI consisting of 64 items and, in the 1990s, Fisher, Fraser and Wubbels (1993) developed an Australian version with 48 items. The QTI was translated from Dutch to English and used in a validation study in the USA (Wubbels & Levy, 1991). One purpose of this study was to test the reliability and structural validity of the translated Dutch version of the QTI in an American setting. This study also compared the interpersonal teacher behavior of Dutch and American secondary school teachers. The results showed that the Dutch and English versions of the QTI displayed similar internal structure and validity.

Table 2.2 Description and Sample Item for Each Scale in the QTI

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

Adapted from Wubbels and Levy (1991)

The Australian version of the QTI was used in the present study (Appendix 1). This version has eight scales, each with six items, which correspond to the eight sectors of the model. The QTI questions are arranged in a cyclic order to facilitate scoring of the test. Items 1 to 24 assess the four scales of Leadership, Understanding, Uncertain and Admonishing. Items 25 to 48 assess the other four scales of Helping/Friendly, Student Responsibility/ Freedom, Dissatisfaction and Strict (Wubbels, 1993).

The questions are also arranged cyclically in blocks so that in the top half of the questionnaire, the first question of each block relates to Leadership behavior, the second to Understanding behavior, the third to Uncertain behavior and the fourth question to Admonishing behavior. In the second half of the questionnaire, the first question in each block relates to Helpful/Friendly behavior, the second to Student Responsibility/Freedom behavior, the third to Dissatisfied behavior and the fourth to Strict behavior. Table 2.2 provides a description and sample item for each scale of the QTI, while Appendix 1 contains a copy of the complete questionnaire.

2.6.3 Reliability and Validity of the QTI

Reliability and validity of the QTI have been confirmed in various studies in different countries. In the Netherlands, Wubbels and Levy (1993) found the QTI to be a valid and reliable instrument. Wubbels and Levy (1991), using the 64-item version of the QTI in the USA, confirmed the cross-cultural validity of the QTI. Using the Cronbach alpha coefficient, they found acceptable internal consistency reliabilities for different scales ranging between 0.76 and 0.84 with the student as the unit of analysis. In Australia, Wubbels (1993) obtained Cronbach alpha coefficients for different QTI scales ranging between 0.80 and 0.95 for students.

In order to be a valid instrument, the QTI should be able to distinguish between classes on the basis of an analysis of intra-class correlations between scales (Wubbels, Brekelmans & Hooymayers, 1991). Wubbels, Créton and Hooymayers (1985) found that 48% to 62% of the total variance in the subscales scores is accounted for by the effects of the teacher. They therefore concluded that the QTI is a useful instrument for demonstrating the differences in the behavior of different teachers (Wubbels, Créton & Hooymayers, 1985). Overall, this body of past research provides strong support for the validity and reliability of the QTI.

Studies involving the use of the QTI include: research in secondary science classrooms (Fisher, Goh, Wong & Rickards, 1996); the investigation of sex differences in biology students' perceptions of teacher-student relationships (Henderson, Fisher & Fraser, 1995a); associations between learning environments and student outcomes (Henderson, Fisher & Fraser, 1995a); and the relationship between science students' cultural environment and preferred student-teacher interpersonal behavior (Waldrip & Fisher, 1996). Numerous other studies have used the QTI as the learning environment instrument (Brekelmans, Wubbels & Créton, 1990; Fisher, Fraser, & Henderson, 1995; Fisher, Fraser & Rickards, 1997; Levy, Rodriguez & Wubbels, 1992; Wubbels, 1993; Wubbels, Brekelmans & Hermans, 1987; Wubbels, Brekelmans & Hooymayers, 1991; Wubbels, Créton & Hooymayers, 1985). Overall, this body of past research provides strong support for the validity and reliability of the QTI.

Studies of associations between student outcomes and interpersonal teacher behavior were also conducted in Israel (Kremer-Heyon & Wubbels, 1992), Singapore (Goh &

Fraser, 1998), Brunei (Scott & Fisher, 2004) and Australia (Henderson, Fisher & Fraser, 2000; Wubbels, 1993). All of these studies supported the cross-national validity of the QTI.

An Australian study of secondary science and mathematics classes (Wubbels, 1993) suggested that interpersonal teacher behavior is an important aspect of the learning environment that is related to student cognitive and affective outcomes. Teachers exhibiting more leadership, friendly and understanding behavior in their interaction with students were found to encourage greater student achievement, while those who showed uncertain, dissatisfied and admonishing behavior produced the opposite result. Kent (1992), in an Australian study, used teacher and student perceptions to examine the relationship between interpersonal teacher behavior and teacher personality in the secondary classroom.

As noted in Section 2.3.8, the QTI was the natural choice for my study because, of the eight instruments reviewed in Table 2.1, it is the only one which focuses specifically on teacher-student interactions in the classroom. Moreover, as illustrated in this section, the QTI has exhibited consistently high levels of reliability and validity in past research internationally.

2.7 Gender-Related Differences in Student Perceptions of Teacher-Student Interpersonal Behavior

Because my study involved the investigation of gender differences, this section is devoted to past research on gender differences. Of all school subjects, the greatest inequity between the sexes in participation, achievement and attitudes is probably science (Baker, 1997; Parker, Rennie & Fraser, 1996; Young & Fraser, 1994). Kahle and Damnjanovich (1997) reported that the level of interest in science as a career is similar for both boys and girls in seventh grade, but that most girls lose interest by the eleventh grade. Morrell and Lederman (1998) found that, among 5th, 7th and 10th graders, females were slightly more positive about school than males. No gender differences were found with respect to classroom attitudes, and fifth graders had significantly more positive attitudes than students in the higher grades. However, Speering and Rennie (1996) found that some secondary school subjects, particularly the sciences, are perceived negatively by students, especially girls. Therefore the promotion of positive student attitudes is an essential element in encouraging the increased participation of females in science and science-related subjects (Henderson, Fisher & Fraser, 1998b), especially as students get older.

However, various studies point to gender differences in how students perceive the learning environment and in student attitudes to science (Arambula, 1995; Catsambis, 1995; Fraser, Giddings & McRobbie, 1995; Henderson, Fisher & Fraser, 1998; Weinberg, 1995; Zerega, Haertel, Tsai & Walberg, 1986). Beverly and Farenga (1999) found that perceptions of science as an appropriate or inappropriate field of study are developed before the age of nine.

Fisher and Khine (2003) found significant differences between male and female students' perceptions of teacher interpersonal behavior. Their results indicated that females had more positive perceptions of the leadership, understanding and helping/friendly behavior of their teacher. Rickards and Fisher (1997) also found clear differences between male and female student perceptions of teacher interpersonal behavior. They also concluded that females typically perceive their teachers more positively than males, with males perceiving their teachers as more uncertain, dissatisfied, admonishing and strict.

In a study in India using the QTI, Koul and Fisher (2005) found statistically significant gender differences in perceptions of male and female students on seven of the eight QTI scales. Differences in the perceptions of male and female students were not significant for the Strict scale. Female students perceived more positive relationships for the leadership, helpful/friendly and understanding scales, while male students perceived teachers as having more uncertain, admonishing and dissatisfied behaviors and giving more student responsibility. These findings are similar to those reported by Fisher and Rickards (1997) and Khine and Fisher (2001).

In Brunei, Khine and Fisher (2001) found that six scales of the QTI showed significant differences in the perceptions of male and female students. Riah, Fisher & Rickards (1997), in a study in Brunei using 223 boys and 317 girls in chemistry classes, found significant gender differences for four QTI scales. Female students perceived their teachers as good leaders, helping and friendly. Male students saw their teachers as more uncertain and gave them more responsibility and freedom than girls.

Fisher and Rickards (1997), using the QTI in an Australian study, reported that seven scales showed significant differences in the perceptions of male and female students. In Singapore, Goh and Fraser (1998) used the QTI and MCI with 1512 students to detect gender differences in mathematics achievement in favor of boys, but girls generally viewed the classroom environment more favorably than did boys.

Several other studies, using various learning environment instruments, have reported gender differences in science students' perceptions of classroom environment (Aldridge, Fraser, Fisher & Wood, 2002; Fraser, Giddings & McRobbie, 1995; Lawrenz, 1987; Margianti, Fraser & Aldridge, 2004; Raaflaub & Fraser, 2002; Zerega, Haertel, Tsai & Walberg, 1986). Other researchers have documented gender differences in science achievement and motivation (Atwater, Wiggins & Gardner, 1995; Greenfield, 1996; Rech & Stevens, 1996).

2.8 Student Attitudes

One of the goals of this study was to assess the relationship between teacher-student interpersonal relationships and student attitudes and achievement in science. Gardner (1975) proposed two main categories related to attitudes to science: attitudes towards science and scientific attitudes. Attitude towards science in the context of this study refers to the way in which students regard science, such as interesting, boring, dull or exciting. Because of the inclusion of attitudes in my study, Section 2.8.1 discusses the definition of and measuring techniques for attitudes and Section 2.8.2 describes the Test of Science-Related Attitudes (TOSRA), which was the instrument that was adapted for measuring student attitudes to science in my research.

2.8.1 Attitude – Definition and Measuring Techniques

Because attitude is a non-observable psychological construct that can only be inferred from the behavior shown, there is no unanimous agreement on any one definition of attitude. However, Thurstone (1928), who first formulated and popularized the methodology for measuring attitudes, defined attitude as the sum total of a person's inclinations and feelings, prejudice and bias, preconceived notions, ideas, fears, threats and convictions about any specified topic.

Several scaling techniques have been developed to measure attitudes. These include the Likert attitude scaling, Thurstone scaling, Guttman scaling and the semantic differential technique. In Likert attitude scaling (Likert, 1932), the respondent's attitude is measured using a continuum ranging from the extreme end of positive to that of negative. Responses to given statements about an attitudinal object on a five-point continuum (for example, strongly agree, agree, uncertain, disagree and strongly disagree) are recorded and tallied. The TOSRA, which was the instrument used to measure attitudes in this study, was scored using a three-point Likert scale.

2.8.2 TOSRA – Test of Science-Related Attitudes

One instrument that uses the Likert scale technique is the TOSRA (Test of Science-Related Attitudes). Fraser (1978) developed the TOSRA to measure seven science-related attitudes among secondary school students. The theoretical basis for TOSRA came from Klopfer's (1971) categories for the affective domain in science education. The names of the TOSRA scales are Social Implications of Science, Normality of Scientists, Attitude to Science Inquiry, Adoption of Science Attitudes, Enjoyment of Science Lessons, Leisure Interest in Science and Career Interest in Science.

Table 2.3 shows these scales and sample items for each scale. Each scale contains ten items and responses are arranged on a five-point Likert scale ranging from Strongly

Agree to Strongly Disagree. The seven scales are suitable for group administration and can be administered during the duration of a normal class lesson. TOSRA has also been carefully developed and extensively field tested and has been found to be highly reliable.

Table 2.3 Klopfer's (1971) Classification and Sample Item for Each TOSRA Scale

Scale	Klopfer (1971) Classification	Sample Item
Social Implication of Science	Manifestation of favorable attitudes toward science and scientists	Money spent on science is worth spending. (+)
Normality of Scientists	Acceptance of scientific inquiry as a way of thought	Scientists usually like to go to their laboratories when they have a day off. (-)
Attitude to Scientific Inquiry	Acceptance of scientific attitudes as a way of thought	I would prefer to find out why something happens by doing an experiment than by being told. (+)
Adoption of Scientific Attitudes	Adoption of 'scientific attitudes'	I am curious about the world in which we live in. (+)
Enjoyment of Science Lessons	Enjoyment of science learning experiences	I dislike science lessons. (+)
Leisure Interest in Science	Development of interest in science and science related activities	I would like to belong to a science club. (+)
Career Interest in Science	Development of interest in pursuing a career in science	I would dislike being a scientist after I leave school. (-)

*Adapted from Fraser (1981a).
Items designed (+) are scored 1, 2, 3, 4, 5, respectively, for the responses strongly disagree, disagree not sure, agree and strongly agree. Items designated (-) are scored in the reverse manner. Missing or invalid responses are scored 3.

Since the initial validation of TOSRA in 1977, cross-validation data has become available from other studies in Australia and the United States. Lucas and Tulip (1980) used 567 year 10 students and 273 year 12 students. Schibeci and McGaw (1981) studied 1041 year 8–10 students. In Sydney, Australia, Fraser and Butts (1982) studied 546 year 9 girls and 712 year 7 students in 23 classes. All the samples yielded high internal consistency reliability and satisfactory discriminant validity for TOSRA scales. These results are important, not only because they provide additional support for the validity of TOSRA when used with Australian students, but they also support the cross-cultural validity of TOSRA when used with American students.

Fraser (1981) assessed student attitude to their science subjects and their science classes using a questionnaire adapted from the Test of Science Related Attitudes (Fraser, 1981). It was found that Leisure Interest in Science, Career Interest in Science and Enjoyment of Science Lessons have high intercorrelations, which means that they measure overlapping dimensions. Therefore, all three can be merged into a single scale for most research purposes (Fraser, 1981; Khalili, 1987; Schibeci & McGaw, 1981). Fraser (1981) believes that this high intercorrelation is to be expected because students who enjoy science lessons would be more likely to have a leisure and career interest in science. Because of the overlap of these three dimensions, some researchers decided to select only some of the scales in the TOSRA instead of using them all (Aldridge, Fraser, Taylor & Chen, 2000; Lee, 2001; Wong & Fraser, 1996).

Wong and Fraser (1996) investigated environment-attitude associations for 1592 tenth grade chemistry students in Singapore using the SLEI and three of the seven TOSRA scales, renamed slightly for the context of the chemistry laboratory environment (Attitudes to Science Inquiry in Chemistry, Adoption of Scientific Attitudes in Chemistry and Enjoyment of Chemistry Lessons). The simple correlations between each laboratory classroom environment and each attitude scale were all found to be positive except for the Open-Endedness scale.

Adolphe et al. (2003) used the WIHIC and TOSRA with 594 students in Indonesia and 567 students in Australia to assess the relationship between student attitudes and scales of the WIHIC. A revised version of the TOSRA, using three of the original scales containing 20 items, was used and significant multiple correlations were found between each attitude scale and the set of WIHIC scales for both Indonesian and Australian students.

A major advantage that TOSRA has over other science attitude tests is that it gives a separate score for a number of distinct categories. This makes it possible to obtain a profile of attitude scores for groups of students. When interpreting scores obtained on TOSRA relative interpretation can often be more meaningful than absolute ones. For example, comparison of an individual's score, or preferably, a class's mean scores, at two separate times can provide valuable information about changes occurring in student attitudes. TOSRA can be useful in comparing the attitude of two groups of students such as groups of students after alternative teaching strategies or different curriculum materials. It could be sometimes helpful for teachers to compare the scores obtained by a larger or broader sample.

A scale based on the Test of Science-Related Attitudes was used in the present study (see Appendix 2). This scale consisted of 10 items based on two of the scales of the original TOSRA, namely, Enjoyment of Science Lessons and Adoption of Scientific Attitudes. The five-point response scale was also modified to a three-point response scale consisting of Disagree, Not Sure and Agree. This was done to minimize the loss of the students' instructional time as a result of participating in the surveys for this study.

My decision to select items from TOSRA's Enjoyment of Science Lessons and Adoption of Scientific Attitudes scales for use in my study was based simply on their close relevance to the attitudinal aims of the Grade 6–8 science program in the middle school in which my study was conducted. The stated goals of this science program include students' enjoyment their science instruction and developing scientific attitudes (e.g. curiosity about the natural world).

2.9 Summary

This chapter was devoted to a review of literature relevant to this study, especially the field of learning environments which underpinned my research. Learning environment research could be considered as originating with Lewin (1936) and Murray (1938). Other researchers, including Moos (1974) and Walberg and Anderson (1968a), fine tuned and developed this field of education. This chapter reviewed numerous learning environment questionnaires that have been developed, validated and widely used since this time.

Based on previous research, Wubbels, Cretón and Hooymayers (1985) developed the Model of Interpersonal Teacher Behavior and the original Dutch version of the Questionnaire on Teacher Interaction (QTI), which was the main instrument used in my study. Wubbels and Levy (1991) developed an American version in the late 1980s, consisting of 64 items. The Australian version, containing 48 items and developed by Fisher, Fraser and Wubbels (1993), was well suited to my research.

Several studies have shown the QTI is a reliable and valid instrument with Dutch samples (den Brok, 2001; Wubbels, Brekelmans & Hermans, 1987; Wubbels, Créton and Hooymayers, 1992), American samples (Wubbels & Levy, 1991), and Australian samples (Fisher, Henderson & Fraser, 1995; Wubbels, 1993). Data from various studies show that there is a strong relationship between student perceptions of teacher interpersonal behavior and affective outcomes (Wubbels, 1993) as well as cognitive outcomes (Fisher, Henderson & Fraser, 1995). This pattern of findings from past research helped to justify my decision to use the QTI and to investigate associations between teacher interpersonal behavior and student outcomes.

In order to provide insights into my study's research questions involving gender differences in teacher-student interactions and student outcomes, literature in these areas was reviewed. With reference to gender, female students generally tend to perceive their teachers more positively than do male students (Fisher & Rickards, 1997). Despite this, it has been found that some secondary school subjects, in particular the sciences, often are perceived negatively by students, especially girls (Speering & Rennie, 1996).

The present study attempted to validate the QTI and show whether there are any gender differences in student-teacher interpersonal relationships and student outcomes (attitudes and academic achievement) in middle-school science. Because my study involved investigation of associations between student attitudes and teacher-student interaction, Chapter 2 also included a review of literature on attitudes and their assessment, as well as on past studies of outcome-environment associations.

In the next chapter, the methodology used in collecting, analyzing and interpreting data for the study is discussed.

Chapter 3

METHODOLOGY

3.1 Introduction

Chapter 2 presented a review of literature pertinent to the present study. This included the theoretical basis for studies on learning environment research, as well as the historical development and past uses of learning environment instruments.

In this chapter, the research design and research methods of the study are described. This includes identification and description of the sample, procedures for gathering the data, and how the data were analyzed. Section 3.2 recapitulates the research questions and Section 3.3 describes the background to and the selection of the sample. The selection and a description of the two instruments used in the study are presented in Section 3.4. Section 3.5 describes how the data were collected. In Section 3.6, data analyses procedures, including the unit of statistical analysis used, are outlined. The final section, Section 3.7, summarizes the entire chapter.

The QTI (Questionnaire on Teacher Interaction) is the learning environment instrument used in this study to investigate student perceptions of teacher interpersonal behavior. The TOSRA (Test of Science Related Attitudes) is the instrument used to assess student attitudes to science.

3.2 Research Questions

The QTI has been shown to be valid and reliable when used in the United States and other countries (see Chapter 2, Section 2.6.3), but few studies have focused on teacher-student interpersonal relationships in middle-school science classes in South Florida. Therefore the first research question is:

Research Question #1

Is the Questionnaire on Teacher Interaction (QTI) valid and reliable when used in middle-school science classrooms in South Florida?

The TOSRA has also been validated in past studies (see Chapter 2, Section 2.8.2) but this study specifically focused on middle-school science classrooms in South Florida. The second research question is:

Research Question #2

Is an attitude scale modeled on the Test of Science-Related Attitudes (TOSRA) reliable when used in science classrooms in South Florida?

As indicated in Chapter 2, Section 2.5, student attitudes to and achievement in science have been linked to students' perceptions of teacher-student interpersonal behavior. The third research question is stated as:

Research Question #3

Are there associations between the nature of interpersonal teacher behavior and students':

a) attitudes towards science

b) science achievement?

Previous studies have reported gender differences in students' perceptions of teacher-student interpersonal behavior and student outcomes (see Section 2.7). Therefore the last research question is as follows:

Research Question #4

Are there gender differences in student perceptions of teacher interpersonal behavior, attitudes, and achievement?

3.3 Background to and Selection of the Sample

This study was conducted at one middle school in South Florida. Using only one school was a limitation to my study that is discussed further in Chapter 5, Section 5.5. This school has been rated as an A-school by the Florida Department of Education for five consecutive years, meaning that it has attained or surpassed the standards set for academic achievement. An A grade suggests that the results obtained, using this school in my study, could represent positive teacher-student interpersonal interactions and therefore this study could possibly be used as a standard to which other schools in South Florida could be compared. However, care must be taken in applying these results to all middle schools in South Florida because there could be other variables, such as socio-economic or cultural influences, that could be affecting the results.

This school is part of the public school system and is known as a magnet school because it is one which attracts approximately 20% of its students from outside the school-attendance boundaries to a school that has a strong visual and performing arts program. The ethnic composition of the student population at this school is fairly representative of the population of Miami and comprises White (36%), Hispanic (36%), Black (21%) and Asian/Indian/Multiracial (7%) students.

An initial step in this study involved informing the school principal about the surveys that were about to be administered and obtaining her permission. Then the students were given a permission letter to take home to their parents (refer to Appendix 3). This letter outlined the purpose of the surveys and guaranteed the anonymity of any information or data collected. If the parents did not want their children to participate, they were asked to indicate this either on the letter that was sent home or in a separate letter. If there was no written objection to a student participating in the surveys, the student was included in the study.

Students in Grades 6, 7 and 8 responded to the two questionnaires (TOSRA and QTI) on different days, to avoid the risk of student fatigue or boredom, thus raising the possibility that some students (due to absence) did not complete both questionnaires. If students did not complete both the TOSRA and QTI, their responses were not included in the data that were subjected to statistical analysis. Seventy-eight (78) students were eliminated from the study for this reason. Due to the two reasons given above, absence for one or both of the questionnaires or lack of parental permission, the final sample consisted of 1228 students, of whom 540 were boys and 668 were girls, in 47 science classes.

Students, rather than teachers, were used as the main data sources for the following reasons. First, students' perceptions usually vary from teachers' perceptions of the classroom environment (Fraser, 1998b; Levy, Wubbels & Brekelmans, 1992) and tend to reflect a more accurate interpretation of the classroom dynamics. Second, students' perceptions of teacher communication style are a better predictor of student outcomes than are teachers' perceptions (Fisher, Fraser & Wubbels, 1993; Levy, Wubbels & Brekelmans, 1992).

3.4 Instrument Selection

3.4.1 Questionnaire on Teacher Interaction (QTI)

Classroom learning environments have been studied for approximately 40 years using numerous instruments which have been developed and widely validated. These instruments include the Learning Environment Inventory (LEI), Classroom Environment Scale (CES), My Class Inventory (MCI), Science Laboratory Environment Inventory (SLEI), Constructivist Learning Environment Survey (CLES), What Is Happening In this Class? (WIHIC), and the Questionnaire on Teacher Interaction (QTI). These learning environment instruments were previously described in Section 2.3 of Chapter 2.

After examining the various instruments used to assess classroom learning environments, with particular emphasis on teacher-student interpersonal behavior, it was decided to utilize the QTI (Questionnaire on Teacher Interaction) (see Appendix 1). The decision to use the QTI as the learning environment instrument was based partly on literature reviews (see Chapter 2), convenience, established validity and consultation with my research supervisor. Most importantly, the QTI was most relevant to my study because it was specifically developed for evaluating teacher-student relationships in secondary classrooms (Wubbels, Brekelmans & Hooymayers, 1991), which was the central focus of my study, and was ideal for assessing the perceptions of middle-school students. The 48-item Australian version of the QTI was chosen because it could be easily administered during a class period, which lasts approximately 55 minutes. The age and developmental level of the students were also considerations because a longer questionnaire could have produced boredom with the task and an accompanying decrease in the accuracy of recording of student perceptions. The students completed only the actual form of the QTI questionnaire (as the preferred form was not directly relevant to my research questions). However, the major reasons for choosing the QTI for my study were its proven validity in the extensive past research in numerous countries as reviewed below and the fact that it is the only questionnaire in Table 2.1 that focuses specifically on teacher-student ineraction.

The QTI was designed according to the two-dimensional Leary model (1957) and eight sectors to map teacher-student interpersonal interactions (see Chapter 2, Section 2.6). It was originally developed in the Netherlands in 1985 (Wubbels & Levy, 1993), with a 64-item American version being developed in 1988 (Wubbels & Levy, 1991) and a 48-item Australian version developed in 1993 (Fisher, Fraser & Wubbels, 1993). The 48-item version consists of 8 scales each having 6 items.

Several studies have been conducted into the reliability and validity of the QTI in various countries including the Netherlands (Brekelmans, Wubbels & Créton, 1990; den Brok, 2001; den Brok et al., 2003; Wubbels et al., 1985), America (Wubbels & Levy, 1991) and Australia (Fisher, Fraser & Wubbels, 1992; Fisher, Henderson & Fraser, 1995). In Singapore, Goh and Fraser (1995, 1996, 1998) cross-validated the QTI for use in that country. Quek et al. (2005a) provided further support for the validity of the QTI in Singapore. In Brunei Darussalam, Scott and Fisher (2004) cross-validated a version of the QTI which was translated into Standard Malay. As noted in Section 2.6.3, the QTI has been crossvalidated by Soerjaningsih et al. (2001) among Indonesian university students in Indonesia, and among students from the six countries of Singapore, Brunei, America, The Netherlands, Slovakia and Australia (den Brok et al., 2003).

Table 3.1 shows the internal consistency reliabilities (alpha reliability coefficient) found for QTI scales in past studies in Australia, the Netherlands and the United States (Wubbels & Levy, 1993). The analysis uses both the individual student and the class mean as the unit of analysis. The alpha reliability for the different QTI scales, when the student was used as the unit of analysis, ranged from 0.68 to 0.90. The alpha reliability coefficients, using the class mean as the unit of analysis, were higher as expected, ranging from 0.80 to 0.96. All these reliability figures are above 0.65, which is suggested as an acceptable level for research purposes (Wubbels, Levy & Hooymayers, 1993).

For any instrument that measures classroom environment to be effective, it should be able to differentiate between the perceptions of students in different classrooms (Fisher & Rickards, 1997). In other words, students in one class should perceive their teacher in a similar manner, but differently from students in other classes. Therefore, a one-way analysis of variance (ANOVA) often has been performed in past research with the scores on a QTI scale as the dependent variable and class membership as the independent variable. The eta^2 statistic from ANOVA represents the amount of variance in students' perceptions of teacher interpersonal behavior accounted for by class membership. The QTI's ability to differentiate between classrooms has been established in numerous past studies (Fisher & Rickards, 2000; Henderson, Fisher & Fraser, 2000; She & Fisher, 2000; Wubbels & Levy, 1991). The ability to differentiate between classrooms in my study is reported in Section 4.2.3.

Table 3.1 Internal Consistency (Alpha Reliability Coefficient) for QTI Scales for Perceptions of Teacher-Student Interpersonal Behavior in Three Countries in Past Research

Scale	Unit of Analysis	Alpha Reliability USA	Australia	Netherlands
DC Leadership	Individual	0.83	0.83	0.83
	Class Mean	0.94	0.94	0.94
CD Helpful/Friendly	Individual	0.88	0.85	0.90
	Class Mean	0.95	0.95	0.95
CS Understanding	Individual	0.88	0.82	0.90
	Class Mean	0.94	0.94	0.96
SC Student Responsibility/Freedom	Individual	0.76	0.68	0.74
	Class Mean	0.86	0.80	0.85
SO Uncertain	Individual	0.79	0.78	0.79
	Class Mean	0.96	0.92	0.92
OS Dissatisfied	Individual	0.83	0.78	0.86
	Class Mean	0.90	0.93	0.92
OD Admonishing	Individual	0.84	0.80	0.81
	Class Mean	0.92	0.92	0.90
DO Srict	Individual	0.80	0.72	0.78
	Class Mean	0.95	0.90	0.89
Sample Size	Students	1606	792	1106
	Classes	66	46	66

Source: Wubbels & Levy (1993, p.166)

Because the QTI is based on a two-dimensional circumplex model (see Section 2.6 in Chapter 2), there should be a high and positive correlation between adjacent scales, while opposite scales should be highly and negatively correlated with each other. As another measure of the validity of the QTI, inter-scale correlations have been reported in past studies (Goh & Fraser, 1996; Fisher & Khine, 2003b; Scott & Fisher, 2004). The inter-scale correlations for my study are reported in Section 4.2.2.

3.4.2 Test of Science Related Attitudes (TOSRA)

TOSRA is based on the six categories of student attitudes devised by Klopfer (1971) – attitude to science and scientists; attitude to inquiry; adoption of scientific attitudes; enjoyment of science learning experiences; leisure interest in science; and interest in a career in science. These six categories were used as the basis for developing the TOSRA's seven scales (Fraser, 1978, 1981).

The TOSRA was developed in three main stages (Fraser, 1981). First, a version of each scale was assembled based on the existing instruments and reactions from teachers and experts in educational measurement. Next, a revised version, based on evidence from analysis of the data collected during the field testing of the first version of the scales using a sample of 165 Year 7 students, was assembled. Finally the revised version of each scale was tested with a large sample of 1,337 Year 7–10 students and was shown to have satisfactory reliability (with alpha coefficients ranging from 0.64 to 0.93 for different scales for different grade levels).

The TOSRA contains seven attitude scales: Social Implication of Science, Normality of Scientists, Attitude to Scientific Inquiry, Adoption of Scientific Attitudes, Enjoyment of Science Lessons, Leisure Interest in Science and Career Interest in Science. Each scale contains 10 items. Each item is scored on a five-point Likert scale (Likert, 1932) with the response alternatives of Strongly Agree (SA), Agree (A), Not Sure (N), Disagree (D) and Strongly Disagree (SD). Half of the items in the original version of TOSRA are negatively-worded or reversed-scored.

As noted in Section 2.8.2, a major reason for selecting TOSRA for use in my study is that considerable past research has replicated its validity and reliability in the United States (Lightburn & Fraser, 2007), Australia (Fraser & Butts, 1982), Singapore (Wong & Fraser, 1996) and Indonesia (Adolphe, Fraser & Aldridge, 2003).

To measure student attitudes to science in my study, a modified 10-item attitude to science scale was developed based on two scales of the original TOSRA (see Appendix 2). From the seven original TOSRA scales, the two scales from which items were selected were Enjoyment of Science Lessons, which measures contentment with science learning experiences at school, and Adoption of Scientific Attitudes, which measures a willingness to modify or change opinions after acquiring new information. All the questions were positively-worded and positively-scored to avoid students' misinterpretation of the questions asked. Negative items from the original TOSRA were reworded.

The responses were scored using a three-point scale consisting of Disagree=1, Not Sure=2 and Agree=3 instead of the original TOSRA's five-point response alternatives. Appendix B shows the version of the TOSRA used in this study. The modification of the original TOSRA, in terms of reducing the number of questions and scoring categories and avoiding negatively-worded items, was done to improve the quality and validity of the data collected with students in this age group.

3.4.3 Assessment of Achievement

In this study, student achievement was measured by using the letter grade given to students in the nine-week period during which the learning environment and attitude questionnaires were completed. This grade is the average of all the assessed work completed during a nine-week (quarterly) period. An explanation of the grading system is given in Section 1.2.3. This quarterly grade is representative of student achievement over a period of time because it is based on an average of class work, homework, laboratory activities, tests and projects or special assignments completed during that period.

Because the same textbook is used at each grade level, the assignments given to students are the same, but different teachers might use supplemental materials. But, overall, uniform grading is attained because of Miami-Dade Public Schools' grading policy in which percentages are converted to a corresponding letter grade. In addition, human error is minimized because all teachers use an electronic grade book into which they enter students' grades and the computer averages the final grade. As discussed in Section 5.5, student achievement ideally would have been gauged by averaging performance at the school level and on standardized tests. Nevertheless, the quarterly grade still was a satisfactory indicator of student achievement (with its recognized quality justifying its use as the determinant of whether a student is retained or progresses to the next grade level).

3.5 Data Collection

The nine science teachers who agreed to administer the surveys were given class sets of the QTI and TOSRA questionnaires and a two-week period in which to administer them. They were asked to administer the questionnaires on different days to avoid student fatigue and/or boredom as previously mentioned. The teachers were asked to read aloud the instructions for completing the questionnaires to the students before they completed the questionnaire. When all the questionnaires were collected, the teachers bundled them according to class period and returned them to me.

At the end of the quarter (nine-week grading period), the academic grade for science was obtained from the respective teachers. This grade was a letter grade ranging from A to F, where A represents four points, B three points, C two points, D one point and F no points. These letter grades were changed to the corresponding number of points and entered on a Microsoft Excel spreadsheet together with the responses to the QTI and TOSRA.

Only students who responded to both the QTI and TOSRA questionnaires were used in this study. If a value for one of the items of the QTI was missing, the mid-range score (2) was assigned. The same procedure was followed for the TOSRA where the middle score was also 2 based on possible responses of 1, 2 or 3. Each student was identified by his/her student identification number, which is unique to each student in the Miami-Dade County Public Schools system and is used to identify them during their school career as they move from elementary to high school. The data were analyzed statistically using SPSS software as described in the next section.

3.6 Data Analysis

This section describes the statistical analysis of the data obtained. In Section 3.6.1, use of two units of statistical analysis used is discussed. Section 3.6.2 discusses the validation procedures for the QTI and the TOSRA. In Section 3.6.3, simple correlation and multiple regression analyses for investigating outcome-environment associations are outlined, using the individual student and class means as the units of analysis. Section 3.6.4 discusses the statistical analyses that were conducted to examine gender differences in teacher-student interactions, attitudes, and achievement.

3.6.1 Unit of Statistical Analysis

The two most commonly-used units of analysis in previous studies of classroom learning environments have been the individual student and the class mean, though some studies have used the school mean (Brookover, Schweitzer, Schneider, Beady, Flood & Wisenbaker, 1978), the mean of subgroups of students within the class (Walberg, Singh & Rasher, 1977), or the deviation of a student's score from the class mean (Sirotnik, 1980). In this study, the two units of analysis used were the individual student score (between-student analysis) and the class mean score (between-class analysis).

According to Fraser (1998b), it is important to choose the appropriate unit of analysis when carrying out statistical analyses. Measures having the same operational definition can have different substantive interpretations depending on the unit of analysis chosen. Also, there could be a difference in magnitude or sign in relationships obtained when different units of analysis are used. If the incorrect unit of analysis is used, it could violate the requirement of independence of observations and the results of statistical significance tests obtained could be questionable. Finally, using different units of analysis can involve the testing of conceptually different hypotheses.

In this study, both the student and the class mean were used as units of analysis. As well, for investigating gender differences, the within-class gender mean was used as the unit of statistical analysis. Because males and females are not found in equal numbers in every class, the within-class gender mean can be used to provide a matched pair of means – one within-class mean for male students and one within-class mean for female students. This reduces confounding in that there is a corresponding group of male and female students in the same classroom.

3.6.2 Procedures for Validation of QTI and TOSRA

Research Questions 1 and 2 asked whether the QTI and TOSRA are valid and reliable when used in middle-school science classes in South Florida. The correlation coefficient for each item with the other items in the same scale was calculated to determine the consistency of individual items with others within the same scale. One item exhibited very low correlations with others in the same scale and was omitted from statistical analysis. This was Item 12 from the Strict scale of the QTI.

The internal consistency reliability of each scale in the QTI and TOSRA was determined by using the Cronbach alpha coefficient for two units of analysis, namely, the individual and the class mean. According to Cronbach (1951), a scale score can is interpretable only when the scale possesses substantial internal consistency in that each item in the scale measures the same construct as the other items.

An important characteristic of the QTI is that each of the eight scales should be related to each other in a predictable pattern. Therefore, the pattern of inter-scale correlations was examined. Because the eight scales of the QTI are arranged in a circular pattern (see Chapter 2, Section 2.6), it would be expected that adjacent scales would have the highest positive correlation and scales opposite each other should have the greatest negative correlation.

A one-way ANOVA was calculated for each scale of the QTI, with the scores on each QTI scale as the dependent variable and class membership as the independent variable. Usually students in the same class should perceive the classroom environment relatively similarly, while the class mean should vary from classroom to classroom. Two measures obtained by using a one-way ANOVA include the significance level and the eta^2 statistic. The eta^2 statistic, which is the ratio of ‘between’ to ‘total’ sums of squares, indicates the proportion of variance explained by class membership.

3.6.3 Simple Correlation and Multiple Regression Analyses for Outcome-Environment Associations

Research Question 3 asked whether there were associations between interpersonal teacher behavior and students’ attitude toward science and achievement in science**.** Simple correlation and multiple regression analyses using two units of analysis (individual student and class mean) were conducted. A simple correlation analysis of relationships between individual outcome measures and individual environment scales was performed to provide information about associations between particular environment variables and particular outcomes. Multiple regression analysis was conducted to show the relationship between each outcome measure and the set of environmental scales as a whole. To determine which individual scales were making the largest contribution to explaining variance in learning outcomes, regression weights were examined to see which ones were statistically significant. A regression weight describes the influence of a particular environment variable on an outcome when all other environment variables in the regression analysis are mutually controlled.

3.6.4 MANOVA for Gender Differences in Teacher-Student Interpersonal Interactions, Attitudes, and Achievement

Research Question 4 asks whether there are gender differences in student perceptions of teacher-interpersonal behavior, student attitudes and student achievement. In this study, student gender differences were examined using a two-way MANOVA (multivariate analysis of variance) for repeated measures. Gender was the independent variable and the eight QTI scales and attitude and achievement scores were the dependent variables. MANOVA was used to test whether there were gender differences for the set of dependent variables as a whole prior to interpreting the results of the ANOVA for each separate dependent variable.

As explained in Section 3.6.1, because there were unequal numbers of male and female students in each class, the within-class gender mean was chosen as the unit of analysis in this study. A class mean for male and female students in each class was calculated and these matched pairs of means were used as the unit of analysis. Previous studies of gender differences in student perceptions of classroom environments that have utilized within-class gender means as the unit of analysis include Fisher, Fraser and Rickards (1997), Lawrenz (1987), and Young and Fraser (1994).

In addition to investigating the statistical significance of gender differences, the effect size (Cohen, 1988) of each difference was also calculated for each QTI, attitude and achievement scale. Effect size, which is the difference between means expressed in standard deviation units (Thompson, 1998) is an index of magnitude of educational importance. Effect size was calculated by dividing the difference between male and female students by the pooled standard deviation.

3.7 Summary of Methodology

This chapter described the methods and sample used in this study. It also included information about the instruments used, the procedures followed, and the statistical analyses of the data obtained. The study's main aims were to validate questionnaires, to investigate environment-outcome associations, and to explore gender differences in teacher-student interactions and student outcomes.

The study utilized a sample of 1228 students in 47 science classes in a public middle school in Miami-Dade County Public Schools in South Florida. The fact that the sample was drawn entirely from a single school limited the generalizability of results.

The students' attitudes toward science were assessed using a 10-item modified version of the TOSRA. The instrument chosen to assess students' perceptions of the classroom was the 48-item Australian version of the Questionnaire on Teacher Interaction. Student achievement was obtained by using the nine-week (quarterly) grade which is a letter grade ─ A, B, C, D or F ─ that was converted to a numerical value for use in the statistical analyses.

The data collected for the QTI were statistically analyzed to ascertain the internal consistency reliability and ability to differentiate between classrooms to further support the validity and reliability of the QTI as a learning environment instrument. Also the validity of the QTI was explored by checking the consistency of the pattern of inter-scale correlations with that predicated by the circumplex model underlying the QTI. The TOSRA scale was also analyzed in terms of internal consistency reliability to determine if it was reliable when used with the sample in this study.

Data obtained from the QTI and TOSRA were statistically analyzed using MANOVA to investigate gender differences in student perceptions of the learning environment, attitudes toward science, and science achievement.

The data were also analyzed using simple correlation and multiple regression analyses to determine if there were associations between students' perceptions of the learning environment and the students' outcomes of attitudes and achievement.

In Chapter 4, the findings from statistical analyses of the quantitative data are reported.

Chapter 4

RESULTS

4.1 Introduction

This chapter presents results to support the validity and reliability of the Questionnaire on Teacher Interaction (QTI) and a 10-item attitude scale modeled on the Test Of Science-Related Attitudes (TOSRA) when used with a sample of secondary school science students in South Florida. Also provided in this chapter are the results of my investigation into associations between student-teacher interactions and students' outcomes (attitudes and achievement) and into gender differences of student-teacher interactions, attitudes and achievement.

Data collected from 1,228 students in 47 science classes involving the QTI, an attitude scale, and the average of science grades from one nine-week grading period were statistically analyzed to answer the research questions of this study (see Section 1.5 to view the research questions). The results of the analyses are reported in three sections. Section 4.2 reports results for the validity and reliability of the QTI questionnaire and the attitude scale. Section 4.3 provides results for associations between student-teacher interactions and student outcomes. Section 4.4 focuses on the results of gender differences in terms of teacher-student interpersonal relationships and student outcomes (attitudes towards science and science achievement).

4.2 Validity and Reliability of the QTI and Attitude Scale

Previously, the Questionnaire on Teacher Interaction (QTI) has been used to measure teacher-student interpersonal behaviors in the Netherlands (Wubbels & Levy, 1993), Australia (Fisher, Kent, & Fraser, 1998), Israel (Kremer-Hayon & Wubbels, 1992), Brunei (Scott & Fisher, 2004), Singapore (Goh & Fraser, 1995; Quek, Wong, & Fraser, 2005a), Korea (Lee, Fraser, & Fisher, 2003), and the U.S.A. (Wubbels & Levy, 1991) (see Section 2.3.8, 2.6 and 3.4.1). From the numerous versions of the QTI that are currently available, the 48-item Australian version of the QTI (6 items in each of 8 scales) was used in my study (Fisher, Fraser, & Wubbels, 1993) to assess Leadership, Helping/Friendly, Understanding, Student Responsibility/Freedom, Uncertain, Dissatisfied, Admonishing, and Strict behavior.

A 10-item attitude scale modeled on the Test Of Science-Related Attitudes (TOSRA; Fraser, 1981) was used in this study to assess students' attitudes towards science (see Appendix 2). The original version of the TOSRA and translated and/or modified versions of it have been field-tested in various parts of the world with positive results (Aldridge, Fraser, & Huang, 1999; Allen & Fraser, 2007; Fraser & Butts, 1982; Fraser & Fisher, 1982). The 10 items used in my study were taken from the Enjoyment of Science Lessons and Adoption of Scientific Attitudes scales. Although the original TOSRA includes negatively-phrased items, I either chose positively-phrased items or reworded negatively-phrased items because negatively-phrased items proved confusing to students in a pilot study.

The analyses and results for the following research questions are discussed in this section:

Research Question #1

Is the Questionnaire on Teacher Interaction (QTI) valid and reliable when used in science classrooms in South Florida?

Research Question #2

Is an attitude scale modeled on the Test Of Science-Related Attitudes (TOSRA) reliable when used in science classrooms in South Florida?

The QTI and attitude responses from 1,228 science students in 47 classes in one secondary school in South Florida were analyzed to check the validity and reliability of the QTI in terms of scale internal consistency reliability (Section 4.2.1) and the ability to differentiate between classes using one-way ANOVA (Section 4.2.3). The internal consistency reliability was also checked for the 10-item attitude scale (Section 4.2.1). Because the QTI is based on a two-dimensional circumplex model (Wubbels, Créton, Levy, & Hooymayers, 1993), in which adjacent scales are supposed to be highly correlated with each other while opposite scales are supposed to be negatively and highly correlated with each other, it was not appropriate to conduct factor analysis for the QTI (see Section 2.6). However, to check the validity of the QTI, the pattern of inter-scale correlations was used instead of factor analysis, and this is reported in Section 4.2.2.

4.2.1 Internal Consistency Reliability for the QTI and Attitude Scales

Initially, for the QTI and the 10-item attitude scale, item analyses were conducted to check if there were any items with a low item-remainder correlation. Item analysis is used to ascertain if removing certain items from a scale would improve the internal consistency reliability of that particular scale. It was found that all items, with the exception of Item 12 in the Strict scale of the QTI, had a sizeable item-remainder correlation. Thus, Item 12 was removed from the QTI prior to conducting subsequent analyses.

Once any faulty questionnaire items had been identified and removed, internal consistency reliability analysis was conducted to determine the extent to which each item in a scale assesses a similar construct. The Cronbach alpha coefficient was used as an index of scale internal consistency for each QTI scale and the one attitude scale. Table 4.1 displays the Cronbach alpha coefficient for each of the eight scales of the QTI and the one attitude scale for two commonly-used units of analysis, namely, the individual student score (*N*=1228) and the class mean score (*N*=47).

Table 4.1 shows that the QTI scales have satisfactory reliability, with alpha coefficients ranging from 0.51 to 0.83 for different scales when using the individual student as the unit of analysis and from 0.54 to 0.96 when using the class mean as the unit of analysis. As expected, the reliability estimates were higher for all scales when the class mean was used as the unit of analysis.

These reliability figures obtained for the QTI are approximately the same as those found in two studies conducted in the Netherlands, USA and Australia (Rickards, 1998; Wubbels, 1993). The highest alpha coefficient occurred for the Helping/Friendly teacher behavior scale for these two previous studies. In the present study, this scale also had one of the higher alpha coefficients, with the Leadership and Understanding scales also having high alpha coefficients.

Table 4.1 Internal Consistency Reliability (Cronbach Alpha Coefficient) and Ability to Differentiate between Classrooms (ANOVA Results) for Two Units of Analysis for the QTI and Attitude Scale

Scale	No. of Items	Unit of Analysis	Alpha Reliability	ANOVA Eta^2
Leadership	6	Individual	0.79	0.25**
		Class Mean	0.96	
Helping/Friendly	6	Individual	0.83	0.25**
		Class Mean	0.95	
Understanding	6	Individual	0.81	0.25**
		Class Mean	0.96	
Student Responsibility/ Freedom	6	Individual	0.64	0.11**
		Class Mean	0.77	
Uncertain	6	Individual	0.73	0.11**
		Class Mean	0.90	
Dissatisfied	6	Individual	0.76	0.14**
		Class Mean	0.91	
Admonishing	6	Individual	0.65	0.12**
		Class Mean	0.72	
Strict	5	Individual	0.51	0.02
		Class Mean	0.54	
Attitudes	10	Individual	0.81	
		Class Mean	0.93	

* $p<0.05$, ** $p<0.01$
The sample consisted of 1,228 students in 47 classes.
The eta^2 statistic (which is the ratio of 'between' to 'total' sums of squares) represents the proportion of variance explained by class membership.
Item 12 was removed from the Strict scale.

For the 10-item attitude scale, the alpha reliability estimate was 0.81 with the individual student as the unit of analysis and 0.93 for the class mean as the unit of analysis. Just like the QTI, the attitude scale had a higher alpha coefficient when using the class mean.

These results suggest that the QTI and attitude scales have satisfactory internal consistency reliability when used with secondary science students in the South Florida context. As in past research in the Netherlands, the USA, and Australia (Wubbels, 1993), the Strict scale was found to have lower reliability than the other QTI scales.

4.2.2 Pattern of Inter-Scale Correlations for the QTI

As discussed in Section 2.6, the QTI is a unique learning environment questionnaire because it is based on a two-dimensional circumplex model. Unlike other learning environment questionnaires for which there should be a low correlation between all scales, the adjacent scales of the QTI are supposed to be highly and positively correlated with each other, while opposite scales are supposed to be highly and negatively correlated with each other. The magnitude of the correlation should diminish as the scales become increasingly different as they move further apart from each other until they are diametrically opposite to each other. As another measure of the validity of the QTI, inter-scale correlations for the student as the unit of analysis were calculated. The pattern of inter-scale correlations is shown in Table 4.2.

Table 4.2 QTI Inter-scale Correlations with Student as Unit of Analysis

Scale	DC	CD	CS	SC	SO	OS	OD	DO
DC Leadership	1.00	0.64	0.67	0.02	-0.50	-0.43	-0.34	0.03
CD Helping / Friendly		1.00	0.71	0.23	-0.41	-0.51	-0.40	-0.11
CS Understanding			1.00	0.21	-0.36	-0.50	-0.53	-0.16
SC Student Resp / Freedom				1.00	0.26	0.14	0.01	-0.18
SO Uncertain					1.00	0.53	0.49	0.12
OS Dissatisfied						1.00	0.57	0.34
OD Admonishing							1.00	0.36
DO Strict								1.00

N= 1,228 in 47 classes.

As shown in Table 4.2, generally the inter-scale correlations are highest between adjacent scales and lowest between opposite scales. In order to illustrate the pattern of inter-scale correlations for the Helping/Friendly scale, the sector profile in Figure 4.1 shows the correlation of this scale with each of the other seven QTI scales when the student was used as the unit of analysis. For instance, as shown in Figure 4.1, the Helping/Friendly scale is highly and positively correlated with its two adjacent scales of Leadership (*r*=0.64) and Understanding (*r*=0.71). Furthermore, as one moves around the chart away from the Helping/Friendly scale, the correlation between scales decreases. As a matter of fact, when one reaches the Dissatisfied scale, which is opposite to Helping/Friendly, it is the most highly and negatively correlated to Helping/Friendly in Figure 4.1 (*r*=-0.51). In addition, as shown in Figure 4.1, the inter-scale correlations are of small magnitude between the Helping/Friendly scale and the scales of Student Responsibility/Freedom (*r*=0.23), Uncertain (*r*=-0.41), Admonishing (*r*=-0.40), and Strict (*r*=-0.11). The results reported in Table 4.2 and Figure 4.1 support the circumplex nature of the QTI, thus replicating those of previous studies (Fisher et al., 1993; Fisher et al., 1998; Quek et al., 2005b; Rickards, 1998).

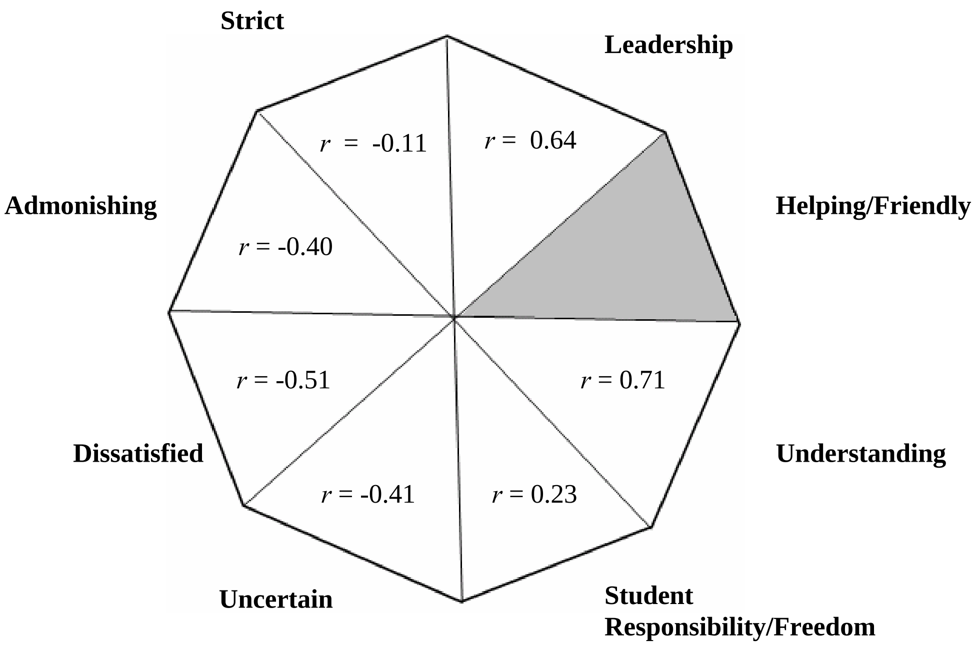

Figure 4.1 Correlation of Helping/Friendly Scale with Each of the Other Seven QTI Scales

4.2.3 Ability of the QTI to Differentiate between Classrooms

To further validate the QTI, a one-way ANOVA was used to indicate whether each scale of the questionnaire was able to differentiate significantly between perceptions of students in different classes. Scores on a QTI scale were used as the dependent variable and class membership was used as the independent variable. The eta^2 statistic (an estimate of the strength of the association between class membership and the dependent variable) ranged from 0.02 to 0.25 for the different scales, and was statistically significant ($p<0.05$) for seven out of the eight scales (see Table 4.1). These results suggest that students in the same class perceived teacher-student interaction in a relatively similar way, while the within-class mean perceptions of the students varied between classes.

In conclusion, all of the validation results presented in this section are consistent with past studies that found the QTI to be a valid and reliable instrument that can be used in a variety of countries for measuring teacher-student interpersonal behavior (Fisher et al., 1993; Fisher, Fraser, Wubbels, & Brekelmans, 1993; Goh & Fraser, 1998; Lee et al., 2003; Quek et al., 2005b; Rickards, 1998; Scott & Fisher, 2004; Wubbels, 1993). Furthermore, the internal consistency reliability results previously reported in Section 4.2.1 support that attitude scale modeled on the Test Of Science-Related Attitudes (TOSRA) is a reliable tool to be used with secondary students in the South Florida context.

4.3 Associations between Student Outcomes and QTI Scores

Not only were the Questionnaire on Teacher Interaction (QTI) and an attitude scale modeled on the Test Of Science-Related Attitudes (TOSRA) administered to 1,228 secondary science students in 47 classes in one school in South Florida, but also these students' average science grades for one nine-week grading period were obtained as a measure of science achievement. This achievement measure is described in section 3.4.3. All of the data gathered were statistically analyzed to investigate associations between student outcomes (attitudes towards science and science achievement) and students' perceptions of student-teacher interaction. The results of simple correlation and multiple regression analyses using two unit of analysis (individual and class mean) are reported in this section. The following research question was answered:

Research Question #3

Are there associations between the nature of interpersonal teacher behavior and students':

a) attitudes towards science

b) science achievement?

The simple correlation analysis provides information about the bivariate association between each student outcome and each learning environment scale. As shown in Table 4.3, the simple correlation between an environment scale and student attitudes was statistically significant ($p<0.05$) for both units of analysis for six QTI scales (Leadership, Helping/Friendly, Understanding, Uncertain, Dissatisfied and Admonishing). For student achievement, the simple correlation was statistically significant for both units of analysis for five QTI scales (Leadership, Helping/Friendly, Understanding, Uncertain and Dissatisfied) and for one unit of analysis for the other three QTI scales (Student Responsibility, Admonishing and Strict). All of these statistically significant correlations are positive for the four QTI scales with a positive connotation (the first four scales) and negative for the four QTI scales with a negative connotation (the second four scales), thus confirming a positive link between favorable teacher-student interaction and student outcomes.

To reduce the Type I error rate and provide a more parsimonious picture of the joint influence of correlated learning environment scales on student outcomes, a multiple regression analysis was conducted for each outcome for two units of analysis (individual and class mean). The multiple correlation (*R*) between the set of eight QTI scales and the students' attitudes is 0.45 (individual student) and 0.85 (class mean). The multiple correlation coefficient obtained for the set of eight QTI scales and students' achievement was 0.30 (individual student) and 0.78 (class mean). The multiple correlation between the eight learning environment scales and each student outcome (attitudes and achievement) was statistically significant ($p<0.01$) for both the individual student and the class mean as the units of analysis. This suggests a relationship between student outcomes (attitudes and achievement) and the set of scales assessing teacher-student interactions.

The standardized regression weights were examined to provide information about the contribution of each learning environment scale to the variance in an outcome score when all the other learning environment scales were mutually controlled. The standardized regression weights (β) shown in Table 4.3 indicate that:

- Leadership and Understanding behaviors are positive, significant, and independent predictors of students' attitudes when controlling for the other seven QTI scales with the individual student as the unit of analysis.

Table 4.3 Simple Correlation and Multiple Regression Analyses for Associations between Two Student Outcomes (Attitudes and Achievement) and Dimensions of the QTI for Two Units of Analysis

Scale	Unit of Analysis	Attitudes		Achievement	
		r	*β*	*r*	*β*
Leadership	Individual	0.43**	0.29**	0.24**	0.07
	Class	0.82**	0.50	0.51**	-0.09
Helping/Friendly	Individual	0.36**	0.08	0.26**	0.11*
	Class	0.73**	0.16	0.69**	0.25
Understanding	Individual	0.38**	0.10*	0.25**	0.06
	Class	0.82**	0.49	0.59**	-0.30
Student Responsibility/ Freedom	Individual	0.05	0.01	0.05	0.04
	Class	0.21	-0.08	0.51**	0.57**
Uncertain	Individual	-0.22*	0.04	-0.21*	-0.09*
	Class	-0.60**	0.17	-0.54**	-0.47*
Dissatisfied	Individual	-0.27**	-0.05	-0.20*	-0.30
	Class	-0.65**	0.38	-0.50**	-0.30
Admonishing	Individual	-0.24*	-0.05	-0.18	-0.03
	Class	-0.67**	-0.24	-0.45**	-0.02
Strict	Individual	-0.05	-0.00	-0.05	0.01
	Class	-0.15	0.02	-0.27*	0.19
Multiple Correlation (*R*)	Individual		0.45**		0.30**
	Class		0.85**		0.78**

$*p<0.05$, $**p<0.01$
N= 1,228 students in 47 science classes.
Item 12 was removed from the Strict scale.

- There is a positive, significant, and independent association between academic achievement and Helping/Friendly behavior at the individual level of analysis and Student Responsibility/Freedom behavior at the class mean level of analysis.
- Uncertain behavior is a negative, significant, and independent predictor of academic achievement with either the individual student or the class mean as the units of analysis.

It is noteworthy that every statistically significant regression weight is positive for scales that represent positive teacher-student interactions (i.e., Leadership, Student Responsibility/Freedom, and Understanding) and negative for the scale that assess negative teacher-student interactions (i.e., Uncertain). These results suggest that students reported more positive attitudes towards science when they perceived higher levels of leadership and understanding in their science classes. Additionally, students who perceived their teacher to be more helping/friendly and less uncertain had higher academic achievement in science.

Overall, the results in Table 4.3 provide strong support for associations between student outcomes (attitudes and achievement) and their perceptions of student-teacher interactions, thus replicating those obtained in previous studies (Goh & Fraser, 1998; Lee et al., 2003; Quek et al., 2005a; Rickards, 1998; Scott & Fisher, 2004; Wubbels, 1993). For example, in an earlier meta-analysis of 12 studies encompassing 17,805 students from four nations (Haertel, Walberg & Haertel, 1981), better achievement on a variety of outcome measures was consistently found in classes with greater cohesiveness and goal direction and less disorganization and friction. Specifically in science laboratory classrooms, higher achievement and attitude scores were found in classrooms with more integration of theory and practical work (McRobbie & Fraser, 1993). For past research that specifically involved the use of QTI, numerous studies yielded the same pattern of results as my study, namely, the existence of statistically significant positive associations between student outcomes (attitudes and achievement) and positive teacher-student interactions (i.e. higher scores on the QTI’s first four scales and lower scores on the QTI’s second four scales). For example, such positive associations between student outcomes and most QTI scales were reported: for attitude outcomes among 543 Grade 8 science students in Korea; (Kim, Fisher & Fraser, 2000); for a satisfaction outcome among 497 Grade 10 chemistry students in Singapore (Quek, Wong & Fraser, 2005a); for both liking of and achievement in mathematics among 1,512 primary-school children in Singapore (Goh & Fraser, 1998); and for the outcomes of attitude to class, attitude to laboratory work, examination scores and practical test performance for a sample of 489 Australian biology students (Henderson, Fisher & Fraser, 2000).

4.4 Gender Differences in Teacher-Student Interactions, Attitudes, and Achievement

In this section, gender differences in teacher-student interactions, attitudes, and achievement are reported based on data from the Questionnaire on Teacher Interaction (QTI) for students' perceptions of interpersonal teacher behavior, from the 10-item attitude scale for students' attitudes to science, and from each student's average science grade for one nine-week period for academic achievement. The same sample of 1,228 secondary science students in 47 classes in one school in South Florida was used. There were 540 male students and 688 female students. So, approximately 44% of the students surveyed were male and 56% were female. The data gathered were statistically analyzed to answer the following research question:

Research Question #4

Are there gender differences in student perceptions of teacher interpersonal behavior, attitudes, and achievement?

Gender differences in teacher-student interactions, attitudes and achievement were examined using MANOVA (multivariate analysis of variance) with the within-class gender mean as the unit of analysis. This was done by calculating the male mean and female mean for each participating class, and then running MANOVA using the matched pairs of means (see Section 3.6.1). The importance of choosing an appropriate unit of analysis is considered below.

Stern, Stein, and Bloom (1956) made a distinction between *private beta press* (the idiosyncratic view that each person has of the environment) and c*onsensual beta press* (the shared view that members of a group hold about the environment). According to Fraser (1998a), in learning environment studies, it is critical for the researcher to decide whether analyses will involve the perception scores obtained from individual students (*private beta press*) or if the individual scores will be combined to obtain the mean of the perception scores of all students within the same class (*consensual beta press*).

Fraser (1998a) argues that it is important to select the correct unit of analysis for several reasons. First, measures having the same operational definition can have different substantive interpretations with different levels of aggregation. Second, relationships obtained using one unit of analysis could differ in magnitude or sign from relationships obtained with a different unit of analysis. Third, utilizing the incorrect unit of analysis (i.e., individual students when classes are the primary sampling units) violates the requirement of independence of observations and calls into question the results of any statistical significance tests because an unjustifiably small estimate of the sampling error is used. Fourth, the use of different units of analysis involves the testing of conceptually different hypotheses.

As previously mentioned, the unit of analysis which I chose for the MANOVA was the within-class gender mean. As explained in Section 3.6.1, because males and females were not found in equal numbers in every class, the within-class gender mean was used to provide a matched pair of means – one within-class mean for male students and one within-class mean for female students. This reduces confounding in that there is a corresponding group of male and female students in each classroom in the sample.

For the MANOVA, the eight QTI scales and attitude and achievement scores were used as the dependent variables and gender was the independent variable. Because the multivariate test yielded statistically significant (p<0.01) gender differences for the set of dependent variables overall using Wilks' lambda criterion, the univariate ANOVA was interpreted for each dependent variable individually. Table 4.4 displays the results of the ten ANOVAs in the last column.

Statistically significant (p<0.05) gender differences can be seen in Table 4.4 for three of the eight QTI scales (namely, Helping/Friendly, Dissatisfied and Admonishing) and for achievement. For these three QTI scales, female students had more positive perceptions than males in terms of more helpful, less dissatisfied and less admonishing behaviors on the part of their teachers. Also, females had significantly higher science achievement scores than did males. These results are consistent with those of Rickards (1998) who also found significant gender differences for the same three QTI scales, with females perceiving more helping/friendly, less dissatisfied, and less admonishing teacher behaviors than males.

Interestingly, other past studies have found significant differences between males and females in terms of students' learning environment perceptions (Dorman, Adams, & Ferguson, 2001; Fisher, Fraser, & Rickards, 1997; Fraser, Giddings, & McRobbie, 1995; Khoo & Fraser, in press) and achievement (Dimitrov, 1999; Fierros, 1999; Goh & Fraser, 1998). Fraser, Giddings and McRobbie's (1995) study of Australian senior high school science laboratory classrooms suggested that females generally had more positive perceptions of their classroom learning environments than did males in the same classrooms. Similarly, in a study involving use of the QTI among 497 tenth grade chemistry students in Singapore, Quek, Wong and Fraser (2005a) found that females reported more positive classroom environment perceptions than males in terms of teachers being more helpful/friendly, giving students more responsibility, and being less dissatisfied and strict. However, other past studies have revealed that males have more favourable perceptions than females on some learning environment dimensions. In a study involving 250 working adults undertaking computer application courses in Singapore, females perceived significantly higher levels of classroom equity, whereas males perceived significantly greater class involvement (Khoo & Fraser, in press). In New York, Wolf and Fraser's (in press) study involving 1,434 middle-school science students revealed that females perceived more student cohesiveness and cooperation, but less teacher support and investigation. In Korea, Kim, Fisher and Fraser (2000), found that males had significantly more favorable perceptions than did females on most scales of the WIHIC and QTI (except that females perceived that their teachers exhibited significantly less dissatisfactied and strict behaviors.

Whereas the MANOVA results provide information about the statistical significance of differences, the effect size (the difference between means expressed in standard deviation units) was calculated to provide an index of the magnitude of a gender difference and therefore its educational importance (Thompson, 1998). Thus, the effect sizes for the learning environment, attitude, and achievement measures are reported in the penultimate column of Table 4.4.

According to Cohen (1988), effect sizes can be considered small (0.10), medium (0.25) or large (0.40). For each of the three QTI scales (namely, Helping/Friendly, Dissatisfied and Admonishing) that showed statistically significant gender differences, the effect size ranges from 0.21 to 0.33 standard deviations (see Table 4.4), suggesting small to medium effect sizes according to Cohen's criteria.

Table 4.4 Average Item Mean, Average Item Standard Deviation, and Difference between Males and Females (Effect Size and MANOVA Results) for Scores on QTI, Attitude, and Achievement Measures Using the Within-Class Gender Mean as the Unit of Analysis

Scale	Average Item Mean[a]		Average Item Standard Deviation		Difference	
	Male	Female	Male	Female	Effect Size	*F*
Leadership	2.73	2.69	0.50	0.51	-0.08	0.83
Helping/Friendly	2.62	2.74	0.57	0.55	0.21	1.51*
Understanding	2.62	2.71	0.56	0.56	0.16	1.30
Student Resp/Freedom	1.70	1.77	0.32	0.30	0.23	1.36
Uncertain	0.91	0.83	0.38	0.33	-0.22	1.32
Dissatisfied	1.26	1.12	0.48	0.35	-0.33	1.55*
Admonishing	1.29	1.19	0.44	0.37	-0.24	1.42*
Strict	1.68	1.63	0.24	0.20	-0.23	1.04
Attitudes	2.27	2.28	0.23	0.23	0.04	0.66
Achievement	2.55	2.79	0.60	0.49	0.44	2.26**

*$p<0.05$, **$p<0.01$
N=688 females and 540 males in 47 science classes.
[a] Average item mean=Scale mean divided by the number of items in that scale.
Item 12 was removed from the Strict scale of the QTI.

These small to medium effect sizes for QTI scales suggest some moderately important gender differences in teacher-student interpersonal behavior. Furthermore, the effect size for achievement is 0.44, suggesting a larger and more educationally important difference in achievement between male and female students (see Table 4.4).

Table 4.4 also reports the average item mean (scale mean divided by the number of items in that scale) and average item standard deviation for each learning environment, attitude and achievement measure. Figure 4.1 graphically represents the average items means shown in Table 4.4 to illustrate the differences between males' and females' mean scores on the QTI, attitude, and achievement measures. Figure 4.2 and Table 4.4 show a pattern in favor of female students in that they consistently tend to have more positive perceptions of their teachers' interpersonal behaviors.

Figure 4.2 provides a picture of the average pattern of teacher interpersonal behavior for my sample of teachers and classes in South Florida. For the four QTI scales with a positive connotation, high scores suggest that teacher interpersonal behavior is quite positive for the first three scales (Leadership, Helping/Friendly, and Understanding) whereas lower scores suggest only a moderately positive level of Student Responsibility/Freedom. For the four QTI scales with a negative connotation, low mean scores in Figure 4.2 again suggest positive teacher interpersonal behavior in terms of low Uncertain, Dissatisfied, Admonishing and Strict behaviors. Furthermore, the profile of average QTI scores in Figure 4.2 for my sample in South Florida is quite similar to the average QTI scores reported by

Wubbels (1993) for a sample of 792 students in 46 typical Grade 11 science and mathematics classes in Western Australia.

For the three QTI scales for which gender differences were statistically significant, females had more favorable perceptions of teacher-student interpersonal behaviors, which is consistent with past research (Dorman et al., 2001; Fisher et al., 1997; Fraser et al., 1995; Goh & Fraser, 1998; Henderson, Fisher, & Fraser, 1995; Rickards, 1998). Figure 4.2 and Table 4.4 also show that females had higher academic achievement than males do.

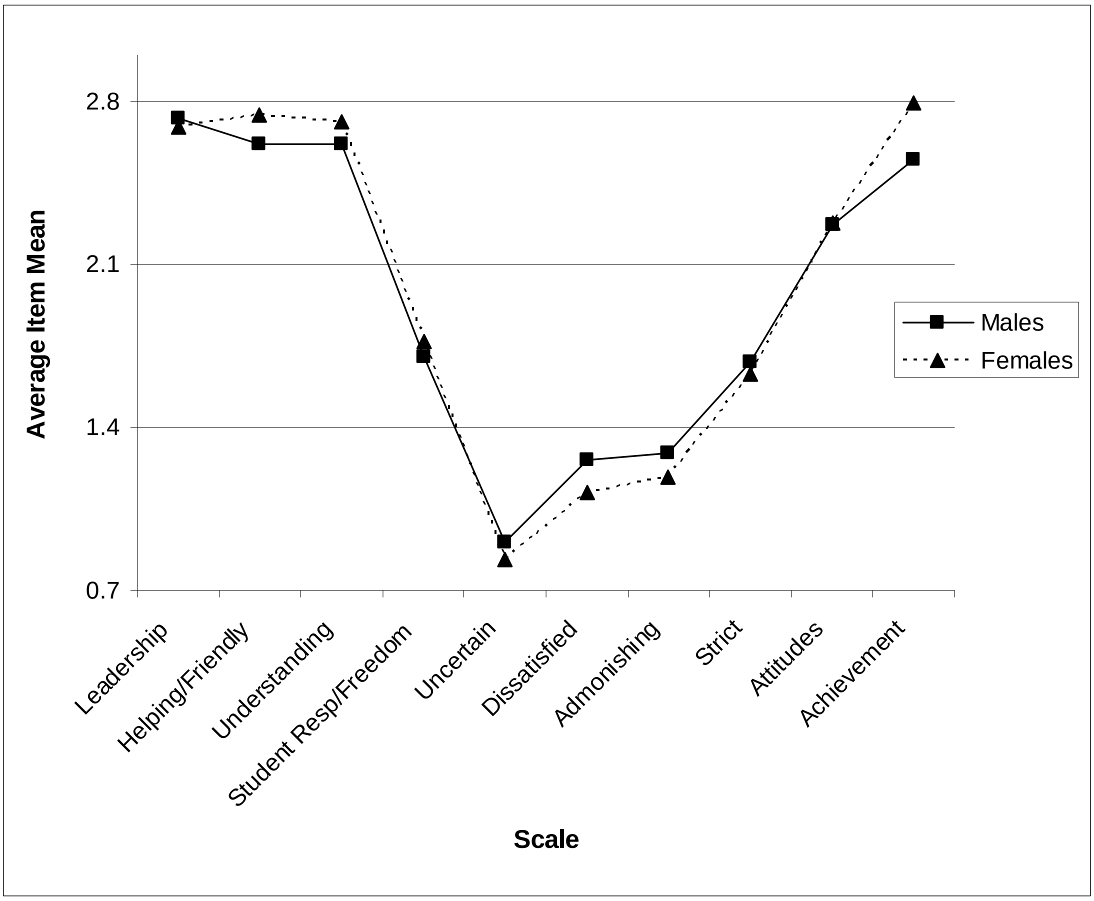

Figure 4.2 Male and Female Students' Average Item Means on the QTI, Attitude, and Achievement Measures (*N*=540 Males and 688 Females in 47 Classes)

4.5 Summary and Conclusions

The analyses and results for my study into gender differences in terms of student-teacher interactions, attitudes and achievement were reported in this chapter. The sample for my study consisted of 1,228 secondary science students in 47 classes in one school in South Florida. The instruments used to collect the data from the student sample were the 48-item Australian version of the Questionnaire on Teacher Interaction (QTI) and a 10-item attitude scale modeled on the Test Of Science-Related Attitudes (TOSRA). The QTI was utilized to measure students' perceptions of their teachers' interpersonal behaviors, and the students' attitudes towards science were measured with the attitude scale. As well, each student's average science grade for one nine-week grading period was also collected as a measure of achievement in science.

In order to determine if the QTI questionnaire and the attitude scale were valid and reliable instruments, the collected data were subjected to several statistical analyses: internal consistency reliability analysis, inter-scale correlations, and one-way ANOVA. The internal consistency reliability analysis revealed satisfactory internal consistency reliability for the QTI, with alpha reliability coefficient ranging from 0.51 to 0.83 for the different scales with the student as the unit of analysis and from 0.54 to 0.96 for class means. For the 10-item attitude scale, the alpha coefficient was above 0.80 for both student and class mean as the unit of analysis, demonstrating high internal consistency reliability.

Although it is appropriate to conduct factor analysis for most learning environment questionnaires, it is not relevant for the QTI's two-dimensional circumplex structure

(Wubbels et al., 1993) in which adjacent scales are supposed to be highly and positively correlated with each other, while opposite scales are supposed to be highly and negatively correlated with each other. Therrefore, as an alternative measure of validity for the QTI, the pattern of scale inter-correlations was examined. The results showed that inter-scale correlations were high and positive between adjacent scales, high and negative between opposite scales, and of small magnitude between scales that are neither adjacent nor opposite each other. For example, the Helping/Friendly scale was closely and positively correlated with its two adjacent scales (namely, Leadership and Understanding) and closely and negatively correlated with its opposite scale (namely, Dissatisfied). However, correlations between Helping/Friendly and the other QTI scales of Student Responsibility/Freedom, Uncertain, Admonishing, and Strict were smaller in magnitude. These results supported the circumplex nature of the QTI.

One-way ANOVA results demonstrated that seven out of the eight QTI scales were able to differentiate significantly ($p<0.05$) between the perceptions of the students in the different classrooms.

Overall, the results of the statistical analyses suggested that the QTI questionnaire and the attitude scale are valid and reliable instruments for use with secondary science students in South Florida. Thus, the data collected during the field-testing, along with students' science grade averages, were further analyzed to investigate associations between students' outcomes (attitudes and achievement) and their perceptions of their teachers' interpersonal behaviours, as well as gender differences.

A positive and statistically significant ($p<0.05$) bivariate association was found between student attitudes and six scales of the QTI with either the individual student or the class mean as the units of analysis (with the exceptions being Student Responsibility/Freedom and Strict). For at least one unit of analysis, there was a statistically significant simple correlation between achievement and each QTI scale. Furthermore, a strong multivariate relationship was found between student outcomes (attitudes and achievement) and the set of eight QTI scales as a whole with either the individual or the class mean as the unit of analysis. In particular, regression coefficients revealed that, when teachers exhibited more leadership and understanding behaviors, students' attitudes towards science were more positive. Science achievement was higher when teachers were friendlier and less uncertain and allowed more student responsibility/freedom.

Another aim of my study was to investigate if gender differences exist in terms of students' perceptions of their teachers' interpersonal behaviors, attitudes and achievement. Overall, the use of MANOVA tentatively suggested that gender differences exist in students' perceptions of teacher interpersonal behavior, attitudes towards science, and science achievement. However, the difference between males and females was statistically significant only for the Helping/Friendly, Dissatisfied, and Admonishing scales of the QTI and for achievement. The effect sizes for gender differences on these four measures ranged from 0.21 to 0.44 standard deviations, suggesting some educationally important gender differences in terms of teacher-student interpersonal behavior and achievement. Moreover, it was found that, relative to males, female students generally had more positive perceptions of teacher interpersonal behavior and higher academic achievement.

It is interesting that female students generally had more positive perceptions of their learning environments than males did, which is consistent with some past research (Dorman et al., 2001; Fisher et al., 1997; Fraser et al., 1995; Khoo & Fraser, in press; Rickards, 1998). Although I cannot be sure about why females perceived their teachers to have more positive interpersonal behaviors than did males (in terms of more helping/friendly, less dissatisfied, and less admonishing behaviors), I can speculate that they might have been more lenient when rating their teachers. Regardless of the advancement of females in our society, due to societal and cultural expectations, most females are still less assertive and opinionated than males. Thus, they could have been inclined to answer more positively on the QTI. In my study, it would have been useful to interview several female and male students to further investigate and clarify why female students perceived their learning environments more positively than male students did. However, due to the lack of time and resources, I was not able to conduct such interviews. This is a limitation in my study, which is further discussed in Section 5.5 of Chapter 5.

In Chapter 5, I provide a detailed discussion of the findings, distinctive contributions and possible limitations of my study, as well as suggestions for future research.

Chapter 5

CONCLUSION AND SUMMARY

5.1 Introduction

This study examined gender differences in teacher-student interpersonal behavior and student attitudes and achievement in middle-school science classes in South Florida. It also investigated associations between teacher-student interpersonal behavior and student attitudes and achievement. The research was conducted in one middle school in South Florida among a sample of 1228 science students in 47 classes. Two questionnaires, the Questionnaire on Teacher Interaction (QTI) and Test of Science-Related Attitudes (TOSRA), were used. This chapter gives an overview of the thesis (Section 5.2), summarizes its major findings (Section 5.3), and considers its contributions (Section 5.4) and limitations (Section 5.5). Finally, recommendations for future research are made in Section 5.6.

5.2 Overview of the Thesis

This thesis was divided into five chapters. Chapter 1 gave an overview of the entire thesis. It provided the context in which the study was undertaken, established the background to the study, and described the learning environment instrument used. Finally, the significance and objectives of the study were described. The four research questions were:

Research Question #1

Is the Questionnaire on Teacher Interaction (QTI) valid and reliable when used in science classrooms in South Florida?

Research Question #2

Is an attitude scale modeled on the Test Of Science-Related Attitudes (TOSRA) reliable when used in science classrooms in South Florida?

Research Question #3

Are there associations between the nature of interpersonal teacher behavior and students':

a) attitudes towards science

b) science achievement?

Research Question #4

Are there gender differences in student perceptions of teacher interpersonal behavior, attitudes, and achievement?

Chapter 2 reviewed literature relevant to the study in terms of the conceptual framework and the historical background of some learning environment instruments, with specific emphasis on the learning environment instrument, the QTI, used in this study. Finally, research in the areas of teacher-student interactions, gender differences, and student attitudes and achievement in science classrooms was reviewed.

In Chapter 3, the research design of the study was described, including the research methods used, description and identification of the sample, and how the data were analyzed. The selection of the two instruments (QTI and TOSRA) used in the study was discussed and, finally, methods of data analysis, including questionnaire validation procedures, were outlined.

Chapter 4 described the analyses of the data collected and the results obtained. These results included support for the reliability and validity of the QTI and TOSRA when used in middle-school science classes in South Florida. Results of analyses of associations between teacher-student interactions and student attitudes were reported. Finally, findings pertaining to gender differences in teacher-student interactions, student attitudes and student achievement were reported.

Chapter 5 now concludes this thesis by giving an overview of the entire thesis. In addition, major findings, contributions and limitations of the study are addressed. The final section suggests ways in which the findings of this study might be enhanced and/or extended in future research.

5.3 Major Findings of the Study

Research Question #1

Is the Questionnaire on Teacher Interaction (QTI) valid and reliable when used in science classrooms in South Florida?

The sample used in this study consisted of 1228 students in 47 science classes in one South Florida middle school. The QTI was administered to the students and the data were analyzed to check the validity and reliability of the QTI in terms of internal consistency reliability, pattern of interscale correlations, and the ability to differentiate between the perceptions of students in different classes.

The QTI scales were found to have satisfactory reliability, with alpha coefficients ranging from 0.51 to 0.83 for different scales when the individual was the unit of analysis and from 0.54 to 0.96 with the class mean as the unit of analysis. As with previous studies in the Netherlands, the USA and Australia (Rickards, 1998; Wubbels, 1993), it was found that the Helping/Friendly teacher behavior scale had one of the highest alpha coefficients and the Strict scale had the lowest reliability. The Leadership and Understanding scales also had high alpha coefficients. The internal consistency was also checked for the attitude scale and it was found to be satisfactory

The inter-scale correlations for two units of analysis (individual student and the class mean) were examined. It was found that adjacent scales correlated most highly and positively with each other, with the magnitude of the correlation decreasing as one moves and around the circumplex and the scales become increasingly different from each other. Opposite scales were found to have the highest negative correlation. For example, Helping/Friendly was highly and positively correlated with its two adjacent scales, Leadership (r=0.64) and Understanding (r=0.71), but was highly negatively correlated with the Dissatisfied scale (r=-0.51), which is directly opposite to it in the circumplex model (see Figure 2.3 of Chapter 2). These findings were consistent with those obtained by Wubbels et al. (1993).

A one-way ANOVA was used to check whether each scale of the QTI was able to differentiate between perceptions of students in different classes. The eta^2 statistic (i.e. the proportion of variance attributable to class membership) ranged from 0.02 to 0.25 for the different scales and was statistically significant (p<0.05) for seven of the eight scales, the exception being the Strict scale.

Research Question #2

Is an attitude scale modeled on the Test Of Science-Related Attitudes (TOSRA) reliable when used in science classrooms in South Florida?

For the 10-item modified TOSRA, the alpha reliability figure was 0.81 when the individual student was the unit of analysis and 0.93 when the class mean was used as the unit of analysis. These results suggest that the attitude scale used in this study is highly reliable when used with secondary science students in South Florida.

Research Question #3

Are there associations between the nature of interpersonal teacher behavior and students':

a) attitudes towards science

b) science achievement?

To answer Research Question #3, simple correlation and multiple regression analyses using two units of analysis (individual and class mean) were conducted. Simple correlation provides information about the bivariate association between each student outcome and each learning environment scale. The simple correlation between an environment scale and each student outcome (attitude and achievement) was statistically significant for at least one unit of analysis for all QTI scales for achievement and for all QTI scales except Student Responsibility and Strict for attitudes. This suggests that there is a positive association between student attitudes and achievement and more favorable teacher-student relationships.

A multiple regression analysis was conducted to gain insights into the joint influence of correlated learning environment scales on student outcomes. Both the individual and class mean were again used as the units of analysis. The multiple correlations between the eight learning environment scales and the students' attitudes was 0.45

when the individual student was the unit of analysis and 0.85 with the class mean as the unit of analysis. The multiple correlation coefficients obtained for the eight QTI scales and students' achievement was 0.30 for individual students and 0.78 for class means. The multiple correlations between the eight learning environment scales and each student outcome (attitudes and achievement) was statistically significant ($p<0.01$) for both the individual student and the class mean as the unit of analysis, suggesting a relationship between student outcomes and the set of scales assessing teacher-student interactions.

The standardized regression weights were examined to give information about the contribution of each learning environment scale to the variance in an outcome score when all the other learning environment scales were mutually controlled. The standardized regression weights (β) (shown in Chapter 4, Table 4.3) indicate that Leadership and Understanding behaviors were positive, significant, and independent predictors of students' attitudes when controlling for the other seven QTI scales with the individual student as the unit of analysis. There was also a positive, significant, and independent association between academic achievement and Helping/Friendly behavior at the individual level of analysis and Student Responsibility/Freedom behavior at the class mean level of analysis. Uncertain behavior was a negative, significant, and independent predictor of academic achievement with either the individual student or the class mean as the unit of analysis.

These findings indicate that students' attitudes were more positive when teachers exhibited more Leadership and Understanding behaviors. As expected, there was a negative association with the scales designated as having negative teacher-student interpersonal interaction such as Strict, Admonishing and Dissatisfied.

Overall, these results provide strong support for associations between student outcomes (attitudes and achievement) and student perceptions of teacher-student interactions and replicate the findings of previous studies (Goh & Fraser, 1998; Lee et al., 2003; Quek et al., 2005b; Rickards, 1998; Scott & Fisher, 2004; Wubbels, 1993).

Research Question #4

Are there gender differences in student perceptions of teacher interpersonal behavior, attitudes, and achievement?

Multivariate analysis of variance (MANOVA) was used to examine gender differences in teacher-student interactions, attitudes and achievement. The unit of analysis used for investigating gender differences was the within-class gender mean. Because males and females were not found in equal numbers in every class, the within-class gender mean was used to provide a matched pair of means – one within-class mean for male students and one within-class mean for female students. This reduces confounding in that there is a corresponding group of male and female students in the same classroom.

For the MANOVA, the eight QTI scales and attitude and achievement scores were used as the dependent variables and gender was the independent variable. Because the multivariate test yielded statistically significant ($p<0.01$) gender differences for the set of dependent variables overall using Wilks' lambda criterion, the univariate ANOVA was interpreted for each dependent variable individually.

Statistically significant ($p<0.05$) gender differences were found for three of the eight QTI scales (namely, Helping/Friendly, Dissatisfied and Admonishing) and for achievement. For these three QTI scales, female students had more positive perceptions than males in terms of more helpful, less dissatisfied and less admonishing behaviors on the part of their teachers. Also, the females had higher science achievement scores than did males. These results are consistent with those of Rickards (1998) who also found significant gender differences for the same three QTI scales, with females perceiving greater helping/friendly, lower dissatisfied, and lower admonishing teacher behaviors than males

The effect size was calculated to provide an index of the magnitude of the gender difference on each scale. For the three QTI scales that showed significant gender differences, the effect size ranged from 0.21 to 0.33 standard deviations, suggesting small to medium effect sizes according to Cohen's criteria (Cohen, 1988). These results suggest some moderately important gender differences in teacher-student interpersonal behavior. Furthermore, the effect size for achievement was larger (0.44) and suggested an educationally important difference in achievement between male and female students.

A summary of the major findings of this study is now given:

- The QTI and TOSRA showed satisfactory validity and reliability when used with a sample of middle-school science students in South Florida.

- There was a statistically significant simple correlation between the student outcomes of attitudes and achievement and most QTI scales.
- Leadership and Understanding behaviors were positive, significant, and independent predictors of students' attitudes when controlling for the other seven QTI scales with the individual student as the unit of analysis.
- There was a positive, significant, and independent association between academic achievement and Helping/Friendly behavior at the individual level of analysis and Student Responsibility/Freedom behavior at the class mean level of analysis.
- Uncertain behavior was a negative, significant, and independent predictor of academic achievement with either the individual student or the class mean as the units of analysis.
- Statistically significant gender differences were found for the Helping/Friendly, Dissatisfied and Admonishing scales of the QTI, with female students having more positive perceptions of these teacher behaviors than did male students.
- Female students had higher academic achievement scores than male students.

5.4 Contributions of the Study

5.4.1 Contributions to the Field of Learning Environments

This study is important because it provided further evidence of validity and reliability of the QTI when used specifically with middle-school science classes in South Florida (Research Question 1). These findings supporting the validity of the QTI are consistent with those found in studies conducted in other countries including the Netherlands (Wubbels & Brekelmans, 2006; Wubbels & Levy, 1993), Brunei (Scott

& Fisher, 2004) Singapore (Goh & Fraser, 1998; Quek, Wong & Fraser, 2005a, 2005b), Australia (Fisher, Henderson & Fraser, 1995; Fisher, Kent & Fraser, 1998) and Korea (Kim, Fisher & Fraser, 2000; Lee, Fraser & Fisher, 2003). Interestingly, as in past research (Wubbels, 1993), the QTI scale with the lowest reliability in my study in Florida was the Strict scale.

Analyses for Research Question #3 suggested that positive teacher-student interactions (more Leadership, Helping/Friendly and Understanding behaviors) were linked to improved attitudes and achievement. On the other hand, Uncertain, Dissatisfied and Admonishing behaviors were negatively related to attitudes and achievement. These results replicate those found in numerous past studies: for attitude outcomes among 543 Grade 8 science students in Korea (Kim, Fisher & Fraser, 2000); for a satisfaction outcome among 497 Grade 10 chemistry students in Singapore (Quek, Wong & Fraser, 2005a); for both liking of and achievement in mathematics among 1512 primary-school children in Singapore (Goh & Fraser, 1998); and for the outcomes of attitude to class, attitude to laboratory work, examination scores, and practical test performance for a sample of 489 Australian biology students (Henderson, Fisher & Fraser, 2000).

Analyses for Research Question #4 revealed gender differences in achievement and in Helping/Friendly, Dissatisfied and Admonishing behaviors. For these three QTI scales, female students had more positive perceptions of their teachers (i.e. more Helping/Friendly behavior and less Dissatisfaction and Admonishing behaviors) than did male students, as well as higher science achievement scores than male students.

Interestingly, Rickards (1998) also found significant gender differences for these same three QTI scales.

Numerous other past studied have reported statistically significant differences between males and females in terms of classroom perceptions when various learning environment instruments were used. Fraser, Giddings and McRobbie's (1995) study of Australian senior high school science laboratory classrooms suggested that females generally have more positive perceptions of their classroom learning environments than do males in the same classrooms. Similarly, in a study involving use of the QTI among 497 tenth grade chemistry students in Singapore, Quek, Wong and Fraser (2005a) reported that females reported more positive classroom environment perceptions than males in terms of teachers being more helpful/friendly, giving students more responsibility, and being less dissatisfied and strict. However, other past studies have revealed that males have more favorable perceptions than females on some learning environment dimensions. In a study involving 250 working adults undertaking computer application courses in Singapore, females perceived significantly higher levels of classroom equity whereas males perceived significantly greater class involvement (Khoo & Fraser, in press). In New York, Wolf and Fraser's (in press) study involving 1434 middle-school science students revealed that females perceived more student cohesiveness and cooperation, but less teacher support and investigation. In Korea, Kim, Fisher and Fraser (2000) found that males had significantly more favorable perceptions than did females on most scales of the WIHIC and QTI (except that females perceived that their teachers exhibited significantly less dissatisfaction and strict behaviors).

5.4.2 Implications for Improving Teaching and Learning

Cross-validation evidence for the QTI with the sample used in my study gives teachers in South Florida confidence in using it for practical purposes. In my classroom, the QTI could be used as an analytical tool to establish whether the same QTI scales (Leadership, Helping/Friendly and Understanding) that were linked to positive attitudes and increased achievement in the present study are consistent predictors of student outcomes over time from one year to another. At the school level, other science teachers could become teacher-researchers in their own classroom by administering the QTI as a pretest and a posttest to determine whether teachers' changing of their own teaching practices (to emphasize those behaviors associated with positive attitudes and increased achievement) does indeed lead to improved student outcomes.

When other teachers use the QTI, it will be practically important for them to interpret results for their own classrooms against a background of the average results emerging from prior studies. For example, Figure 4.2 provides a picture of the average pattern of teacher interpersonal behavior for my sample of teachers and classes in South Florida. For the four QTI scales with a positive connotation, high scores suggest that teacher interpersonal behavior is quite positive for the first three scales (Leadership, Helping/Friendly, and Understanding), whereas lower scores suggest only a moderately positive level of Student Responsibility/Freedom. For the four QTI scales with a negative connotation, low mean scores in Figure 4.2 again suggest positive teacher interpersonal behavior in terms of low Uncertain, Dissatisfied, Admonishing and Strict behaviors. Furthermore, the profile of average QTI scores in Figure 4.2 for my sample in South Florida is quite similar to the average QTI scores reported by

Wubbels (1993) for a sample of 792 students in 46 typical Grade 11 science and mathematics classes in Western Australia.

Unlike the findings of previous studies, this research revealed that female students had higher academic achievement than male students. This could indicate a reversal in the trend of lower academic achievement and gender inequity for females in science education, but further studies would be needed to replicate these results and to support this hypothesis. Teachers at my school could be asked to modify their interpersonal behaviors specifically with their male students who, according to my study, did not perceive their teachers as favorably as did female students. By implementing classroom practices that have been shown to improve teacher-student relationships for both male and female students, teachers are likely to be able to promote increased achievement for all students.

The consistent and positive associations found between student attitudes and achievement and most of the classroom environment scales assessed by the QTI is a further indication that creating positive classroom environments can contribute to improved students' attitudes toward and achievement in science. This suggests the desirability of teachers placing more emphasis on those interpersonal behaviors that could lead to an improvement in student attitudes and achievement and less emphasis on those behaviors that are negatively related to student outcomes.

Another finding of this study was that there was a tendency for female students to perceive the learning environment in a more positive way than did male students. Because no qualitative data were collected, it is difficult to identify specific reasons for this pattern of findings. It is possible that female students are more generous and lenient when rating their teachers. It is desirable that teachers make a conscious effort to examine their interactions with male and female students to see what differences exist and to take appropriate corrective measures so that all students perceive the classroom learning environment in a similar way.

5.5 Limitations of the Study

One of the main limitations to this study was that students in only one middle school were involved. Though the sample size was fairly large – 1228 students in 47 science classes – it was limited to only one school and therefore care has to be taken in extrapolating the results of this study to a broader group of middle schools in South Florida.

In this study, the measure of student achievement was the grade obtained by averaging all the assignments completed and graded during a nine-week period. In situations where assessment of academic achievement is required, the question becomes whether it should be by objective or subjective means. The quarterly grade tends to be a mix of both subjective and objective grading procedures and could vary from teacher to teacher. So, within a school, there could be a certain amount of non-comparability in grades obtained. In addition, the grade received could (and does) vary form one quarter to the next because very few students consistently obtain the same grade every grading period. Therefore the academic achievement grade for the same student can change from one grading period to the next.

A more ideal situation would be to combine standardized test scores, such as the Florida Comprehensive Achievement Test (FCAT), with the four quarterly grades to get a more representative picture of each student's achievement. Both standardized test scores and quarterly grades are used as a means of remediation, retention or promotion of students. As this was not done in this study, it is recommended that future studies implement more comprehensive methods for assessing academic achievement.

Another limitation to this study is the relatively low level of generalizability of findings. Care should be taken when extending these results to all schools in Miami-Dade County Public Schools where this study was conducted. In this county, there is a tiered systems of schools based on students' FCAT scores and the attainment by schools of several other goals, such as increased numbers of students attaining higher scores than in the previous year and increased percentages of students who improved their Reading and Mathematics scores.

When a school is given consecutive D or F grades, the state sets a very strict timetable in which teachers are told what to teach, when to teach it and even, in some cases, how to teach it. Under these circumstances, it would be fair to say that there is a certain amount of pressure on both students and teachers to produce acceptable results, namely, better FCAT scores. Such conditions might result in student perceptions of teacher-student interpersonal behavior that could elicit completely different types of responses from students in these classrooms. Because care must be taken in extending the results of this study to a wide range of middle schools and middle-school students, a larger number of schools should be included in future studies.

Denzin (1988) described the desirability for researchers to triangulate their research design by employing two or more methods or data sources to support their findings. More recently, Tobin and Fraser (1998) suggested the use of both quantitative and qualitative data in classroom environment research. Learning environment studies by Aldridge, Fraser and Huang (1999), Rickards and Fisher (1997), Lee, Fraser and Fisher (2003), She and Fisher (1998) and Waldrip and Fisher (2000) have successfully combined quantitative and qualitative research methods.

There was a distinct disadvantage in not collecting and analyzing qualitative data in this study. This was not possible mainly because the teachers in the study did not have the time to devote to interviews with students. They were all teaching for the entire school day and there was very little time to divert from instructional activities. I was promised substitute coverage, which involved a substitute teacher staying with my class so that I could go to other teachers' classes to conduct the interviews, but there were never enough substitute teachers to permit me to leave my classes. This study has produced the 'what' (possible answers) but not the 'why' (reasons behind the answers). Collection and analysis of qualitative data might have explained the gender differences found in students' perceptions of the learning environment and their attitudes to and achievement in science. Future research should include qualitative methods to possibly give a more accurate and total picture of the phenomena and research questions investigated in this study.

5.6 Recommendations and Suggestions for Future Research

This study provides a foundation which can be used for future research studies involving learning environments, gender and student outcomes. However, as mentioned in Section 5.5, this study was limited to one school and therefore future studies should include a wider range of schools.

As only the actual form of the QTI was used in this study, it might have been illuminating to compare actual and ideal perceptions of classroom learning environments. By comparing the actual and preferred perceptions of students, it might be possible to assess how close actual perceptions are to preferred perceptions for both male and female students. It is possible that female students have more positive attitudes because their actual and preferred perceptions are more congruent than those of male students.

It might be useful in future research to collect data at a range of grade levels so it can be determined whether gender differences vary with grade level and, if so, what variations occur at each grade level.

Finally, future studies should incorporate qualitative methods, such as structured interviews and other qualitative data-collection techniques, as suggested by Tobin and Fraser (1998). Qualitative methods could be used to check the validity of the quantitative responses to questionnaires, to explain and embellish relationships found with the quantitative information, and to furnish possible explanations for the gender differences found in teacher-student interactions.

5.7 Summary

This study has supported the validity and reliability of the QTI when used in middle-school science classes in South Florida. Statistically significant associations were found between student outcomes (attitudes and achievement) and most QTI scales. Once again, the results suggest that the classroom environment can influence student attitudes and achievement in a positive way. Overall, this study provided results which reinforce the findings of previous studies which found associations between students' perceptions of the classroom environment and their attitudes and academic achievement (Fraser, 1998a).

In general, female students had more positive perceptions of teacher interpersonal behavior and higher academic achievement than male students. These findings would suggest that female students are reversing the trend of male dominance in the science classroom, but more studies are needed to support this finding from one study.

There were several limitations to this study, the main one being that the study was confined to only one middle school. However, this should not negate the findings of this study because many of the results obtained replicated results from previous studies.

As stated in Chapter 1, this study started out as a personal mission to gain insights into the interpersonal interactions between my students and me. After completing this study, I believe that I am somewhat closer to getting a feel of the pulse of my students and possibly to improving my interpersonal relations with them. This study has made me realize that the truth lies somewhere in the middle of "Is it me or is it them?" The learning process depends as much on students' perceptions of my interpersonal behavior as it does on the interpersonal behaviors that I actually exhibit.

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Appendix 1

Questionnaire on Teacher Interaction

Student Questionnaire

This questionnaire asks you to describe the behavior of your teacher.

This is NOT a test

Your opinion has 48 statements about the teacher. For each sentence, circle the number corresponding to your response. For example:

	Never				Always
This teacher expresses himself/herself clearly.	0	1	2	3	4

If you think your teacher always expresses himself/herself clearly, circle the number 4. If you think your teacher never expresses himself/herself clearly, circle the number 0. You can choose the numbers 1, 2 and 3, which are in-between. If you want to change your answer, cross it out and circle a new number. Please answer all the questions. Thank you for your cooperation.

The questionnaire in Appendix 1 was developed by Wubbels (1993) and is discussed in Sections 3.4.1 and 4.2 of this thesis. It was used in my study with the author's permission.

Student ID ____________________Class: ___________
Teacher's Name: ___________________

		Never				Always
1.	This teacher talks enthusiastically about her/his subject.	0	1	2	3	4
2.	This teacher trusts us.	0	1	2	3	4
3.	This teacher seems uncertain	0	1	2	3	4
4.	This teacher gets angry unexpectedly.	0	1	2	3	4
5.	This teacher explains things clearly.	0	1	2	3	4
6.	If we don't agree with this teacher, we can talk about.	0	1	2	3	4
7.	This teacher is hesitant.	0	1	2	3	4
8.	This teacher gets angry easily.	0	1	2	3	4
9.	This teacher holds our attention.	0	1	2	3	4
10.	This teacher is willing to explain things again.	0	1	2	3	4
11.	This teacher acts as if she/he does not know what to do.	0	1	2	3	4
12.	This teacher is too quick to correct us when we break a rule.	0	1	2	3	4
13.	This teacher knows everything that goes on the classroom.	0	1	2	3	4
14.	If we have something to say, this teacher will listen.	0	1	2	3	4
15.	This teacher lets us boss her/him around.	0	1	2	3	4
16.	This teacher is impatient.	0	1	2	3	4
17.	This teacher is a good leader.	0	1	2	3	4
18.	This teacher realizes when we don't understand.	0	1	2	3	4
19.	This teacher is not sure what to do when we fool around.	0	1	2	3	4
20.	It is easy to pick a fight with this teacher.	0	1	2	3	4
21.	This teacher acts confidently.	0	1	2	3	4
22.	This teacher is patient.	0	1	2	3	4
23.	It's easy to make a fool out of this teacher.	0	1	2	3	4
24.	This teacher is sarcastic.	0	1	2	3	4
25.	This teacher helps us with our work.	0	1	2	3	4
26.	We can decide some things in this teacher's class.	0	1	2	3	4
27.	This teacher thinks that we cheat.	0	1	2	3	4
28.	This teacher is strict.	0	1	2	3	4
29.	This teacher is friendly.	0	1	2	3	4
30.	We can influence this teacher.	0	1	2	3	4
31.	This teacher thinks we don't know anything.	0	1	2	3	4
32.	We have to be silent in this teacher's class.	0	1	2	3	4
33.	This teacher is someone we can depend on.	0	1	2	3	4
34.	This teacher lets us fool around.	0	1	2	3	4
35.	This teacher puts us down.	0	1	2	3	4
36.	This teacher's tests are hard.	0	1	2	3	4
37.	This teacher has a sense of humor.	0	1	2	3	4
38.	This teacher lets us get away with a lot in class.	0	1	2	3	4
39.	This teacher thinks that we can't do things well.	0	1	2	3	4
40.	This teacher's standards are very high.	0	1	2	3	4
41.	This teacher can take a joke.	0	1	2	3	4
42.	This teacher gives us a lot of free time in class.	0	1	2	3	4
43.	This teacher seems dissatisfied.	0	1	2	3	4
44.	This teacher is severe when marking papers.	0	1	2	3	4
45.	This teacher's class is pleasant.	0	1	2	3	4
46.	This teacher is lenient.	0	1	2	3	4
47.	This teacher is suspicious.	0	1	2	3	4
48.	We are afraid of this teacher.	0	1	2	3	4

Appendix 2

Test of Science Related Attitudes (TOSRA)

Attitude Scale – Student

Student ID________________ Class____________

Teacher's Name ________________________

Directions:

This test contains a number of statements about science. You will be asked how often each practice takes place. There are no "right" or "wrong" answers. Your opinion is what is wanted.

For each statement draw a circle around:

1. If you DISAGREE with the statement
2. If you are NOT SURE about the statement
3. If you AGREE with the statement

The questionnaire in this appendix was developed by Fraser (1981) and is discussed in Sections 3.4.2 and 4.2 of this thesis. It was used in my study with the author's permission.

1.	I look forward to science lessons.	Disagree	Not Sure	Agree
2.	Science lessons are fun.	Disagree	Not Sure	Agree
3.	I enjoy the activities we do in science.	Disagree	Not Sure	Agree
4.	Science is one of the most interesting school subjects	Disagree	Not Sure	Agree
5.	I want to find out more about the world in which we live.	Disagree	Not Sure	Agree
6.	Finding out about new things is important.	Disagree	Not Sure	Agree
7.	I enjoy science lessons in this class.	Disagree	Not Sure	Agree
8.	I like talking to my friends about what we do in science.	Disagree	Not Sure	Agree
9.	We should have more science lessons each week.	Disagree	Not Sure	Agree
10.	I feel satisfied after a science lesson.	Disagree	Not Sure	Agree

Appendix 3

Student Permission Letter

Southwood Middle School Center for the Arts

Ms. Kristal B. Hickmon
Principal

Ms. Deborah Leal
Ms. Lisa Pizzimenti-Bradshaw
Mr. Alfred Sciabarassi
Assistant Principals

Mr. Gregory Beckford
Administrative Assistant

Ms. Bea Llano-Scherker
Magnet Lead Teacher

Miami-Dade County School Board
Dr. Michael M. Krop, Chair
Dr. Robert B. Ingram, Vice Chair
Mr. Agustin J. Barrera
Mr. Frank Bolanos
Mr. Frank J. Cobo
Ms. Perla Tabares Hantman
Ms. Betsy H. Kaplan
Dr. Marta Perez
Dr. Solomon C. Stinson
Mr. Merrett R. Stierheim
Superintendent of Schools

Mr. John F. Gilbert
ACCESS Center 5 Asssistant Superintendent

March 12, 2004

Dear Parent/Guardian:
Permission is requested for --------------------------------------- attending Southwood Middle School to participate in a research study. The purpose of the research is to evaluate the effect of middle school students' attitudes to science and their inter-relationship with their teacher and to correlate this data with their achievement in science. Participants will be asked to be involved in one or several of the following data collection methods:

- Completion of two pre- and post- attitudinal surveys
- Interviews
- Classroom observations
- Release of science academic grades

The pre- and post- attitudinal surveys will be administered in March and April. Small samples of students will be randomly selected for 5-10 minute interviews. This contact will be non-intrusive- it will not disrupt classroom lessons. The student sampling will not be identifiable and confidentiality will be maintained. Participation in this study will be beneficial in providing information about the effects of attitudes to science and the teacher and achievement in science. This will allow for teacher evaluation of interaction with students and the enhancement of teaching strategies that would lead to improved student achievement. Please indicate below whether you will give permission for your child to participate in this valuable research study and return it to your child's science teacher.
I will be the person responsible for this research. Should you have any questions, feel free to contact me by telephone at 305-251-5361 Extension 5218 or by email at leccles@dadeschools.net
Sincerely,
Lynette Eccles,
Science teacher
Southwood Middle School

YES, Permission is granted to participate

____
Parent/Guardian Signature

No, Permission is denied to participate

____
Parent/Guardian Signature