Science and Mathematics Education Centre

Evaluation of a Professional Development Program on Integrating Technology into Middle Schools: Classroom Environment and Student Attitudes

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DECLARATION

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

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Date: July 2008

ABSTRACT

The Alliance+ project is a teacher professional development program that integrates technology into mathematics and science lessons. The effectiveness of this innovative program was evaluated in terms of students' perceptions of the classroom learning environment and their attitudes towards science/mathematics. The sample consisted of 759 students of seven mathematics/science teachers (four Alliance+ participants and three non-participants) in one middle school in Miami-Dade County, Florida. The students responded to learning environment scales based on the Constructivist Learning Environment Survey (CLES) and the What Is Happening In this Class? (WIHIC) questionnaires to assess their perceptions of the classroom learning environment. Additionally, they responded to an attitude scale modeled on the Test Of Science-Related Attitudes (TOSRA) to assess their attitudes towards mathematics/science.

It was found that Alliance+ teachers were more successful than the non-Alliance+ teachers in promoting a classroom environment with more cooperation among students during the science/mathematics lessons. Additionally, Alliance+ professional development model was differentially effective for mathematics and science teachers in terms of three learning environment scales (namely, Teacher Support, Cooperation, and Critical Voice), but not in terms of students' attitudes to science. In terms of Cooperation, Alliance+ teachers were more effective than non-Alliance+ teachers for mathematics, but comparable in effectiveness to non-Alliance+ teachers for science. For Critical Voice, Alliance+ teachers were slightly more effective than non-Alliance+ teachers for mathematics, but considerably less

effective than non-Alliance+ teachers for science. In terms of Teacher Support, Alliance+ were less effective than non-Alliance+ teachers for science, but comparable in effectiveness to non-Alliance+ teachers for mathematics.

However, teachers who did not participate in the Alliance+ project were more effective than the teachers who participated in the Alliance+ project in providing a positive learning environment in which the students perceived more teacher support and in promoting positive attitudes towards science/mathematics. Qualitative data results revealed that the Alliance+ teachers had not received sufficient support from their school administrators and Alliance+ trainers and lacked the resources that were necessary for them to implement the project successfully, which could possibly be an explanation for the quantitative results in favor of the non-Alliance+ teachers.

This study also investigated outcome-environment associations. It was found that associations existed between students' attitudes towards science/mathematics and their perceptions of the classroom leaning environment (especially personal relevance, teacher support, and cooperation).

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INTRODUCTION AND BACKGROUND

1.1 Introduction to Chapter 1

Today the trend in education is from traditional four-walled classrooms to the more common use of the Internet as an extension of the classroom. The American Council on Education makes a compelling case that the preparation and development of the nation's teachers must improve to better meet the challenges of this growing trend (Boggs, 2000).

Because teachers are the linchpins of success for students, their individual requirements for mastering new methods, knowledge, and techniques deserve particular attention. Professional development programs should be tailored to help teachers to ensure that technology is brought to the learning environment as a valuable tool for creativity, collaboration, and innovation (CEO Forum on Education & Technology, 1999). The present study evaluated the efficacy of an innovative professional development program that integrates technology into mathematics and science education.

This chapter is organized into specific areas to give a well-rounded foundation for understanding the nature of this study. In Section 1.2, the context of Miami-Dade County Public Schools is described. The background that led to the present study is discussed in Section 1.3. Section 1.4 discusses the significance of this study. Section

1.5 describes the purpose of this study, and the research questions are delineated in Section 1.6.

1.2 Context of Miami-Dade County Public Schools

The present study consisted of surveying students in the Miami-Dade County Public Schools (M-DCPS) system in Florida, USA. M-DCPS is the largest school district in the state of Florida and the fourth largest in the United States with a student enrollment of 414,128 as of February 15, 2007. The district is also the second largest minority public school system in the country, with 60% of its students being of Hispanic origin, 28% African American, 10% White, and less than 3% non-white of other minorities (Miami-Dade County Public Schools, 2006).

This study was conducted in one middle school in the M-DCPS district (for further information about the participating middle school, refer to Section 3.3). The purpose and function of the middle school in the U.S. is to create an arena that meets the intellectual, social, emotional, and physical-developmental needs of the young adolescent (Clark & Clark, 1993).

Teachers in M-DCPS's middle schools are all governed by Florida's Sunshine State Standards. The Department of Education began developing the Sunshine State Standards in 1994 and finalized them in the spring of 1996. Schools were to implement them during the 1996–1997 school year (Miami-Dade County Public Schools, 2001). The Sunshine State Standards were approved by the State Board of Education to provide expectations for student achievement in Florida. The standards approved were written in seven subject areas: language arts, foreign languages, mathematics, science, physical education, the arts, and social studies. None of the original standards included technology. In the description of each set of objectives, technology was discussed by one line that read “Technology is available for students to develop competencies” (Miami-Dade County Public Schools, n.d.). When Florida teachers were given their curriculum packages at the beginning of the year, they were given the Internet address to four web sites and instructed by the guidelines to integrate technology into the classroom. In M-DCPS, all middle-school teachers must adhere to the federal, state, and district standards and curriculum guidelines. Each activity in a teacher’s lesson plan must correspond to one of the standards and be so designated (Miami-Dade County Public Schools, n.d.).

1.3 Background of This Study

The Internet has become an integral part of everyday life. Advertisements suggest that ordering products through .com addresses, voting electronically via touch screen, and even banking and bill paying can be accomplished online. Education in today’s classrooms must reflect the changes in technology in society in order to stimulate student learning and interest. Thus, today, teachers are required to integrate technology into the curriculum. The National Council for Teachers of Mathematics (NCTM) and the American Association for the Advancement of Science (AAAS) are mandating standards for their respective curricula (Soloway, Becker, Norris, & Topp, 2000).

The Alliance project was developed in an attempt to integrate computer technology into mathematics and science curricula in U.S. schools (Friedman, 1998, 1999, 2001; Kirshstein, Birman, Quinones, Levin, Stephens, & Loy, 2000). It began as a three-year (1997–2000) program with a grant received by the Stevens Center for Improved Engineering and Science (CIESE) directed by the Stevens Institute of Technology (SIT) in New Jersey. Stevens is a small private technological university that was founded in 1870. Stevens does not have a teacher education program. It has been an innovator in the application of computers and information technology in the education of scientists and engineers for more than 20 years. The CIESE was established in 1988 by SIT to bring computer education expertise to teachers and school systems (Friedman, 1999).

Since 1994, CIESE has been a pioneer in the development of Internet-based lessons that exploit the unique and compelling aspects of this technology. The terms unique and compelling at CIESE define the various ways in which their teachers teach Internet integration. The methods of real-time data acquisition, participation in online collaborative projects, and creating a web site are some of the methods used when CIESE documents refer to unique and compelling tools. Focusing on the use of real-time data and global telecollaborative initiatives, the projects introduced to teachers through CIESE's many programs engage students in authentic science investigations in which they perform experiments, collect and record real data, make predictions and, in effect, become real scientists. Through e-mail and other web-based forums, students are able to communicate and collaborate with other students and scientists around the world.

In 1998, the Alliance project was expanded as a five-year award from the U.S. Department of Education for $9.3 million. Matched funds were then added to the $9.3 million by the public school systems. Funding by a U.S. Department of Education Office of Educational Research and Improvement grant and a U.S. Department of Education Fund for the Improvement of Education grant reformed the Alliance project to what became the Alliance+ project. Five schools across the United States were chosen to become part of the Alliance+ project. Enough computers were donated to each participating school to allow at least one class to provide each student with a computer in the classroom and at home. The teachers participating in the program also received computers for classroom and home use.

During the second year of the Alliance + project, the concentration was on the middle school population. It was not until 2000 that an independent Alliance+ curriculum was designed for the elementary level. The high school version is still under development. It was decided by the U.S. Department of Education that research on the projects would involve assessing the changes made during the study to best meet the needs of middle-school teachers to integrate technology in a systematic, time-efficient, productive, and continuing manner (Kirshstein et al., 2000).

There were no teaching or curriculum requirements. Teachers chose how and when they wanted to incorporate the computers into their daily schedules (Huang, Ring, Toich, & Torres, 1998). It was decided that the Alliance+ project would follow the methodology and constructivist pedagogy of the Apple Classroom of Tomorrow (an ongoing project that investigated the role of computers in education), but it added the component of ongoing independent evaluation, modification, and follow-through after training.

The key partners in the Alliance+ project were the League of Innovations in the Community Colleges; Maricopa Community College in Phoenix, Arizona; Miami-Dade Community College, Miami, Florida; Cuyahoga Community College, Cleveland, Ohio; and neighboring school systems in Miami, Cleveland, and Phoenix.

These community colleges committed to collaborate with neighboring schools to create trainers to train other teachers in the integration of technology into K–12 science and mathematics curriculums and other disciplines. The goal of Alliance+ was to provide approximately 10,000 teachers with 30 hours of hands-on training during the five years of the program (Friedman, 1998, 1999).

Teacher training in the Alliance+ project involved workshops, lectures, video-conferencing, hands-on activities, participation in online collaborative projects, Internet correspondence, and a listserv. The various sites associated with the Alliance+ project differed in location, time allocations, and the learning styles of the instructors. Miami-Dade Community College in Miami, Florida, which was one of the key partners of the Alliance+ project, provided training for participating teachers in the Miami-Dade County Public Schools (M-DCPS) system. The M-DCPS mathematics and science teachers who were trained under the Alliance+ project attended 10 workshops at which they were taught principles of web development, cooperative learning, and PowerPoint presentation and were given access to online collaborative units around the world. They were also taught techniques for improving their classroom learning environment. An extension of the Alliance+

project consisted of encouraging teachers and students to design projects that would be displayed online to share with other teachers and students around the world.

The Alliance+ project was chosen for evaluation because of its substantial use of multiple teaching strategies aimed at assisting teachers to learn about the integration of technology into curricula and change students' attitudes towards mathematics and science through the introduction of constructivist curriculum methods. A great source of data were used to evaluate the effectiveness of the program including written communication, project reports, minutes of meetings, letters, interviews, observations, and teacher and student surveys during its early years of implementation (Biggs & Fraser, 2006; Yepes-Baraya & Biggs, 2001).

Data gathered from 530 teachers from 53 middle schools within a year of participation in the project were generally positive. During interviews with teachers, it was found that teachers believed in the program and felt that Internet resources added excitement to their lessons and created motivation for their students towards science and mathematics (Yepes-Baraya & Biggs, 2001).

Observations in the science classrooms demonstrated that constructivist techniques were implemented by the teachers during lessons. Furthermore, teachers were observed playing the role of facilitator, which is a very important aspect of constructivist methodology. It was also observed that students were generally more involved in learning, spent more time on task, cooperated more with their classmates, and were more involved in the decision-making process, such as choosing media and resources for the classroom lessons. However, in the mathematics classrooms, it was observed that very little change had occurred in the instructional methods being utilized and that the level of computer usage had not changed. It was also observed that rote-learning predominated active learning in the mathematics classrooms (Yepes-Baraya & Biggs, 2001).

Based on student surveys and interviews conducted during the early stages of the Alliance+ project, it was found that students frequently felt more interested in the subject as a result of participating in lessons that were constructivist in nature. In addition, many students and teachers alike were eager and willing to participate in online activities suggested by the Alliance+ training team.

Because most of the research on the effectiveness of the Alliance+ project was conducted during early implementation stages of the program, there was no evidence of its long-term effect. Having been involved in the early training and evaluation stages of the project myself and realizing the amount of time and resources that had been invested in the project, I chose to evaluate the effectiveness of the Alliance+ professional development model two years after the program had ended. Thus, this became the main goal of the present doctoral study.

Having concluded that it was important to evaluate the long-term effectiveness of the Alliance+ project, the subsequent task was to determine the criteria that would be used in the evaluation process. A key aim of the Alliance+ project had been to provide resources and train mathematics and science teachers to optimize the use of technology in the classroom and to implement constructivist-like lessons. It had been hypothesized that creating that type of learning environment would spark students' interest and attitudes towards science and mathematics. As was mentioned earlier, that seemed to be the case at the onset of the project based on teacher and student interviews and observations. Consequently, it seemed productive to evaluate the long-term effectiveness of the Alliance+ project in terms of teachers' students' perceptions of their classroom learning environments and their attitudes towards science/mathematics. The literature about the study of learning environments provided strong support for this decision.

Within the last 30 years, researchers have discovered the significance that learning environments have for student learning and retention. The field of learning environments has become well established in the educational research journals, with many studies being conducted throughout the world (Fraser, 1994, 1998a, 2007; Fraser & Walberg, 1991).

Learning environments often are evaluated by measuring the shared perceptions of the students and teachers in a specific environment (Fraser, 1994). In order for active learning to occur, the classroom environment must be equally comfortable and nourishing for the student and the teacher. Many methods have been used in studies that have been conducted worldwide into the concept, utilization, assessment, and investigations of learning environments. One common method is the use of economical, valid, and widely-applicable questionnaires for assessing student perceptions of the classroom environment (Fraser, 1998a, 1998b).

The literature shows that classroom environment instruments have been useful in assessing the effectiveness of educational innovations in terms of students' perceptions of their learning environment. One example is the early study involving the Australian Science Education Project (ASEP), which was evaluated in terms of secondary science students' perceptions of their classroom learning environment (Fraser, 1979). In another study, the Geography Classroom Environment Inventory (GCEI) questionnaire was developed and used to evaluate the effectiveness of a computer-assisted learning program in Singapore (Fraser & Teh, 1994). This study consisted of administering the questionnaire to secondary geography students to gather their perceptions of the classroom environment after participating in the computer-assisted learning program. This study also involved the collection of achievement and attitudinal data for evaluating the program. Several other studies have used students' perceptions of their classroom learning environment as a criterion to evaluating the effectiveness of an innovative teaching approach or program (Khoo & Fraser, 2008; Lightburn & Fraser, 2007; MacDowell-Goggin & Fraser, 2004; Mink & Fraser, 2005; Peiro & Fraser, 2005; Spinner & Fraser, 2005).

1.4 Significance of This Study

Technology has become an integral part of the education and commerce arenas. Today's workforce must be computer literate. Many high schools require every student to pass a computer literacy examination before graduation. Schools must prepare students for the society in which they live. To do so, teachers must be competent in the use of technology in teaching and learning, as well as being able to create a learning environment conducive to students' learning.

Professional development is required in the United States to maintain and renew teacher certification. But, how that professional development leads to improvement in the learning environment of these teachers' schools classrooms is seldom evaluated. Although there are many learning environment studies, few focus on evaluating professional development (Fraser, 1998b; Pickett & Fraser, 2004). The present study will be among the pioneers in this area. It is time to study the learning environment as a whole.

The American Council on Education makes a compelling case that the preparation and development of teachers must improve (Boggs, 2000). The question of how to use the Internet most appropriately in instruction is a constant concern (Friedman, 1999). Most teachers are in their 40s or 50s and were poorly trained in technology skills, if at all, and thus have no standards by which to teach (Ducharme & Ducharme, 1999). In some cases, school systems are providing teachers with training. However, in many scenarios, the systems are too small to be able to grapple effectively with the challenges of technology in education. Larger school systems have problems due to bureaucracy or social and behavioral problems (Friedman, 1999). Rowe (1999) observed that, in the rush to use technology, professionals have not been fully trained. The training has to include familiarity with the technology and how to 'teach' or deliver the material. The Alliance+ project used the resources of public schools and the community college teacher training programs to unify and jointly tackle these problems even though the use of technology varied between classes (Friedman, 1999). Thus, evaluating the effectiveness of the Alliance+ project in the present research study is significant.

It is also potentially significant that the findings of the present study might show the needs and desires of middle school teachers in reference to integrating technology into their daily curriculum and having a comfort level for both students and teachers in the classroom. This study is likely to benefit middle school teachers, trainers, and developers who are striving to make training activities and environments more exciting and meaningful. Not only was the use of technology looked at; but, after a lapse of time after the workshops, the quality of teaching also was investigated from the perspective of the learning environment and students' attitudes towards science and mathematics.

1.5 Purpose of This Study

The purpose of this study was to evaluate a design for improved professional development for middle-school teachers in terms of their students' attitudes and classroom environment perceptions. Secondary research questions involved validating a learning environment questionnaire based on scales from the Constructivist Learning Environment Survey and the What Is Happening In this Class? questionnaire and an attitude scale modeled on the Test Of Science-Related Attitudes, as well as investigating attitude-environment associations.

The main and unique purpose of the present study was to compare the attitudes and learning environment perceptions of students taught by teachers who have been through the Alliance+ professional development workshops relative to students taught by teachers who have not had the experience.

1.6 Research Questions

The following four research questions were investigated:

Research Question # 1

> *Are learning environment scales based on the CLES and WIHIC and an attitude scale based on TOSRA valid when used with this sample of middle-school students?*

Research Question #2

> *Is the Alliance+ professional development model effective in terms of middle-school students':*
>
> *a) perceptions of classroom learning environment*
>
> *b) attitudes to science/mathematics?*

Research Question #3

> *Is the Alliance+ professional development model differentially effective for mathematics and science teachers in terms of middle-school students':*
>
> *a) perceptions of classroom learning environment*
>
> *b) attitudes to science/mathematics?*

Research Question #4

> *Are there associations between students' attitudes to science/mathematics and their perceptions of classroom learning environment?*

1.7 Overview of the Chapters of this Study

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

Chapter 2 comprehensively reviews literature on areas related to this study. First, the literature review provides insights into historical and qualitative studies. Then, it provides information about the development, history, and validation of instruments for measuring learning environments. Chapter 2 also gives a comprehensive overview of literature devoted to the assessment of students' attitudes, as well as a history of computers and grants related to professional development.

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

Chapter 4 presents the results of this study. It provides results pertinent to the validation of the instruments that were used to assess students' perceptions of their learning environments and attitudes towards science/mathematics. In Chapter 4, I also report, in terms of students' perceptions of their classroom learning environments and their attitudes towards science/mathematics, results for the effectiveness of the Alliance+ professional development program and for the differential effectiveness of Alliance+ for science and mathematics teachers. Finally, results for associations betweens students' perceptions of their classroom learning environment and their attitudes towards science/mathematics are reported.

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

Chapter 2

REVIEW OF THE LITERATURE

2.1 Introduction to Chapter 2

The teacher cannot create a positive learning environment unless he/she is first aware of what that environment looks and feels like to students and how they react to it (Friedman, 1999). This thesis discusses ways in which to train the seasoned teacher to be aware of his/her own environment through their students' perceptions while integrating technology into the classroom curriculum.

Teachers have voiced feelings of not being trained adequately enough to teach and/or integrate technology into the curriculum. Another concern of teachers has been the thought that, if they are uncomfortable when teaching, then the class environment will also be unsteady or uncomfortable for the students (Yepes-Baraya, 1999). Teachers are correct in feeling that it is not a waste of time to devote energy and knowledge to improve the classroom environment (Fraser, 1999). Teachers, however, resent being taught how to improve their own classrooms and to add new teaching strategies to the curriculum. This in itself is a contradiction; teachers want good classroom environments, but they do not want to take the time to learn how to make that happen or to add new facets to the curriculum (Yepes-Baraya, 1999). Many teachers have already spent 20,000 hours in educational institutions by the time they are put in charge of a classroom of their own (Fraser, 2001). Most of today's teachers were taught strategies and classroom environment techniques (behavior management, setting placement, etc.) before the advent of computers in the classroom. Yet, they are being required to integrate technology into science and mathematics curricula.

An initial review of literature reveals that the last 20 years have seen limited attention to the attitudes, educational styles, the nature of the classroom environment, and the instructional methods of teachers (Putnam & Borko, 2000). Also, there is a relatively small amount of literature dealing with the effectiveness of methods used for teaching educators new techniques for enriching the classroom environment. An enduring research void exists despite the growing need to have technology-literate educators for students. Much of the literature that exists point to the reasons behind teachers' reluctance to use technology in the classroom rather than to find methods to ease reluctance (Boyd, 1997). The reluctance seems to stem from a perception of negativity towards computer classes and computer laboratory experiences.

This literature review is organized into specific topics that are central to the problem being investigated in this thesis. The literature review includes information about the history of the field of learning environments (Section 2.2), learning environments instruments (Section 2.3), past learning environments studies (Section 2.4), assessment of learners' attitudes (Section 2.5), history of computer use in the classroom (Section 2.6), and an overview of education grant projects (Section 2.7).

2.2 Historical Background of Learning Environments

Over the past 30 years, the importance of learning environment studies has been increasingly recognized. Progress in research and assessment techniques has broadened the concept (Fraser, 1994, 2007; Fraser & Walberg, 1991). In the beginning, learning environments were studied through observation techniques and the perceptions of the viewer. This field of study began with the work of Herbert Walberg and Rudolf Moos who studied participants' perceptions of various learning situations (Moos, 1974, 1979). Studies of the learning environment and its effects on student outcomes began in the 1960s. During that era, Herbert Walberg and Rudolf Moos began the early development of learning environment assessment tools which would later become the foundation of the field of learning environments as we know it today. The first developmental study began in 1968 as part of the evaluation activities of Harvard Project Physics (Walberg, 1979).

The first social climate scales were developed by Moos in 1968 (Moos & Houts, 1968) for use in psychiatric hospitals and correctional institutes. This led to the development of the widely-known Classroom Environment Scale (Moos & Trickett, 1974). Moos (1974) developed a theory of sorting human environment dimensions into three areas: relationship, personal development, and system maintenance and system change.

Through the early work of these researchers, the foundation for studying classroom learning environments was laid. Further studies, books and journal articles on the subject have helped to bring the topic to worldwide attention and established it to be an important concept to study (Fraser, 1990, 1998b, 2001, 2007; Fraser & Walberg, 1991; Walberg & Anderson, 1968).

Over the past few decades, the study of learning environments has reached the attention not only of researchers but also teachers, school administrators and administrators at the school district level. Because of this sudden awareness, more instruments have been developed.

2.3 Learning Environment Instruments

Various learning environments instruments have been created since the early 1960s. The questionnaires are suitable for a variety of grade levels and subject areas. This section reviews the creation, validation, and uses of the questionnaires that are currently available for researchers and educators to measure students' learning environment perceptions. In Section 2.3.1, I provide an overview of eight learning environment questionnaires. A more detailed description is provided below for two instruments that I selected from the eight questionnaires for my research study. The development and validation of the Constructivist Learning Environment Survey (CLES) and the What Is Happening In this Class? (WIHIC) are discussed in Sections 2.3.2 and Section 2.3.3, respectively.

2.3.1 Overview of a Variety of Questionnaires

Teachers have a major effect on the learning environment in the classroom; they can promote a positive or negative atmosphere among their science or mathematics students. The environment of the classroom influences students' success (Fisher & Waldrip, 1999; Fraser, 2007).

Over the past several decades, a variety of widely-applicable questionnaires have been developed for assessing student perceptions of the learning environment (Fraser 1998a, 1998b, 2007). Literature traces the development of these questionnaires through conceptualization, assessment, and validation. Pertinent to my study were a number of studies conducted to validate the WIHIC and CLES two questionnaires for assessing students' perceptions of the learning environment (Aldridge, Fraser, Taylor, & Chen, 2000; Chionh & Fraser, in press; Huang, Fraser, & Aldridge, 1998; Kim, Fisher, & Fraser, 1999; Ogbuehi & Fraser, 2007).

Survey instruments have been widely used in collecting data on perceptions in the learning environment field. In the late 1960s, Walberg (1976) and Moos (1968), though working independently of each other, formed the foundation of current learning environment research. Walberg (1976) focused on the notion that psychology is a science of mental life and that a key aspect of mental life is perception. Walberg realized that surveying students' perceptions was a valid method for measuring teacher effectiveness. It was also cost-effective and less time-consuming than classroom observations. Walberg developed the Learning Environment Inventory (LEI) as part of research and evaluation activities of Harvard Project Physics (Anderson & Walberg, 1968; Walberg, 1976; Walberg & Anderson, 1968) and was influenced by the theoretical writings of Getzels and Thelen (1960) who viewed the class as a social system. Walberg (1976) also postulated that "students' perceptions, as partakers of classroom social transaction, are of great value, and it is easy enough (and incrementally valid) to ask the students for them" (p. 159).

Moos (1974) was interested in the underlying dimensions of social climates. Moos researched the perceptions of the members of the environment as well as the well-being of the participants. Moos's (1974) social climate scales were developed for use in hospital wards, juvenile and adult correctional facilities, residential care settings, therapeutic groups, sheltered workshops, work settings, families and classrooms. Moos (1986) designed an instrument, the Work Environment Scale (WES), whose scales are also appropriate for examining the dimensions of school environments. Moos’s instruments were designed to gather data on the key dimensions of Personal Growth, Relationship, and System Maintenance and Change. Data gathered through the use of the WES were able to shed light on staff involvement, peer cohesion, supervisor support, autonomy, work pressure, clarity, control, innovation and physical comfort (Moos, 1986).

This part of the review discusses some of the various instruments developed and validated over the years. Those used most often are reviewed in Table 2.1. The table identifies the instrument, year of development, and classification of the scales according to Moos’s dimensions of human environment (Moos, 1974). Moos’s dimensions are: Relationship; Personal Development; and System Maintenance and System Change. Relationship dimensions refer to the kind and strength of the personal relationships in the environment, the degree of people’s involvement in the environment and the assistance given to each other. Personal Development dimensions measure the fundamental path of personal growth and self-enrichment. System Maintenance and System Change dimensions measure the degree of orderliness, control and responsiveness to change in the environment. Knowledge of the scales is important to this study for appreciation of the evolution and significance of the instruments and for guiding choices of scales to use in this study.

As part of this study, it was important to know the variety of instruments available and to choose an ideal instrument for answering the research questions of this study. The most common instruments used today are described in more detail later.

The initial development and validation of a preliminary version of the *Learning Environment Inventory* (LEI) began in the late 1960s in conjunction with the evaluation and research related to Harvard Project Physics (Fraser, Anderson, & Walberg, 1982; Walberg & Anderson, 1968). The final version contains a total of 105 statements (or seven per scale) descriptive of typical school classes. The respondent expresses degree of agreement or disagreement with each statement using the four response alternatives of Strongly Disagree, Disagree, Agree and Strongly Agree. The scoring direction (or polarity) is reversed for some items. A typical item in the Cohesiveness scale is "All students know each other very well" and in the Speed scale is "The pace of the class is rushed".

The *Classroom Environment Scale* (CES) was developed by Rudolf Moos at Stanford University (Fisher & Fraser, 1981; Moos, 1979; Moos & Trickett, 1987) and grew out of research involving perceptual measures of a variety of human environments including psychiatric hospitals, prisons, university residences and work milieus (Moos, 1974). The final published version contains nine scales with 10 items of True–False response format in each scale. Published materials include a test manual, a questionnaire, an answer sheet and a transparent hand scoring key. Typical items in the CES are “The teacher takes a personal interest in the students” (Teacher Support) and “There is a clear set of rules for students to follow” (Rule Clarity).

The *Individualized Classroom Environment Questionnaire* (ICEQ) focuses on the areas of the environment that make it differ from conventional classrooms. The initial development of the ICEQ (Rentoul & Fraser, 1980) was guided by: the literature on individualized open and inquiry-based education; extensive interviewing of teachers and secondary school students; and reactions to draft versions sought from selected experts, teachers and junior high school students. The final published version of the ICEQ (Fraser, 1990) contains 50 items altogether, with an equal number of items belonging to each of the five scales. Each item is responded to on a five-point scale with the alternatives of Almost Never, Seldom, Sometimes, Often and Very Often. The scoring direction is reversed for many of the items. Typical items are “The teacher considers students' feelings” (Personalisation) and “Different students use different books, equipment and materials” (Differentiation). The published version has a progressive copyright arrangement which gives permission to purchasers to make an unlimited number of copies of the questionnaires and response sheets.

The LEI was simplified to form the My Classroom Inventory (MCI) for use among children aged 8–12 years (Fisher & Fraser, 1981; Fraser et al., 1982; Fraser & O'Brien, 1985). Although the MCI was developed originally for use at the primary school level, it also has been found to be very useful with students in the junior high school, especially those who might experience reading difficulties with other instruments. The MCI differs from the LEI in four important ways. First, in order to minimize fatigue among younger children, the MCI contains only five of the LEI's original 15 scales. Second, item wording has been simplified to enhance readability. Third, the LEI's four-point response format has been reduced to a two-point (Yes–No) response format. Fourth, students answer on the questionnaire itself instead of on a separate response sheet to avoid errors in transferring responses from one place to another. The final form of the MCI contains 38 items altogether, with typical items being “Children are always fighting with each other” (Friction) and “Children seem to like the class” (Satisfaction). Although the MCI traditionally has been used with a Yes–No response format, Goh, Young, and Fraser (1995) have successfully used a three-point response format (Seldom, Sometimes and Most of the Time) with a modified version of the MCI which includes a Task Orientation scale.

Majeed, Fraser and Aldridge (2002) reported a study of lower secondary mathematics classroom learning environment in Brunei Darussalam and its association with students’ satisfaction with learning mathematics among a sample of 1565 students from 81 classes in 15 government secondary schools. Students’ perceptions of the classroom learning environments were assessed with a version of the MCI that had been modified for the Brunei context. The study revealed a satisfactory factor structure for a refined three-scale version of the MCI assessing cohesiveness, difficulty and competition, which is noteworthy because the factorial validity of the MCI had not previously been established in past research in other countries. Also each scale displayed satisfactory internal consistency reliability and discriminant validity and was able to differentiate between the perceptions of students in different classes. In England, Sink and Spencer (2005) administered the MCI to more than 2800 upper-elementary students. They evolved a psychometrically-sound 18-item version with four scales (cohesion, competition, friction and satisfaction), and drew out implications for using the revised version of the MCI for school counselling programs and practice.

Although some notable prior work had focused on the institutional-level or school-level environment in colleges and universities (Halpin & Croft, 1963; Stern, 1970), surprisingly little work has been done in higher education classrooms. Consequently, the (CUCEI) was developed for use in small classes (30 or fewer students) sometimes referred to as 'seminars' (Fraser & Treagust, 1986; Fraser, Treagust, & Dennis, 1986). The final form of the CUCEI contains seven seven-item scales. Each item has four responses (Strongly Agree, Agree, Disagree, Strongly Disagree) and the polarity is reversed for approximately half of the items. Typical items are “Activities in this class are clearly and carefully planned” (Task Orientation) and “Teaching approaches allow students to proceed at their own pace” (Individualization).

During these times, research in The Netherlands focused on the nature and quality of interpersonal relationships between teachers and students (Créton, Hermans, & Wubbels, 1990; Wubbels, Brekelmans, & Hooymayers, 1991; Wubbels & Levy, 1993). Drawing upon a theoretical model of proximity (cooperation–opposition) and influence (dominance–submission), the Questionnaire on Teacher Interaction (QTI) was developed to assess student perceptions of eight behaviour aspects. Each item has a five-point response scale ranging from Never to Always. Typical items are “She/he gives us a lot of free time” (Student Responsibility and Freedom behavior) and “She/he gets angry” (Admonishing behavior).

Although research with the QTI began at the senior high school level in The Netherlands, cross-validation and comparative work has been completed at various grade levels in the USA (Wubbels & Levy, 1993), Australia (Fisher, Henderson, & Fraser, 1995), Singapore (Goh & Fraser, 1998; Quek, Wong, & Fraser, 2005), Korea (Kim, Fisher, & Fraser, 2000) and Brunei (Riah, Fraser, & Rickards, 1997; Scott & Fisher, 2004), and a more economical 48-item version has been developed and validated (Goh & Fraser, 1996). Also, Creswell and Fisher (1997) modified the QTI to form the *Principal Interaction Questionnaire* (PIQ) which assesses teachers' or principals' perceptions of the same eight dimensions of a principal's interaction with teachers.

Because of the critical importance and uniqueness of laboratory settings in science education, an instrument specifically suited to assessing the environment of science laboratory classes at the senior high school or higher education levels was developed (Fraser et al., 1995; Fraser & McRobbie, 1995; Fraser, McRobbie, & Giddings, 1993). The Science Laboratory Environment Inventory (SLEI) has five scales (each with seven items) and the five response alternatives are Almost Never, Seldom, Sometimes, Often and Very Often. Typical items are "I use the theory from my regular science class sessions during laboratory activities" (Integration) and "We know the results that we are supposed to get before we commence a laboratory activity" (Open-Endedness). The Open-Endedness scale was included because of the importance of open-ended laboratory activities often claimed in the literature (Hodson, 1988). The SLEI was field tested and validated simultaneously with a sample of over 5,447 students in 269 classes in six different countries (the USA, Canada, England, Israel, Australia and Nigeria), and cross-validated with 1,594

Australian students in 92 classes (Fraser & McRobbie, 1995), 489 senior high school biology students in Australia (Fisher, Henderson, & Fraser, 1997) and 1,592 grade 10 chemistry students in Singapore (Wong & Fraser, 1995).

The SLEI has been used in a recent study conducted in the U.S. Lightburn and Fraser (2007) utilized a modified version of the SLEI to gather biology students' perceptions of their learning environment in a high school. The modified version of the SLEI was crossvalidated with a sample of 761 students, and administered to 158 students as a pretest and a posttest before and after the students participated in the implementation of an anthropometric activity. The purposes of this research were to validate the SLEI and to investigate if the anthropometric activity was effective in improving students' perceptions of their learning environment.

In this study, scales selected from two of the instruments listed in Table 2.1 were chosen to assess the classroom environment: the Constructivist Learning Survey (CLES) and the What Is Happening In this Class? (WIHIC). Therefore, these questionnaires are discussed in depth in Sections 2.3.2 and 2.3.3 below.

2.3.2 Constructivist Learning Survey (CLES)

The Constructivist Learning Survey (CLES) was designed to enable teachers to monitor the development of learning environments while initiating constructivist approaches to school science and mathematics. The scales used in the CLES were developed from the view of critical constructivism (Taylor, 1994), which is based on the notion that the cognitive constructive activity of the learner occurs within and is inhibited by the socio-cultural context.

The scales of the CLES are Personal Relevance, Shared Control, Critical Voice, Uncertainty, and Student Negotiation. The scales give a clear view of the environment present in the classroom. The Personal Relevance scale measures the connectedness of the curriculum to the learner's out-of-school experiences. This involves the relevance of the environment to the students.

The Shared Control scale is concerned with the learners' ability to articulate their own goals and design a management plan for their achievement. The Critical Voice scale assesses if the learners feel comfortable about voicing their opinions and questions. The Uncertainty scale measures the extent to which opportunities are provided for the learners to experience mathematics and science knowledge as arising from theory-dependent inquiry and involving human experience and values. The Student Negotiation scale assesses to what extent opportunities exist for learners to explain and justify to other learners their newly-developing ideas. Table 2.2 shows a sample item along with a description for each CLES scale.

Creators of the CLES encountered several design problems during its first validation stages. From student interviews, it was found that students tended to refer to past learning environments, instead of the present environment in the science class, when answering the items in the CLES. Therefore, a phrase was included at the beginning of each question that read "in this science class . . ." Negatively-worded items in the CLES also caused confusion for students. So, the use of negatively-worded items in the CLES was minimized. Items in the CLES were organized into blocks according to their respective scales (in contrast to using a random or cyclic ordering of items) because it had been found that arranging the items in a format that prevented respondents from identifying the scales to which items belonged still didn't keep the respondent from answering in a biased manner.

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

Instrument	Author & Date Developed	Items per scale	Scales Classified According to Moos's Scheme: Relationship Dimensions	Personal Development Dimensions	System Maintenance & Change Dimensions
Learning Environment Inventory (LEI)	Walberg & Anderson (1968)	7	Cohesiveness Friction Favoritism Cliqueness Satisfaction Apathy	Speed Difficulty Competiveness	Diversity Formality Material Environment Goal Direction Disorganizations Democracy
Classroom Environment Scale (CES)	Moos (1974)	10	Involvement Affiliation Teacher Support	Task Orientation Competition	Order and Organization Rule Clarity Teacher Control Innovation
Individualized Classroom Environment Questionnaire (ICEQ)	Rentoul & Fraser (1979)	10	Personalization Participation	Independence Investigation	Differentiation
College and University Classroom Environment Inventory (CUCEI)	Fraser & Treagust (1986)	10	Personalization Involvement Student Cohesiveness Satisfaction	Task Orientation	Innovation Individualization
Questionnaire on Teacher Interaction (QTI)	Créton et al. (1990)	8–10	Leadership Helping/Friendly Understanding Student Responsibility Uncertain Dissatisfied Admonishing Strict		
Science Laboratory Environment Inventory (SLEI)	Fraser, Giddings, & McRobbie (1995)	7	Student Cohesiveness	Open Endedness Integration	Rule Clarity Material Environment
Constructivist Learning Environment Survey (CLES)	Taylor & Fraser (1991)	7	Personal Relevance Uncertainty	Critical Voice	Student Negotiation
What Is Happening In this Class? (WIHIC)	Fraser, McRobbie, & Fisher (1996)	8	Student Cohesiveness Teacher Support Involvement	Investigation Task Orientation Cooperation	Equity

Adapted from Fraser (1998b)

Table 2.2 Description and Sample Item of each CLES Scale

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

Adapted from Fraser (1998a)

The CLES contains five scales with six items in each scale. There are 30 items in total with five response alternatives to choose from. The frequency response alternatives range from Almost Always to Almost Never.

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

Another study using the CLES was focused on assisting South African teachers to become reflective practitioners in their mathematics classroom teaching. The CLES was used to assess learners' perceptions of the emphasis on constructivism in the classroom environment (Aldridge, Fraser, & Sebela, 2004). This study cross-validated actual and preferred forms of a modified version of the CLES with 1,864 mathematics students in grades 4–9. Data analysis showed a strong factor structure for both forms of the modified version of the CLES. Each scale of the actual and preferred forms of the modified version of the CLES showed alpha reliability coefficients ranging from 0.56 to 0.9, thus demonstrating good internal consistency reliability for the instrument. The discriminant validity (mean correlation of a scale with other scales) was also calculated for the actual and preferred forms of the modified version of the CLES. The results indicated that each scale of both forms of the modified version of the CLES measures fairly distinct aspects of the classroom learning environment. Additionally, one-way ANOVA results showed that all CLES scales were able to differentiate significantly ($p<0.01$) between students' perceptions in the different mathematics classes.

Kim et al. (1999) also used actual and preferred forms of a Korean version of the CLES in a study designed to assess the curriculum in Korea. Both forms of the CLES in Korean were administered to 1,083 Grades 10 and 11 science students, and data were analyzed in terms of factor structure, internal consistency reliability, and discriminant validity. The results revealed a strong factor structure for both forms of the CLES in Korean. The alpha reliability coefficients for all scales of the actual and preferred forms were 0.64 and above. Discriminant validity results showed that each scale of the actual and preferred forms of the CLES in Korean measures a distinct aspect of the classroom learning environment.

A cross-national study between Taiwan and Australia also crossvalidated the CLES (Aldridge et al., 2000). There were 1,081 Australian and 1,879 Taiwanese high school science students who participated in the study. The students were administered either the English or Chinese version of the CLES depending on their language. The English and Chinese versions of the CLES were found to be valid and reliable. According to factor analysis results, the internal structure of the English and Chinese versions of the CLES was strong. The alpha reliability coefficients ranged from 0.73 to 0.98 for scales of the English and Chinese versions of the CLES, which demonstrated good internal consistency reliability. One-way ANOVA results indicated that both the English and Chinese versions of the CLES were able to differentiate between science learning environments in 50 Australian classes and 50 Taiwanese classes.

2.3.3 What Is Happening In this Class? (WIHIC)

One of the most recent instruments for investigating learning environments is the What Is Happening In this Class? (WIHIC), which is designed to measure students' perceptions of the classroom environment and to provide insight into the effects of existing programs. This learning environment instrument combines scales from a wide range of other learning environment instruments and includes some new scales. Developed by Fraser et al. (1996), the WIHIC questionnaire has been validated in many studies in various subject areas, age levels, and countries. The validity of the WIHIC in numerous studies in various countries is described below.

The WIHIC was originally comprised of eight scales, but has now been reduced to seven scales. Of the WIHIC'S scales, Student Cohesiveness, Teacher Support, and Involvement measure the environment from Moos's (1974) relationship perspective from the student to teacher and vice versa. Investigation, Task Orientation and Cooperation measure the elements of Moos's (1974) personal development dimension, focusing on motivation and unique learning styles. The seventh scale, Equity, is based on Moos's (1974) system maintenance and change dimensions relative to the perceived fairness of the classroom structure and instructor. Each scale consists of eight questions and is responded to using a five-point frequency scale (Almost Never to Almost Always). A composite score for each scale is produced for data analysis.

The scales chosen for my study were Teacher Support, Involvement, Investigation, and Cooperation. The four scales together give a clear view of the students' perception in the classroom. Teacher Support measures to what extent the teacher helps, befriends, trusts and is interested in the students. Involvement is concerned with the extent to which the students have interest, participate in discussions, do additional work and enjoy class. Investigation measures the emphasis on the skills and process inquiry and their use in problem solving and investigation. Cooperation assesses the extent to which students cooperate rather than compete with one another on learning tasks.

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

A study was also conducted in Singapore (Khoo & Fraser, 2008) involving 250 working adults attending courses in five computer education centers. This study validated a modified version of the WIHIC. A five-factor structure for the modified version of the WIHIC was strongly supported and replicated based on factor analysis results. The alpha reliability coefficient for each of the five scales of the modified WIHIC ranged from 0.74 to 0.92, suggesting satisfactory reliability. One-way ANOVA results showed that four out of the five scales of the modified WIHIC were able to differentiate significantly ($p<0.01$) between the different classes.

Another validation study was conducted by Chionh and Fraser (in press). They validated the WIHIC in Singapore with a sample of 2,310 geography and mathematics students in 75 high schools. A 70-item version of the WIHIC was accepted based on factor analysis results. All scales of the WIHIC exhibited adequate internal consistency reliability and the ability to differentiate significantly between the perceptions of the students in the different classes.

A cross-validation study for an English and Mandarin version of the WIHIC supported the flexibility of this questionnaire when translated into a language other than English (Aldridge & Fraser, 2000; Aldridge, Fraser, & Huang, 1999). The sample consisted of 1,879 junior high school students in 50 science classes in Australia and Taiwan. Statistical analyses consisted of factor structure, internal consistency reliability, and ability to differentiate between classrooms using one-way ANOVA. Results of factor analysis supported a 56-item version of the WIHIC in both countries. Internal consistency reliability for different scales of the English and Mandarin versions of the WIHIC ranged from 0.85 to 0.97. Thus, the results suggest that the scales of the WIHIC are highly reliable with students in both Taiwan and Australia. One-way ANOVA results demonstrated that each WIHIC scale in Mandarin and English had the ability to differentiate between the perceptions of students in different classes.

A large-scale study was conducted by Khine and Fisher (2001) in Brunei to validate a modified version of the WIHIC. A 56-item version of the WIHIC was administered to 1,188 students from 54 science classes in ten secondary schools. Each scale of the modified WIHIC showed satisfactory internal consistency with Cronbach alpha coefficients ranging from 0.78 to 0.94. One-way ANOVA results demonstrated that each scale of the modified WIHIC was able to differentiate significantly ($p<0.01$) between students' perceptions in the different classes.

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

In the United States, a study was conducted among 4^{th} and 5^{th} grade students in South Florida (Allen & Fraser, 2007). This study was unique in that it also involved parents' perception in conjunction with students' perceptions. The WIHIC was modified to accommodate young students and their parents. There were 520 students in 22 classes and 120 parents in three schools who answered the questionnaire. The modified English version of the WIHIC was also translated into Spanish. Factor analysis resulted in the acceptance of a 37-item English and Spanish version of the WIHIC. Cronbach alpha coefficients ranged from 0.67 to 0.90. This suggests satisfactory internal consistency reliability for each WIHIC scale in English and

Spanish. One-way analysis of variance (ANOVA) was conducted to determine the ability of each WIHIC scale to differentiate between the perceptions of students in different classes. The eta^2 statistic was computed to determine how strong the association was between class membership and each WIHIC scale. The eta^2 statistic results demonstrated significant differences between students' perceptions in different classes for three of the six WIHIC scales (namely, Involvement, Equity, and Investigation).

The validity of the WIHIC was also investigated in other classroom situations in various parts of the world. Researchers have validated and used the WIHIC in Brunei using a sample of 644 Grade 10 chemistry students (Riah & Fraser, 1998), in a large-scale validation study with 1,173 high school technology students in Canada (Raaflaub & Fraser, 2002), in the United States with 364 Biology I high school students in North Carolina (Moss & Fraser, 2002), in Indonesia with 422 students enrolled in 12 university level classes (Soerjaningsih, Fraser, & Aldridge, 2001), and in Korea with a sample of 543 Grade 8 students in 12 schools (Kim et al., 2000).

2.4 Past Studies of Learning Environments

For years, educators have focused most of their attention on achievement through the use of standardized achievement testing. According to Fraser (1998a), the quality of school life, which has been neglected in favor of the overemphasis of academic achievement, needs to be given more serious attention by researchers and educators. However, although the study of learning environments has evolved only within the past three decades, notable progress has been made in this area of study.

As the field of learning environments has expanded, several lines of research have emerged, such as the investigation of associations between students' perceptions of the learning environment and student outcomes (Chionh & Fraser, in press; Fisher et al., 1997; Margianti et al., 2004; Quek et al., 2005; Riah & Fraser, 1998; Soerjaningsih et al., 2001); changes in students' learning environments perceptions during the transition from elementary to high school (Ferguson & Fraser, 1998); differences between student and teacher perceptions of actual and preferred learning environments (Fisher & Fraser, 1983; Sinclair & Fraser, 2002); differences between students' and parents' perceptions of actual and preferred classroom environments (Robinson & Fraser, 2003); determinants of classroom environments (Hirata & Sako, 1998; Khine & Fisher, 2001; Margianti et al., 2004); evaluation of educational innovations (Khoo & Fraser, 2008; Maor & Fraser, 1996; Raaflaub & Fraser, 2002); cross-national investigations (Aldridge & Fraser, 2000; She & Fisher, 2000); and combining quantitative and qualitative research methods (Adamski, Peiro, & Fraser, 2005; Aldridge et al., 1999; Fraser, 1999; Fraser & Tobin, 1991; Tobin & Fraser, 1998); and teachers' practical attempts to use feedback from classroom environment questionnaires to guide improvements in their classrooms (Aldridge, Fraser & Sebela, 2004: Sinclair & Fraser, 2002).

One aim of my research study was to evaluate a professional development project called Alliance+ for middle-school teachers in terms of their students' attitudes and classroom environment perceptions. Another aim of the study involved investigating associations between students' attitudes to science/mathematics and their perceptions of their classroom learning environment. Because these aims fit into two past lines of learning environments research, this section reviews those two lines of research in more detail. Section 2.4.1 provides a discussion of past learning environment studies that have involved evaluating educational innovations and Section 2.4.2 discusses past studies of outcome-environment associations.

2.4.1 Evaluation of Educational Innovations

The creation of numerous learning environment instruments has facilitated the assessment of educational innovations in terms of students' learning environment perceptions. Learning environments studies assessing the implementation and effectiveness of educational innovations have been conducted in the Western and Eastern parts of the world in various subject areas and at different grade levels.

In Singapore, the What Is Happening In this Class? (WIHIC) was administered to 250 adult learners in 23 classes to evaluate adult computer application courses in terms of students' perceptions of their classroom learning environment (Khoo & Fraser, 2008). In this particular study, it was found that most students perceived high levels of involvement, teacher support, task orientation and equity in their classroom learning environment, although the effectiveness of the course differed according to the age and sex of students.

In another study in Singapore, the Geography Classroom Environment Inventory (GCEI) was used to evaluate a computer-assisted learning program among geography students at the secondary-school level (Fraser & Teh, 1994). An experimental group (students who were using the computer-assisted learning program) and a control group (students who were not using the computer-assisted learning program) were administered the GCEI, an achievement test, and an attitudinal survey to determine the effectiveness of the computer-assisted learning program in terms of improving students' perceptions of the geography learning environment, attitudes towards geography, and academic achievement. The findings showed that the students who used the computer-assisted learning program had much higher scores for classroom environment, achievement, and attitudes than the students in the control group who were not taught with the computer-assisted learning program.

In the U.S, several studies have been conducted aimed at evaluating educational innovations. For instance, in Charlotte, North Carolina, Moss and Fraser (2002) used a sample of 364 biology high school students in 18 classes to evaluate the implementation of classroom interventions, which were aimed at improving classroom environment perceptions and achievement. One class of students who were likely to fail due to low academic performance was chosen for the implementation of the interventions. It was found that the classroom interventions were effective in considerably improving students' perceptions of the classroom learning environment as assessed by a modified version of the What Is Happening In this Class? (WIHIC). Additionally, findings showed that the intervention class scored at the same level on the school-wide science test as the regular classes at the school. It was also found that there was a smaller difference between black and non-black students' achievement for the intervention class than there was for the other classes at the school.

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

Several recent studies in the U.S. are noteworthy for their use of learning environment dimensions as criteria of effectiveness in evaluating educational programs. In Texas, Nix, Fraser, and Ledbetter (2005) reported use of the CLES in an evaluation of an innovative teacher development program involving the teachers' 1079 students in 59 classes. In California, Ogbuehi and Fraser (2007) used scales from the CLES and WIHIC with 661 middle-school students in 22 classes in part of an evaluation of innovative teaching strategies in mathematics. Also in California, Martin-Dunlop and Fraser (2008) used scales from the SLEI and WIHIC in an evaluation of an innovative science course involving 525 elementary prospective teachers.

Other research that has evaluated educational innovations in Miami-Dade County, Florida include a study conducted with 110 Grade 4 students in four different classes in two elementary schools to evaluate the effectiveness of the implementation of a graphic organizer entitled PRIDE (MacDowell-Goggin & Fraser, 2004); a study conducted with 30 Spanish-speaking LEP kindergarten students in one class to investigate the possibility of using teacher action research to change the science classroom environment to make it more consistent with a constructivist epistemology (Peiro & Fraser, 2005); a study conducted with 158 high school biology students to evaluate the use of anthropometry activities in science lessons (Lightburn & Fraser, 2007); and a study conducted with Grade 5 students to evaluate a literacy project that integrated science and mathematics (Mink & Fraser, 2005).

2.4.2 Studies of Associations between Classroom Environments and Student Outcomes

The quality of the classroom environment is important in developing and strengthening outcome measures such as community, concern for others, commitment, and interests (Fraser, 1986). Results of investigations of outcome-environment associations conducted over the last few decades have shown evidence of a relationship between the learning environment and both cognitive and affective student outcomes (Fraser, 1994, 1998b). For example, a meta-analysis of 734 correlations from 12 studies of 10 data sets from 823 classes in eight subject areas consisting of 17,805 students in four countries showed that there were strong associations between learning environments and both cognitive and affective outcomes (Haertel, Walberg, & Haertel, 1981).

In the Asian context, studies of outcome-environment associations have become popular among researchers. For example, Khine and Fisher (2001) conducted a study in Brunei among 1,188 students from 54 secondary science classes. The What Is Happening In this Class? (WIHIC) and the Test Of Science-Related Attitudes (TOSRA) were administered to the science students to gather their perceptions of the classroom learning environment and their attitudes towards science. Strong associations were found between the students' perceptions of their learning environment and their attitudes to science. Also, in Singapore, a study was conducted with 2,310 mathematics and geography students. Associations were found between students' perceptions of the learning environment and achievement, attitudes, and self-esteem (Chionh & Fraser, in press). Additionally, in Brunei Darussalam, Khine and Fisher (2002) found associations between attitudes to science and the classroom environment for a sample of 1,188 science students. The What Is Happening In this Class? (WIHIC) and Questionnaire on Teacher Interaction (QTI) were used in this study to gather the students' perceptions of the classroom learning environment. A Malay translation of the QTI was administered to 3,104 primary school students to investigate the associations between the science classroom environment and students' enjoyment of science lessons. Strong associations were found between students' perceptions of the learning environment and their enjoyment of science lessons (Scott & Fisher, 2001, 2004).

Other Asian studies that found associations between student outcomes and their perceptions of the classroom learning environment were conducted in:

- Singapore among 1,592 Grade 10 chemistry students (Wong & Fraser, 1996), 671 high school geography students (Teh & Fraser, 1995), and 497 gifted chemistry students (Quek et al., 2005),
- Indonesia and Australia among 1,161 secondary students (Adolphe, Fraser, & Aldridge, 2003),
- Indonesia among 2,498 secondary students (Margianti et al., 2004; Margianti, Fraser, & Aldridge, 2002), and
- Brunei among 644 secondary chemistry students (Riah & Fraser, 1998).

In Western countries, there have been many studies of outcome-environment associations as well. In Australia, a study conducted among 80 high school chemistry students found associations between students' outcomes (achievement and attitude) and the classroom environment (Fraser & McRobbie, 1995). Fisher, Henderson, and Fraser (1997) found associations between student achievement and classroom environment perceptions among 489 biology students at the high school level. Aldridge and Fraser (2000) found relationships between student satisfaction and students' perceptions of the classroom learning environment for a sample of 1,081 Australian students and 1,879 Taiwanese science students. Dorman and Ferguson (2004) found associations between high school students' perceptions of their mathematics classroom environment and their outcomes in Australia and Canada. In North Carolina, associations were found between students' environment perceptions their attitudes towards science and achievement at the high school level (Moss & Fraser, 2002).

In the Western context, other research on outcome-environment associations was conducted in the U.S. (Allen & Fraser, 2007; MacDowell-Goggin & Fraser, 2004; Peiro & Fraser, 2005), Australia (Fisher et al., 1995; Fraser & Butts, 1982; Fraser & Fisher, 1983), Canada (Raaflaub & Fraser, 2002; Zandvliet & Fraser, 2004, 2005), and the Netherlands (Wubbels & Levy, 1993).

2.5 Learner Attitudes

Attitude has been defined and measured in many ways. Attitude is a non-observable psychological process whose presence can only be assumed. Attitudes cannot be observed or measured directly. Their existence must be inferred from their consequences (Mueller, 1986). Thurstone (1928) defined attitude as "the sum total of a man's inclination and feelings, prejudices and bias, preconceived notions, ideas, fears, threats, and convictions about any specific topic" (p. 531). The idea that attitudinal behavior is learned and could be modified is widely accepted today by social scientists. Researchers and educators take the belief one step further and acknowledge the relationship of attitudes to values and beliefs and its impact on the human psyche (McRobbie & Fraser, 1993; Quek et al., 2005; Soerjaningsih, et al., 2001).

In my study, to assess students' attitudes in mathematics and science, I modified an attitude scale, Enjoyment of Science Lessons, from the Test Of Science-Related Attitudes (TOSRA, Fraser, 1981) to make it suitable for both mathematics and science students. The item modifications were slight. I replaced the word 'science' with the word 'mathematics' in the statements (see Section 3.5.2 for further information about the creation and modification of the attitude scale modeled on the TOSRA).

The original TOSRA makes use of Klopfer's (1976) classification of students' attitudinal aims. The TOSRA consists of 70 items, which are spread equally between seven distinct scales. Each scale contains 10 items, with the responses based on a five-point Likert scale ranging from Strongly Agree to Strongly Disagree (Doepken, Lawsky, & Padwa, 1993). Table 2.3 provides Klopfer's (1976) classification for each scale of the TOSRA and a sample item from each of its scale.

Since its development, the TOSRA has been cross-validated in Australia (Fraser & Butts, 1982; Fraser & Fisher, 1983; Lucas & Tulip, 1980), Singapore (Wong & Fraser 1966), and the United States (Farenga & Joyce, 1998; Fraser & Butts, 1982; Martin-Dunlop & Fraser, 2008). Adapted versions of the TOSRA have also been used in many ways and validated. For instance, Tran (2003) altered the TOSRA to fit his research into the use of in Micro Electro Mechanisms Systems (MEMS) as a vehicle for teaching engineering and physical science concepts to middle-school students. At the beginning and at the end of the program, 23 students filled out a questionnaire based on the TOSRA. The modified survey proved to be valid and reliable. In another adaptation, Newbill (2005) used only three of the seven original scales of the TOSRA and modified their names to Student Satisfaction in Computer Studies, Leisure Interest in Computer Skills, and Career Interest in Computers. Another scale, Attitude Towards the Internet, was developed with these adaptations. The modified version of the TOSRA in this study was found to be valid and reliable.

The original/modified versions of the TOSRA have been used in numerous learning environment studies in Western and Asian countries. In Tasmania, Australia, a modified version of the TOSRA was validated in a study of associations between classroom environment and attitudes among 1,083 junior high school students in 116 classrooms (Fraser & Fisher, 1983). Modified English and Spanish versions of the TOSRA were validated in the United States with elementary school students (MacDowell-Goggin & Fraser, 2004; Soto-Rodriguez & Fraser, 2004). In Korea, a modified version of the TOSRA, which included four scales (namely, Social Implications of Science, Normality of Scientists, Attitudes to Scientific Inquiry, and Interest in Science), was validated with 294 science students in three high schools (Lee, 2001). A cross-national study involved validating a 10-item Chinese version of an attitude scale based on a scale from the TOSRA among 1,081 Australian and 1,879 Taiwanese high school students (Aldridge et al., 2000). Another cross-national study between Australia and Indonesia involved validating a modified version of the TOSRA with a sample of 594 Indonesian students and 567 Australian students in Grades 9–10 (Adolphe et al., 2003).

Table 2.3 Name, Classification and Sample Item for Each Scale of the TOSRA

Scale Name	Klopfer (1976) Classification	Sample Statement
Social Implications of Science	Manifestation of favorable attitudes towards science	Money spent on science is well worth spending.
Normality of Scientists	Manifestation of favorable attitudes towards scientists	Scientists usually like to go to their laboratories when they have a day off.
Attitude to Scientific Inquiry	Scientific inquiry as a way of thought	I would prefer to do experiments than to read about them.
Adoption of Scientific Attitudes	Adoption of 'scientific attitudes'	I dislike repeating experiments to check that I get the same results.
Enjoyment of Science Lessons	Enjoyment of science learning experiences	Science lessons are fun.
Leisure Interest in Science	Development of interest in science and science-related activities	I get bored when watching science programs on TV at home.

Adapted from Fraser (1981)

2.6 History of Computer Use in the Classroom

My research study consisted of evaluating the Alliance+ project, which is a professional development program that was developed in an attempt to integrate computer technology into mathematics and science lessons. Thus, this section is dedicated to reviewing the history of computer use in the classroom and several studies in the area of computer usage in the classroom.

The history of the modern computer age in education is a brief one. It has only been about 60 years since the first operational computer (the MARK 1 in 1949) was put into public use at Harvard University (Molnar, 1997).

In 1959, the PLATO project began the first of a long line of projects and grants aimed at integrating computers into education. Through PLATO, several thousand terminal systems were set up to serve undergraduates and elementary schools in Chicago (Office of Technology Assessment, 1995).

In 1963, the language of computers, FORTRAN, seemed to be slow and tedious to learn for educational purposes. At Dartmouth College, the easy-to-use language of BASIC was developed. It spread rapidly and was used to create instructional materials for all levels and subject areas in education (Kemeny & Kurtz, 1968).

The basic growth of computers in education surged in the late 1960s. The National Science Foundation supported the development of 30 regional computing networks to service 300 institutions of higher education and secondary schools (Molnar, 1975).

In the 1970s, experts again simplified mathematics education with their own computer language called LOGO (Papert, 1980).

Computers have been part of the academic curriculum since the mid-1990s. In the beginning, the teaching of new technology uses was undertaken in separate classes called Computer Science, Data Processing, etc. (Newby & Fisher, 1997). Today, computer technology is becoming integrated into the general classroom curriculum. It is especially being interwoven into language arts, science, and mathematics classes.

Warner and Akins (1999) analyzed the problem of how to get teachers to effectively use computers. They observed similar situations and produced similar findings as Bailey and Collar (1994) regarding the need for hands-on training situations to influence the integration of computers in the classroom. A course was developed to give teachers structured time to develop skills in working with technology-based educational tools, presented in a context of learning where the overall objective required an authentic demonstration of performance. From these studies, it was concluded that teachers need more structured time to develop skills at working with the new technology and to become acquainted with the teaching technologies before using them to develop courses. The teachers were unsure of themselves and thus were slow in developing high-quality programs. Techniques and strategies needed to be demonstrated, and hands-on programs needed to follow the demonstration (Warner & Akins, 1999). Groups of teachers were given three hours a week for a month to develop a course. Teachers need more structured time to develop skills with new technology-based educational tools. These methods need to be presented in a context of learning in which the overall objective requires an authentic demonstration in a performance context (Warner & Akins, 1999).

The joint association for Computing Machinery and the Institute of Electrical Engineers (ACM-IEE) curriculum endorses this teaching method. The ACM-IEE Taskforce recommends that computer science classes should be taught and then followed by hands-on laboratory use. First, the factual should be taught, and then the practical should be practiced (Newby & Fisher, 1997).

The U.S. Department of Education *Statistics in Brief* (Cattagni & Westat, 2001) on teaching quality examined teachers' applications and assignments given to students, as well as their personal use of computers and professional development. In 1999, a Fast Response Survey showed that 99% of those replying had access to the Internet somewhere in their schools. Fewer then 10% of those responding said that they used computers for classroom use and/or in developing lesson plans. Newer teachers were most likely to use computers or the Internet to access model lesson plans or to access research and best practices. Forty-seven percent (47%) of the teachers with 4 to 9 years of experience used the Internet for class awareness compared with 35% of those teachers with 20+ years experience. Teachers who had been given more then 32 hours of professional development in computer integration were more likely to implement technology in the classroom. Only 23% of the teachers felt adequate in computer skills and only 10% felt adequate about integrating technology in the classroom (Rowand, 2000). Carvin (1999) was the first study to show that, of the teachers sampled, only 7% had students use e-mail, 4% had published on the Internet, and only 6% had students participate in online projects.

2.7 Overview of Educational Grant Projects

The Alliance+ project, which I evaluated in my study, was funded with a five-year grant from the U.S. Department of Education for $9.3 million. Thus, it is important to provide in this section an overview of education grant projects and how they have been evaluated.

As early as 1994, the question of integrating technology into the classroom had been discussed at a national level. In the United States, the Technology Literacy Challenge Fund (TLCF) was authorized in 1994 as part of the Elementary and Secondary Education Act. It was the Department of Education's single largest investment dedicated specifically to increasing the use of technology in the nation's elementary and secondary schools. In 1997, the program's first year of operation, $200 million was appropriated for the TLCF program and awards were given to local school districts (Puma, Chaplin, & Pape, 2000).

In addition to the TLCF, a number of other programs were initiated. The Title I program and the Technology Innovation Challenge Grants (TICG, Puma et al., 2000) have been successfully used in many ways. The TLCF Digital Divide Projects included the Kindred Public Schools of North Dakota and the Maine Township High School District #207 of Illinois. Both projects used the money to support technology integration and knowledge and resulted in raising students' academic achievement by two grade levels.

The Technology Innovation Challenge Grant (TICG) provided five-year funding for school districts in partnership with business, community organizations and educational researchers aimed at implementing, evaluating and documenting innovative applications of information and computer technology in systemic educational reform.

In the United States in the 1996–1997 academic years, schools' inventories of computers grew 186%. Yet, the integration of technology into teaching and learning was far from complete (Kirshstein, Birman, Quinones, Levin, & Stephens, 1999).

The timeline for educational technology milestones was moving rapidly. In 1995, the Telecommunications Act called for providing all K–12 public and private nonprofit schools and libraries with discounts for telecommunication services. The Universal Service Fund for Schools and Libraries, known as the Education Rate (E–Rate), was created in 1996 as part of Public Law 104–104. The act is more commonly referred to as the Telecommunication Act of 1996 and was developed by the Federal Communications Commission (FCC). More information concerning their rulings can be found in Puma et al. (2000).

In 1997, the FCC ruled unanimously to provide K–12 schools and public libraries with up to $2.5 billion a year in telecommunication discounts. There was a sliding scale formula set based on income, but the average discount was 60%. Known as the E-Rate, the funds covered the cost of computers, software, or other unrelated services. When the first round of E-Rate applications ended in 1998, more than

30,000 applications had been submitted requesting discounts totally $2.02 billion (U.S. Department of Education, 2002).

The government and other foundations are continually trying to assist public schools to integrate technology into curricula. They have offered help to schools to set up networks, professional development programs, purchases of software and hardware, and other technology advances as needed by school systems (i.e. teleconferencing equipment, wireless internet). Some of the programs sponsored by the government have been through major foundations and grant programs (Yepes-Baraya, 2002).

The EDS (actual name, not an abbreviation) Foundation was created to support EDS's philanthropic efforts in communities where their employees live and work around the world. In support of its mission, the EDS Foundation focuses on supporting solutions to the digital divide that affect communities globally. The EDS Foundation funds programs that provide the following: Access Provision (of computers and Internet connections to community access centers such as schools, libraries, community organizations, and other public access points); Content (educational software and other programs); and Professional Development (training programs targeted at teachers, counselors, program administrators and staff on how to maximize the use of technology). Since EDS began in 2001, it has given over 300 grants to teachers (Yepes-Baraya, 2002).

The United States Department of Education has supported many programs. The Preparing Tomorrow's Teachers to use Technology (PT3) grants help to ensure that tomorrow's teachers are prepared to integrate technology effectively into the curriculum and to use the new teaching and learning styles that are enabled by technology. Since 1999, PT3 has awarded over 400 grants to education consortia to help in addressing this challenge. These grants include projects designed to transform teaching and learning through: teacher development; course restructuring; certification policy changes; online teacher preparation; enrichment via networked and virtual education; video case studies; electronic portfolios; mentoring triads; and embedded assessments (U.S. Department of Education, 2003).

In March 2002, the U.S. Secretary of Education announced a new program for states to apply for grants under the new Enhancing Education Through Technology (ED Tech) program (Paige, 2002). The program, which includes The No Child Left Behind Act, is designed to improve student academic achievement through using technology in elementary and secondary schools. The goal of the program is to ensure that every eighth grader is technology literate and that teachers are able to integrate technology into curricula to improve student achievement. Schools that were applying for funds had until December 31, 2006 to fully integrate technology into their curricula.

The key to consistent integration of technology into a school's curriculum is a solid core of participating teachers (Means & Olsen, 1995). With testing and accountability being major issues in today's education, teachers are reluctant to take time out for professional development. Many districts and states have implemented projects to ease the burden on teachers. The North Carolina ENTech program (McCullen, 2002) is one such statewide initiative that invites school-based teams to participate in five days of technology training off site and two days of on-site followups. The program was implemented by the national non-profit organization, ExplorNet. ENTech takes a problem-based approach, asking teams of teachers to work collaboratively on school improvement projects while learning integration strategies and using scientific methods to explore the ideas and concepts behind the North Carolina State Teaching Standards. Throughout the five-day training, instruction is facilitated in three different modes. The first aspect of the program is immersion. With the ENTech facilitator as the teachers, the teams use role-playing scenarios as they portray students in various learning situations. An activity might include using software to make a map. The second procedure used is peer-to-peer or teacher-to-teacher experiences. Instructors take part in activities with participants and guide them through a question-and-discussion period that helps them to discover uses for technology in their unique situations. The third technique used is to ask the experts. Instructors act as experts and give step-by-step instructions about focusing on a specific technology product or outcome (McCullen, 2002).

The increase of Internet access could have been aided by the 1998 implementation of allocating Federal funds through the Education Rate (E-rate) Program. As of February 28, 2001, $5.8 billion had been committed to E-rate applications throughout the nation. Before the E-rate program, in 1994, 3% of the schools in the nation had Internet access. By 2001, over 77% of the schools were connected to the Internet (Cattagni & Westat, 2001).

2.8 Summary of Literature Review

The main goal of my study was to investigate the effectiveness of the Alliance+ professional development model in terms of middle-school students' perceptions of their classroom learning environment and their attitudes towards science/mathematics. Thus, this literature review began with a historical account of the field of learning environments in Section 2.2. The beginning of this field of study dates back to the early 1960s with the pioneering work of various theorists and researchers such as Walberg and Moos (Moos & Houts, 1968; Walberg & Anderson, 1968) and others. Because the study of learning environments has evolved over the past 30 years, so Section 2.2 also discussed its evolution through time.

As the study of the field of learning environments evolved and expanded, instruments were created, validated, and used internationally in numerous research studies. Section 2.3 discussed the development, validation, and utilization of the eight learning environment instruments that have, thus far, facilitated data collection for learning environments studies. The description of each of the learning environment instruments was provided in Table 2.1. Section 2.3 focused mostly on the development and validation of the Constructivist Learning Environment Survey (CLES) and the What Is Happening In this Class? (WIHIC) questionnaires because they were used in my study. The CLES (Aldridge et al., 2000; Kim et al., 1999; Nix et al., 2005) and the WIHIC (Aldridge & Fraser, 2000; Allen & Fraser, 2007; Chionh & Fraser, in press; Dorman, 2003; Khoo & Fraser, 2008; Zandvliet & Fraser, 2004, 2005) have been extensively validated with a variety of students at various grade levels around the world.

Section 2.4 discussed lines of learning environments research that emerged as the field progressed. More emphasis was placed on two particular types of learning environments studies: learning environments studies that have involved evaluating various educational innovations (Fraser & Teh, 1994; Khoo & Fraser, 2008; Lightburn & Fraser, 2007; Mink & Fraser, 2005; Spinner & Fraser, 2005) and outcome-environments studies (Fraser & McRobbie, 1995; Haertel et al., 1981; Wong & Fraser, 1996; Wubbels & Levy, 1993). My study falls within these two past lines of learning environments research.

Many researchers have studied learners' attitudes towards various subject areas. The field of learning environments has certainly lent itself to the study of students' attitudes as evidenced by the many learning environments studies that have looked into the relationship between students' attitudes and their perceptions of the learning environment as was noted in Section 2.4.2. Thus, Section 2.5 provided a discussion about the very popular attitudinal survey, Test Of Science-Related Attitudes (TOSRA), which has been extensively used in learning environments studies. For my study, I modified a scale, Enjoyment of Science Lessons, from the TOSRA to measure students' attitudes towards science and mathematics. Therefore, reviewing literature pertinent to learners' attitudes and the TOSRA was imperative in Chapter 2.

In my study, I investigated the effectiveness of the Alliance+ project, which is a professional development program aimed at training educators in the integration of technology into science and mathematics lessons. Therefore, it was important to discuss, in Section 2.6, the history of computer usage in the classroom during the past 60 years. The introduction of the computer and related technology into the classroom has occurred at an accelerated pace. Many would argue that the implementation of technology has focused more often on the machine itself rather than on the improvement of the learning environment. A review of the literature revealed that there are obvious tensions between those who see the computer as a replacement for the teacher and those who view the computer as an instructional tool. Much of the early research focused on computer assisted instruction and its impact on learning.

Finally, Section 2.7 provided a discussion of a variety of grant projects that facilitated the integration of technology into the classrooms. The review showed that the Alliance+ project, which was investigated in my study, is just one of many attempts to use technology in various subject areas and as an aid for improving students' educational experiences.

Chapter 3

METHODOLOGY

3.1 Introduction to Chapter 3

The previous chapters provided insight into the theoretical framework that formed a foundation for my research study. Chapter 1 provided a five-year (1998–2003) history of the Alliance+ Project, which was a professional development program sponsored by the U.S. Department of Education to provide training for secondary-school teachers in the integration of technology in science and mathematics classrooms. In the early years of the implementation phase, the effectiveness of the program was evaluated via experimental, qualitative, quantitative and historical research techniques, and the findings were favorable for most of the teachers and students involved (Biggs & Fraser, 2006; Yepes-Baraya & Biggs, 2001). Although a large amount of money was spent by the U.S. Department of Education on the implementation of the Alliance+ model, there was no follow-up of its effects after the first few years. Because I had been involved in the Alliance+ project, I became interested in investigating the long-term effect of this innovative program. Consequently, the purpose of my research study was to investigate the effectiveness of the Alliance+ professional development program two years after it had ended.

In Chapter 2, I provided a literature review about the history and importance of the study of classroom learning environments. The literature suggests that it is important to conduct research in the field of learning environments because the nature of the classroom environment influences students' educational outcomes such as attitudes, motivation, and achievement. Another topic covered in the literature review was students' attitudes to science/mathematics. The literature reviewed in Chapter 2 clearly shows that students' attitudes towards science/mathematics play an important role in their educational experience.

After an examination of the research literature, it became evident that it would be desirable to evaluate the effectiveness of the Alliance+ project in terms of two types of dependent variables (students' perceptions of their classroom learning environment and their attitudes towards science/mathematics). That became the main objective of my doctoral research study. The secondary objectives of my study were to validate two questionnaires assessing learning environment and attitudes, and to investigate associations between students' perceptions of their classroom learning environment and their attitudes towards science/mathematics.

Chapter 3 is devoted to describing the methodology used in investigating the research questions of the present study. The first section defines the study's research questions (Section 3.2). The sections that follow describe the participating school (Section 3.3), the sample used in the study (Section 3.4), the selection, modification, and development of the instruments used in the study (Section 3.5), and procedures followed in collecting (Section 3.6), preparing and analyzing (Section 3.7) the quantitative and qualitative data.

3.2 Research Questions

The main goal of my study was to evaluate the effectiveness of the Alliance+ professional development program in terms of middle-school teachers' students' perceptions of their classroom learning environment and their attitudes towards science/mathematics. So, after reviewing literature about the various questionnaires that are available, I chose scales from two widely-applicable learning environment questionnaires: the Constructivist Learning Environment Survey (CLES, Taylor & Fraser, 1991) and the What Is Happening In this Class? (WIHIC, Fraser, Fisher, & McRobbie, 1996) to measure students' perceptions of their classroom learning environment. Then, I created an attitude scale modeled on the Test Of Science-Related Attitudes (TOSRA, Fraser, 1981) to measure student's attitudes towards science/mathematics. The seven learning environment scales from the CLES and WIHIC and the one attitude scale were all modified and combined into two separate questionnaires, one to gather data from the science students and another to gather data from the mathematics students. Before I could use the two instruments with confidence in my study, they had to be validated, which gave rise to the first research question:

Research Question # 1

> *Are learning environment scales based on the CLES and WIHIC and an attitude scale based on TOSRA valid when used with this sample of middle-school students?*

After validating the two instruments, data had to be collected to answer the main question of my study, which entailed investigating if the Alliance+ professional development program was effective for middle-school mathematics and science students. Thus, the second research question emerged:

Research Question #2

Is the Alliance+ professional development model effective in terms of middle-school students':

c) perceptions of classroom learning environment

d) attitudes to science/mathematics?

To embellish the results for Research Question #2, it was important to investigate if the Alliance+ model was differentially effective for mathematics and science teachers. Consequently, the third research question emerged:

Research Question #3

Is the Alliance+ professional development model differentially effective for mathematics and science teachers in terms of middle-school students':

c) perceptions of classroom learning environment

d) attitudes to science/mathematics?

Research in the field of learning environments has focused on many topics, but studies investigating outcome-environment associations is one of the most common. My fourth research question focused on this very important area within the field of learning environments:

Research Question #4

Are there associations between students' attitudes to science/mathematics and their perceptions of classroom learning environment?

3.3 Participating School

Because I needed a specific sample of teachers (those who had participated in the Alliance+ professional development program), I initially went back to the records from the beginning of the Alliance+ project. It was difficult to locate many of the Alliance+ teachers after so many years because most had either transferred to other schools or had left the school system. The contact information that I had on record was mostly obsolete as well. I found that many of the participants had changed their telephone numbers and e-mail addresses.

When I was finally able to locate some of the Alliance+ teachers at five different middle schools, the next step was to contact the principals at those schools to ask them for permission to collect data. This was a futile task that took almost a year during which time I contacted the five principals by telephone, ground mail, e-mail, and personally. My efforts were to no avail because the principals did not respond.

A year later, I embarked on the task of contacting the five principals again. I sent a letter asking them to volunteer their schools for data collection (Appendix 1 provides a copy of the letter sent to the school principals). Despite my efforts to continue to solicit permission both written and verbally from all five principals, there was only one principal who gave me permission to collect data at her school. It was desirable to include as many Alliance+ teachers as possible in the sample, but having permission to collect data at only one school limited the sample. This became a limitation in my study, which is discussed in more detail in Section 3.4.

There are 58 middle schools serving Grade 6–8 students in the Miami-Dade County Public Schools (M-DCPS) district. The middle school where the data were collected is one of seven neighboring schools located in the northernmost part of the district.

The participating middle school is located in a lower-class to middle-class neighborhood in the city of Miami Gardens within Miami-Dade County, Florida. The residents in the neighborhood are mostly African American (about 79%). The rest of the population is made up of Whites, Hispanics, or other races (Wikipedia, 2007).

The participating middle school is designated by the Florida Department of Education as a School Improvement Zone (SIZ) school using three criteria: low academic performance for three years; located in a neighborhood in which low performance is widespread; and limited leadership capacity.

A SIZ school is different from other schools in the district because it must implement a differentiated approach to public education that promotes high achievement and eliminates low student performance. The academic program in a SIZ school focuses on literacy as the core component of the instructional program using research-based instructional materials. In a SIZ school, student progress is assessed on a weekly or biweekly basis and instruction is adjusted based on that regular assessment using specific interventions. Another unique aspect of a SIZ school is that it uses an extended day and extended school year to allow students more learning time.

A SIZ school, just as any other public school in Miami-Dade County, must adhere to the county's adopted curriculum, the Competency Based Curriculum (CBC), which is associated with Florida's Sunshine State Standards (standards created by Florida's

Department of Education that mandate what each school in Florida's schools is expected to achieve at each grade level). Thus, the mathematics and science lessons taught at a SIZ school correlate directly to the CBC. However, as mentioned earlier in this section, a SIZ school is unique in that students are assessed weekly or biweekly to determine whether or not they are meeting the objectives. Then, the results of the assessments are used to guide instruction.

Table 3.1 provides an overview of the mathematics and science programs implemented in the participating middle school, including a brief description of the program and the interventions implemented school wide in an attempt to improve achievement for students who do not meet mathematics and/or science objectives (Miami-Dade County Public Schools, n.d.).

Table 3.1 Overview of Mathematics and Science Programs Implemented at the Participating Middle School

Subject	Program Description	Interventions for Students Not Meeting Objectives
Mathematics	Focus on number sense, measurement, geometry, algebraic thinking, and data analysis Incorporates hands-on learning through use of manipulatives and concept-development strategies Emphasizes problem-solving for whole groups, small groups, and individualized instruction Uses research-based programs adopted by the state to teach the concepts	Any student not meeting objectives is enrolled in an additional mathematics class in lieu of one elective class such as art, music, physical education, etc. The Plato Math Expeditions program is used during the extra mathematics class. This is a web-based program that contains tutorials, extra practice, and quizzes that students complete independently. The program also contains online tools such as thermometers, protractors, and number lines that could be used as manipulatives for learning the mathematical concepts.
Science	Focuses on physical science, chemistry, earth and space science, life and environmental science, and scientific thinking Incorporates hands-on learning through use of equipment and materials and concept-development strategies Emphasizes inquiry-based learning, problem-solving, experimentation, and communication skills	Unlike mathematics, at this time, there is no extra science class for students who have not met the science objectives. However, within the regular science class, the Riverdeep's Logal Science Program is used to reinforce concepts for below-level learners. This is a web-based program that emphasizes hands-on, interactive learning.

Based partly on Miami-Dade County Public Schools (n.d.)

The participating middle school has a student enrollment of 1,543, with a racial make-up consisting of 8% Hispanics, 88% African American, 2% White, and 2% non-white of other minorities (Miami-Dade County Public Schools, 2006). The number of students and ethnic distribution for each grade level for the participating middle school is shown in Table 3.2.

Table 3.2 Student Enrollment and Ethnic Distribution for Participating Middle School

Grade Level	Number of Students	Ethnicities			
		% White Non-Hispanic	% Black Non-Hispanic	% Hispanic	% Non-White of other Minorities
6	407	1	88	9	2
7	526	2	88	9	2
8	610	2	89	8	1
		27	20	49	4
Total	1,543				

Adapted from Miami-Dade County Public Schools (2006)

The school system assesses a student's socioeconomic status by his/her participation in the free/reduced-cost lunch program. Students who qualify for free/reduced-cost lunch are living at or close to the poverty level. In the participating middle school, 68.5% of all students qualify for free/reduced-cost lunch, which means that more than half of the student population is of low socioeconomic status. Also, the average class size for science is 23.3 students per class and for mathematics it is 23.3 students per class. The mobility index (transfers of students in and out of the school throughout the school year) is 37%. The percentage of students who are suspended indoors (students are removed from the classroom for a definite amount of time for persistent misbehavior, but they remain on school grounds) and outdoors (students are removed from the school for a definite amount of time for persistent misbehavior) throughout the school year is relatively high (59%).

The fact that the middle school where the study was conducted is designated as a School Improvement Zone (SIZ) school, as previously discussed in this section, is a limitation in my study. The category of SIZ means that this particular middle school probably is not very representative of the other schools around the district where the other Alliance+ teachers teach. Thus, it is difficult to generalize my findings to all other Alliance+ teachers who were not given an opportunity to participate in my study. I recommend that others interpret my findings with caution and decide whether they are applicable to their school contexts. I provide descriptive information about the participating middle school from which the sample was drawn (in this section, Section 3.3) and the study participants (Section 3.4) to assist others in determining if my findings are applicable to their situations.

3.4 Study Sample

As mentioned in Section 3.3, I was given access for collecting data at one middle school in Miami-Dade County, Florida. In the participating middle school, there were five mathematics/science teachers who had participated in the Alliance+ professional development program. Because my study aimed to evaluate the effectiveness of the Alliance+ project, an experimental group (Alliance+ teachers) and a control group (non-Alliance+ teachers) were needed for comparison.

Although the five mathematics/science teachers who had participated in the Alliance+ project were invited to participate in the study, only four out of the five Alliance+ teachers volunteered. The other mathematics/science teachers who were working at the school and who had not participated in the Alliance+ project were also invited to participate in my study as part of a comparison group. They were required to have been teaching to the same grade levels and the same subjects as the Alliance+ teachers. From seven non-Alliance+ teachers who were invited to participate, only three teachers volunteered.

The total teacher sample for this study consisted of seven (four science and three mathematics teachers). Out of the seven science/mathematics teachers, four had participated in the Alliance+ project (experimental group) and three had not participated in the Alliance+ project (control group). Descriptive information for each of the seven participating teachers (Alliance+ and non-Alliance+) is provided in Table 3.3, which gives grade level and subject taught, gender, level of professional degree earned, and number of years of teaching experience. All teachers in the Florida school system are required to undertake courses in order to renew their certification every five years. All the teachers in the control group had been offered the same district-offered workshops to gain the credits required. Other training received would have been in the form of courses taken to complete various degrees. Therefore, the differentiation in teacher training is more related to their degree status than to other trainings. The degree status is discussed in Table 3.3.

Table 3.3 Descriptive Information about Each Alliance+ and Non-Alliance+ Teacher Participant

Teacher	Alliance+ Participant	Grade Levels Taught	Subject Taught	Gender	Level of Professional Degree	Years Teaching
1	Yes	7 & 8	Science	Male	Masters	10
2	Yes	6	Science	Male	Specialist	14
3	Yes	7 & 8	Mathematics	Female	Bachelors	11
4	Yes	6 & 7	Mathematics	Male	Masters	15
5	No	6 & 7	Science	Female	Bachelors	7
6	No	7	Mathematics	Female	Masters	13
7	No	8	Science	Male	Specialist*	19

* A Specialist Degree in Science Education certifies one to teach science and mathematics to secondary students.

As discussed in Section 3.3, it was very difficult to gain access to the five middle schools where all of the Alliance+ teachers were working. I would have liked to select my target population (all 17 teachers who had participated in the Alliance+ professional development program), but I was granted permission to collect data in only one middle school. This is a limitation in my study because it is difficult to generalize my findings confidently to all Alliance+ teachers in the district. However, it is important to acknowledge that the four Alliance+ teachers who participated in my study are representative of the set of 17 teachers (i.e. grade level taught, number of years teaching, level of professional degree earned, and gender).

Once I had secured the teacher sample, the teachers gave me access to their classes. But, before I could collect data, I needed permission from the students' parents. A parental permission letter was sent home with each student. A copy of the parental permission letter is found in Appendix 2. Data were only collected from students whose parents allowed them to participate in the study. The total student sample in my study consisted of 759 students (372 mathematics students in 19 classes and 387 science students in 19 classes) in one middle school in Miami-Dade County, Florida.

3.5 Instruments

Instruments were needed for assessing students' perceptions of their science/mathematics classroom environment and their attitudes towards science/mathematics. In this section, I discuss the process followed in selecting and modifying the learning environment scales (Section 3.5.1) and in developing the modified attitude scale (Section 3.5.2). Section 3.5.3 discusses the final steps followed in incorporating the learning environment scales and the one attitude scale into a single instrument.

3.5.1 Selection and Modifications of Learning Environment Scales

To assess students' perceptions of their science/mathematics learning environment, I decided to use scales from the Constructivist Learning Environment Survey (CLES, Taylor & Fraser, 1991) and the What Is Happening In this Class? (WIHIC, Fraser et al., 1996) questionnaires.

The CLES was developed to assess the degree of constructivism perceived by the students in the science/mathematics classroom environment. During the training portion of the Alliance+ project, the teachers were taught how to implement constructivist methodologies into their science/mathematics lessons. Therefore, the CLES seemed like a wise choice to use in my study. Section 2.3.2 provided a detailed description of the development and validation of the CLES.

I chose only Personal Relevance (the degree to which the learning is made relevant to the students' lives), Critical Voice (the extent to which the teacher allows the students to critique their learning activities), and Shared Control (the extent to which the teacher allows the students to share the control of planning, managing and assessing learning activities, and to negotiate social norms) out of the five original CLES scales.

These three scales were the most appropriate for evaluating aspects of the Alliance+ professional development program that the teachers were encouraged to implement in their own classrooms. Only one minor modification was made to the three scales.

The word ‘science’ was added to each scale to remind the respondent to answer the items in terms of his/her science class. For example, the phrase “In this class…” was reworded to “In this science/mathematics class…”.

The WIHIC combines modified versions of the most important scales taken from historically-important learning environment questionnaires with new scales assessing contemporary educational aspects of the learning environment such as cooperative learning and equity. Section 2.3.3 discussed the development and validation of the WIHIC. I chose the four scales that were most relevant for my study, namely, Teacher Support (the extent to which the teacher is interested in the students, while displaying characteristics of helpfulness, trustfulness, friendliness, etc.), Involvement (measures the extent to which students are involved and participate in the class), Investigation (measures the extent to which there is an emphasis on inquiry learning and problem solving), and Cooperation (measures the extent to which students cooperate rather than compete with one another on learning tasks) from the seven original scales of the WIHIC.

Only one modification was made to the items in the four scales. The phrase “In this science/mathematics class…” was added at the beginning of each scale. For example, an item that originally read “I discuss my ideas in class” was reworded to “In this science/mathematics class, I discuss my ideas”. The minor change was basically made to ensure that the items’ format was consistent with the CLES’s format because the scales from the CLES and WIHIC were going to be placed in a single questionnaire.

3.5.2 Development of the Modified Attitude Scale

The attitude scale was modeled on the Test Of Science-Related Attitudes (TOSRA, 1981), which was originally designed to measure seven distinct dimensions of science-related attitudes among students at the secondary school level. Section 2.5 discussed the TOSRA in more detail, including its development and validation. The original TOSRA includes seven scales, but only the Enjoyment of Science Lessons scale was chosen for my study.

Several modifications were made to the items in the chosen scale. First, the items were all reworded to measure enjoyment of the science/mathematics class itself or the lessons within the science/mathematics class. For instance, an item that read "I look forward to science/mathematics lessons" was reworded to "I look forward to this science/mathematics class". Second, the title of the scale was changed to Enjoyment of my Science/Mathematics Class. Third, items that originally were worded in a negative manner such as "I dislike science/mathematics lessons" were rephrased in a positive manner such as "I like the science/mathematics lessons in this class" to avoid confusing the students when responding to the items on the questionnaires. The ability to answer negatively-worded statements in relation to negatively-worded categories on the response scale (i.e., Seldom, Almost Never) is challenging even for high school students (Miller & Cleary, 1993; Taylor, Fraser, & Fisher, 1997). Finally, only eight out of the 10 items in the Enjoyment of Science Lessons scale were chosen because they were the most relevant for my study.

3.5.3 Final Phase of the Development of Instruments

After the selection, development, and modifications of the seven learning environment scales and the one attitude scale were completed, they needed to be placed into a single questionnaire. Because the scales had been chosen from three distinct instruments, I had to merge the scales into a single questionnaire without compromising their original design. Thus, I decided to format the entire questionnaire in the same manner as the CLES to ensure consistency from one scale to the other. First, all items in a particular scale were placed in a block, and the phrase "In this science/mathematics class…" was placed at the beginning of each scale. Also, the same response alternatives (i.e., Almost Never, Seldom, Sometimes, Often, and Almost Always) were used throughout the questionnaire. This required that the Likert-type response format (i.e., Strongly Agree, Agree, Not Sure, Disagree, and Strongly Disagree) unique to the TOSRA was changed to the frequency response format used in the CLES and WIHIC. Finally, one set of instructions had to be used for the entire questionnaire. Because the new questionnaire required that respondents to answer both learning environment and attitude items using the same frequency response scale, it was important to modify the directions to make them more generic and equally suited to the learning environment items and attitude items. For example, a portion of the directions that read "Draw a circle around 1 if the practice takes place Almost Never" was changed to "Draw a circle around 1 if the statement applies Almost Never".

Because the data were going to be collected from science and mathematics students separately, two separate instruments were created, the *Questionnaire about my Science Class* and the *Questionnaire about my Mathematics Class*, each containing the scales I chose from the CLES, WIHIC, and TOSRA. The Questionnaire about my Science Class had the items worded to measure perceptions of the science learning environment and attitudes towards the science class or science lessons. The items in the Questionnaire about my Mathematics Class were worded to measure perceptions of the mathematics learning environment and attitudes towards the mathematics class or mathematics lessons. The completed versions of both instruments used in the present study are provided in Appendix 3 (Questionnaire about my Science Class) and Appendix 4 (Questionnaire about my Mathematics Class).

3.6 Data-Collection Procedures

The present study combined two distinct methods of data collection, namely quantitative data collection and qualitative data collection. Using a combination of quantitative and qualitative methods of data collection in a research study has been proposed as a way of enriching the validity of the findings (Fraser, 1999; Fraser & Tobin, 1991; Tobin & Fraser, 1998). In this section, I discuss how the quantitative (Section 3.6.1) and qualitative (Section 3.6.2) data were collected.

3.6.1 Quantitative Data Collection

Quantitative data were collected with the Questionnaire About My Science Class and the Questionnaire About My Mathematics Class. As discussed in Section 3.5, these two instruments include seven learning environment scales based on the CLES and WIHIC and one attitude scale modeled on the TOSRA. The questionnaires were administered to 759 students of seven mathematics/science teachers (four Alliance+ participants and three non-participants) in one middle school in Miami-Dade County, Florida.

Before administering the questionnaires, they were coded according to teacher, grade level, class, and subject to keep track of them throughout the data-collection process and to make it easier at a later time when entering the data into the data base. The instruments were administered by my research assistant and several other administrators who were trained by her. The training was important to ensure consistency in the data-collection process.

The following steps were taken during the questionnaire administration process:

- The teachers were asked to step out of the classroom during the time when the students were completing the questionnaires. This made the students feel more at ease when answering the statements about their classroom environment.
- The questionnaire administrators read the directions for the students and completed a practice sample item with them.
- Before the students began to answer the questionnaires, the questionnaire administrators clarified any questions that they had. Also, they made the students feel comfortable in answering the questionnaire by advising them that their responses would not be read and that their questionnaires would be placed in a sealed envelope.
- The respondents were allocated unlimited time to complete the questionnaire.
- The questionnaires were collected by one student in the class and placed in an envelope, which was sealed by the one student before handing it to the questionnaire administrator.

Issues of time and fatigue were not considered to be a problem. Students in the Miami-Dade County Public School system are given many diagnostic and state tests throughout the year. Most of these test last two to three hours and have a multitude of directions and answering formats. Because there was no time limit for the questionnaire and the directions for the test and the method of answering were also consistent throughout, a 50-question survey would not pose any fatigue problems for the students. The pressure of doing well was also lifted when students were told that they didn't need to provide their names and that their teachers would not see or read their responses.

3.6.2 Qualitative Data Collection

As discussed in the previous sections, the main data-collection method employed in my study involved the administration of questionnaires to assess students' attitudes and perceptions of classroom learning environment. In addition, as recommended by Tobin and Fraser (2008), my study incorporated a minor qualitative data-collection component based on interviews with a small number of participating teachers (but not students). Although valuable, the qualitative component had a scope that was small enough to represent a limitation of this study and to suggest a springboard for future research.

Qualitative data were collected in the form of interviews. The sample for the qualitative data collection consisted of the four teachers who had participated in the Alliance+ professional development program. They were informally interviewed to get their perspectives on the long-lasting effects of their participation in the project. The qualifications and characteristics of the four Alliance+ teachers are as follows:

- Teacher #1 is a veteran teacher who has worked in the school district for 10 years. He holds a Masters Degree in Science Education and is certified to teach science to students at the secondary school level. He has worked with middle-school students in disadvantaged neighborhoods for most of his teaching career. He is currently the Science Chairperson, which makes him responsible for curriculum issues concerning all Grade 6–8 students at the school.

- Teacher #2 has worked in one middle school and two high schools during his teaching career of 14 years. He currently teaches sixth-grade science but has also taught science and mathematics to students in Grades 7–12. This teacher earned a Masters Degree in Mathematics Education and a Specialist Degree in Science Education. He is certified to teach science and mathematics to secondary students.
- Teacher #3 currently teaches mathematics to students in Grades 7 and 8. She has been working as an educator for 11 years at the same middle school. She holds a Bachelors Degree in Mathematics Education and is certified to teach mathematics at the middle-school level. Teacher #3 was selected as Teacher of the Year by her colleagues on two occasions. She has served as president on several committees at her school and at the district level.
- Teacher #4 has taught mathematics to middle-school students for 15 years. He currently teaches mathematics to 6^{th} and 7^{th} grade students. He earned a Masters Degree in Mathematics Education and National Board Certification (the highest certification received by an educator in the U.S.) in the area of middle-school mathematics (see Table 3.3).

The interviews were conducted in a group setting, which included my research assistant, the four interviewees, and me. The interviewees were made to feel comfortable during the entire process, and they were told that their responses would remain anonymous. A tape recorder was used to audiotape the interviews in order to ensure that all conversations were captured to make it easier when analyzing the data later. Also, notes were taken during the interview process. To better understand the responses, my research assistant and I paraphrased what was being said by the teachers during the interview. This paraphrasing strategy is highly recommended to help to increase the validity of findings (Anderson & Arsenault, 1998).

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

3.7 Procedures for Preparing and Analyzing the Data

To answer the four research questions delineated in Section 3.2, the quantitative and qualitative data that were collected had to be analyzed carefully. The procedures taken to prepare and analyze the data after they had been collected are discussed in this section. First, Section 3.7.1 discusses how the quantitative data were prepared for statistical analyses. Then, Section 3.7.2 discusses the steps taken to analyze the quantitative data. Finally, the preparation and analyses of the qualitative data are discussed in Section 3.7.3.

3.7.1 Preparation of Quantitative Data for Analyses

After the questionnaires had been administered to the 759 students of the seven middle-school teachers who participated in the present study, each student's responses were checked. Fortunately, all instruments were complete, and so the student responses from all 759 questionnaires were entered directly into a database using the Microsoft Excel software by a Data Specialist.

The responses of Almost Never, Seldom, Sometimes, Often, and Almost Always were entered as 1, 2, 3, 4, and 5, respectively, into the database. Other important information such as questionnaire number, teacher's name, class number, and grade level were also entered directly from the questionnaires into the database. After all data had been entered, a hard copy of the database was printed and two other data specialists manually checked it for errors by selecting a random sample of the questionnaire responses and comparing them with the data entered in the database.

3.7.2 Statistical Analysis of Quantitative Data

After the quantitative data had all been entered into the database, they were statistically analyzed to answer the research questions listed in Section 3.2. To answer the first research question concerning the validity and reliability of the learning environment scales based on the CLES and WIHIC and the one attitude scale modeled on the TOSRA, the following analyses were conducted:

- An item analysis was conducted for the 58 items in the learning environment scales and the one attitude scale separately for data gathered from the mathematics and science students. Items having a low item-remainder correlation were removed and excluded from subsequent analyses for both the mathematics and science samples. Eight items were removed in total.
- To examine the internal structure of the remaining 50 items of the learning environment scales and the one attitude scale, the data collected from the mathematics and science students were subjected to principal components factor analysis followed by varimax rotation.
- To check whether every item in each learning environment scale and the one attitude scale assesses a similar construct, the internal consistency reliability was calculated for each scale separately for science and mathematics. The Cronbach alpha coefficient was calculated at two units of analysis (individual and class mean) as the index of scale of internal consistency.
- To check whether each of the learning environment scales and the one attitude scale measures a distinct construct, the discriminant validity was calculated for each scale for two units of analysis (individual and class mean). The mean correlation of a scale with other scales was the convenient index used to determine discriminant validity.
- One-way ANOVA was used to determine the ability of each learning environment scale to differentiate significantly between the perceptions of the mathematics and science students from the different classrooms.

To answer the second research question concerning the effectiveness of the Alliance+ professional development program in terms of middle-school students' perceptions of their classroom learning environment and their attitudes towards science/mathematics, a MANOVA was conducted to determine whether differences existed between the students of teachers who had participated in the Alliance+ project and the students of teachers who had not participated. The dependent variables consisted of the seven learning environment scales based on the CLES and WIHIC and the one attitude scale modeled on the TOSRA. The independent variable used was the method of teacher training (Alliance+ or non-Alliance+).

To answer the third research question, which involved whether or not the Alliance+ professional development program was differentially effective for mathematics and science teachers, a two-way MANOVA was conducted. The seven learning environment scales based on the CLES and WIHIC and the one attitude scale modeled on the TOSRA were used as the set of dependent variables. The two independent variables were a two-level instruction variable (Alliance+ or non-Alliance+) and a two-level subject variable (mathematics or science). The existence of differential effectiveness of Alliance+ for mathematics or science students was indicated by the presence of a statistically significant instruction-by-subject interaction.

To answer the fourth research question concerning whether or not an association exists between students' perceptions of their classroom learning environment and their attitudes toward science/mathematics, simple correlation and multiple regression analyses were performed at two units of analysis (individual and class mean).

The results of all the statistical analyses are reported in Section 4.2 (results for Research Question #1), Section 4.3 (results for Research Question #2), Section 4.4 (results for Research Question #3), and Section 4.5 (results for Research Question #4).

3.7.3 Preparation and Analysis of Qualitative Data

As discussed in Section 3.6.2, the teacher interviews were tape recorded, and field notes were also taken during the interviews (Patton, 1990). In preparing these data for analysis, it was of utmost importance to code the notes from the interview to ensure that it was organized according to the interviewees' comments. The teachers were told before the interview began that they would each have a code number and that they would be referred to as the code number each time they were asked a question during the interview. They were also told to state their code number before responding to a question. This was very important because the interviews were conducted as a whole group, and the data transcribers would have to know later who was responding to each question when listening to the audiotapes.

The interview data that were gathered were analyzed by a research assistant and me. First, the tape recordings were transcribed. Second, another coding system was created to place the data into two distinct categories: data that supported the quantitative findings, and the data that did not. Then, copies were made of all of the transcriptions and the field notes, and then they were organized according to the data categories that had been created. Marginal notes were also taken as the data were being categorized to use later when discussing the results. Next, my research assistant and I reviewed the data again and discussed the patterns that had been found. Finally, the information that was discussed and the marginal notes that were taken were used when reporting the qualitative results in Section 4.3.

3.8 Summary of Methodology

The methodology of my research study was discussed in this chapter. Although the main objective of my study was to investigate the effectiveness of the Alliance+ professional development program in terms of students' learning environment perceptions and their attitudes towards science/mathematics, other secondary objectives emerged. For instance, the first objective became to validate the instruments that were used to gather data. Also, investigating the differential effectiveness of the Alliance+ project for science and mathematics teachers became an objective of my study, as did investigating association between students' perceptions of their classroom learning environment and their attitudes towards science/mathematics. The total student sample in my study consisted of 759 of seven mathematics/science teachers (four Alliance+ participants and three non-participants) in one middle school in Miami-Dade County, Florida.

The instruments used to assess students' perceptions of their classroom learning environment and their attitudes towards mathematics/science included learning environment scales based on the CLES and the WIHIC questionnaires, as well as an attitude scale modeled on the TOSRA. Modifications were made to some of the items and minor adjustments were made to the format of the response scales (see Appendix 3 to view the Questionnaire about my Science Class and Appendix 4 to view the Questionnaire about my Mathematics Class).

In order to investigate the validity of the questionnaire, the data gathered were statistically analyzed in terms of factor structure, discriminant validity, internal consistency reliability and ability to differentiate between classrooms.

The same data collected during the validation of the instruments were used to answer the main research question concerning the effectiveness of the Alliance+ professional development program in terms of students' perceptions of their classroom learning environment and their attitudes towards science/mathematics. A one-way MANOVA was conducted for this purpose. The data were also statistically analyzed using a two-way MANOVA to investigate the differential effectiveness of the Alliance+ professional development program for mathematics and science teachers. Finally, the same data were statistically analyzed using simple correlation and multiple regression analyses to determine whether associations exist between students' perceptions of the classroom learning environment and their attitudes towards science/mathematics. The results of all these analyses are reported in Chapter 4.

As a minor component of my overall study, supplementary qualitative data also were collected via interviews with four teachers. The smallness of the scope of my study's qualitative component is a limitation of the research. The next chapter reports the results of my study.

Chapter 4

ANALYSES AND RESULTS

4.1 Introduction to Chapter 4

The effectiveness of the Alliance+, a professional development program for middle-school teachers, was evaluated as the main focus of my research study. This innovative program was evaluated in terms of these middle-school teachers' students' perceptions of the classroom learning environment and their attitudes towards science/mathematics. Data were gathered from 759 students of seven mathematics/science teachers (four Alliance+ participants and three non-participants) in one middle school in Miami-Dade County, Florida. The instruments used to assess students' perceptions of their classroom learning environment and their attitudes towards mathematics/science included learning environment scales based on the Constructivist Learning Environment Survey (CLES) and the What Is Happening In this Class? (WIHIC) questionnaires as well as an attitude scale modeled on the Test Of Science-Related Attitudes (TOSRA).

Before using the instruments with confidence in my study, it was important to check their validity and reliability. Thus, the data gathered from the 759 middle-school students were used for that purpose. In addition, the data were used to explore associations between students' attitudes to science/mathematics and their perceptions of the classroom learning environment.

All data collected from the student sample were statistically analyzed to answer the research questions of my study (see Section 1.6 to view the research questions), and the results are reported in this chapter under four separate sections. In Section 4.2, I report the results for the validity and reliability of the learning environment scales based on the CLES and WIHIC and an attitude scale based on the TOSRA. In Section 4.3, I report the results for the effectiveness of the Alliance+ professional development model in terms of students' perceptions of the classroom learning environment and their attitudes to science/mathematics. In Section 4.4, I report the results for the differential effectiveness of the Alliance+ model for science and mathematics teachers. In Section 4.5, I report the results of analyses for associations between students' attitudes to science/mathematics and their perceptions of the classroom learning environment.

4.2 Validity and Reliability of Learning Environment Scales Based on the CLES and WIHIC and an Attitude Scale Based on the TOSRA

To measure students' perceptions of their classroom learning environment, I chose scales from two widely-applicable learning environment questionnaires: the Constructivist Learning Environment Survey (CLES, Taylor & Fraser, 1991) and the What Is Happening In this Class? (WIHIC, Fraser, Fisher, & McRobbie, 1996). To measure student's attitudes towards science/mathematics, I created an attitude scale modeled on the Test Of Science-Related Attitudes (TOSRA, Fraser, 1981).

According to Fraser (1998b), the CLES is useful for assessing the degree to which the science/mathematics classroom environment is consistent with a constructivist epistemology. This aspect of the CLES was appealing for my study because the professional development program, Alliance+, which I aimed to evaluate as part of my research study, encouraged the use of constructivist ideas in the science and mathematics classrooms. Another feature of the CLES that appealed to me is that its original version, as well as shortened, translated, and/or modified versions, have been found to be valid and reliable when used in small-scale and large-scale studies in different parts of the world such as Australia (Taylor, Fraser, & Fisher, 1997), Korea (Kim, Fisher, & Fraser, 1999), South Africa (Aldridge, Fraser, & Sebela, 2004), and the United States (Dryden & Fraser, 1996, 1998; Johnson & McClure, 2004; Nix, Fraser, & Ledbetter, 2005; Peiro & Fraser, 2005; Spinner & Fraser, 2005). A cross-national study conducted with secondary-school students between Taiwan and Australia (Aldridge, Fraser, Taylor, & Chen, 2000) also found the CLES to be valid and reliable (refer to Section 2.3.2 for more information about the development and validation of the CLES).

From the CLES's five original scales, I chose only three for my study (namely, Personal Relevance, Critical Voice, and Shared Control). Those three scales were appealing for me because the teachers who participated in the Alliance+ professional development program were attempting to improve the aspects of the learning environment assessed by these scales.

The What Is Happening In this Class? (WIHIC) is a combination of modified versions of the most important scales taken from historically-important learning environment questionnaires. To measure contemporary educational aspects of the learning environment such as cooperative learning and equity, additional scales were incorporated into the WIHIC as well (Fraser, 1998b). From all of the existing learning environment questionnaires, none has been more widely applied to a variety of contexts, subject areas, and grade levels than the WIHIC. The original version and/or modified versions of the WIHIC have been used in numerous studies conducted in the United States (Adamski, Peiro, & Fraser, 2005; Allen & Fraser, 2007; Helding & Fraser, 2005; MacDowell-Goggin & Fraser, 2004; Moss & Fraser, 2001; Ogbuehi & Fraser, 2007; Pickett & Fraser, 2004; Robinson & Fraser, 2003; Soto-Rodriguez & Fraser, 2004) and Canada (Raaflaub & Fraser, 2003). The WIHIC is also flexible enough to be translated into other languages, which has allowed researchers in Asian countries to translate either the original version or modified versions of the questionnaire for use in their studies in Singapore (Chionh & Fraser, in press; Khoo & Fraser, 2008), in Brunei (Khine & Fisher, 2001; Riah & Fraser, 1998), in Korea (Kim, Fisher, & Fraser, 2000), and Indonesia (Margianti, Aldridge, & Fraser, 2004; Soerjaningsih, Fraser, & Aldridge, 2001). Cross-national studies using the WIHIC are also common because of the questionnaire's flexible nature. For instance, the WIHIC has been cross-validated between nations such as England, Canada, and Australia (Dorman, 2003), Taiwan and Australia (Aldridge & Fraser, 2000), Canada and Australia (Zandvliet & Fraser, 2004), and Indonesia and Australia (Adolphe, Fraser, & Aldridge, 2003). For further information about the WIHIC's conceptualization and characteristics, refer to Section 2.3.3.

Four of the seven original scales of the WIHIC were chosen for my study. The scales are Teacher Support, Involvement, Investigation, and Cooperation. Minor modifications were made to several items in the four scales. For example, an item that read "I discuss my ideas in class" was reworded to "In this mathematics/science class, I discuss my ideas". The minor changes were basically made to ensure that the wording made sense according to the CLES's format because the scales from the CLES and WIHIC were going to be placed in a single questionnaire.

The Test Of Science-Related Attitudes (TOSRA) was originally designed to measure seven distinct dimensions of science-related attitudes among students in the secondary grades (Fraser, 1981). Original, modified, and translated versions of the TOSRA have been used with success in a number of learning environment studies conducted around the world in a variety of grade levels and subject areas in the United States (Adamski et al., 2005; Allen & Fraser, 2007; MacDowell-Goggin & Fraser, 2004; Peiro & Fraser, 2005; Robinson & Fraser, 2003; Soto-Rodriguez & Fraser, 2004), Indonesia and Australia (Adolphe et al., 2003), Taiwan and Australia (Aldridge, Fraser, & Huang, 1999), Singapore (Chionh & Fraser, in press; Wong & Fraser, 1996), Australia (Henderson, Fisher, Fraser, & Young, 2000), Indonesia (Margianti, Aldridge, & Fraser, 2004), and Brunei (Scott & Fisher, 2004).

The attitude scale that I created was modeled on only one of the seven original scales of the TOSRA, namely, the Enjoyment of Science Lessons scale. However, to make the scale more suitable for my study, I made several modifications to it. First, the items were all reworded to measure enjoyment of the science class itself or the lessons within the science class. For instance, an item that read "I look forward to science lessons" was reworded to "I look forward to this science class". Second, the title of the scale was changed to Enjoyment of my Science Class. Third, items that were negatively phrased, such as "I dislike science lessons", were rephrased in a positive manner, such as "I like the science lessons", to avoid confusing the students when responding to the items on the questionnaires. In the past, it has been found that answering negatively-phrased items on a questionnaire is challenging even for students at the high-school level (Taylor et al., 1997) because it is difficult for them to answer negatively-worded statements in relation to negatively-worded categories on the response scale (i.e., Seldom, Almost, Never). As well, research has revealed various psychometric and statistical problems with questionnaires that include negatively-worded items (Barnette, 2000; Miller & Cleary, 1993; Schriesheim, Eisenbach, & Hill, 1991). Finally, only eight out of the 10 items in the Enjoyment of Science Lessons scale were chosen.

Because the data were going to be collected from science and mathematics students separately, I created two separate instruments, the *Questionnaire about my Science Class* and the *Questionnaire about my Mathematics Class*, each containing the scales I chose from the CLES, WIHIC, and TOSRA. In the Questionnaire about my Science Class, the items were worded to measure perceptions of the science learning environment and attitudes towards science. On the other hand, the items in the Questionnaire about my Mathematics Class were worded to measure perceptions of the mathematics learning environment and attitudes towards mathematics. The format for both questionnaires had to be modified to make it easier for students to respond to the items. For example, one set of instructions and one set of response alternatives (i.e., Almost Never, Seldom, Sometimes, Often, and Almost Always) were used for each questionnaire. For more information about the creation of the Questionnaire about my Science Class and the Questionnaire about my Mathematics Class, including the modifications made to the CLES, WIHIC, and TOSRA scales, refer to Section 3.5. The final versions of both instruments can be viewed in

Appendix 3 (Questionnaire about my Science Class) and Appendix 4 (Questionnaire about my Mathematics Class).

The data collected using the Questionnaire about my Science Class and the Questionnaire about my Mathematics Class from 759 students (372 mathematics students in 19 classes and 387 science students in 19 classes) in one middle school in Miami-Dade County, Florida were statistically analyzed to answer the following research question:

Research Question # 1

> *Are learning environment scales based on the CLES and WIHIC and an attitude scale based on TOSRA valid when used with this sample of middle-school students?*

Statistical analyses used to answer Research Question #1 included factor structure (Section 4.2.1), internal consistency reliability (Section 4.2.2), and discriminant validity (Section 4.2.3) for the learning environment scales based on the CLES and WIHIC and the attitude scale based on the TOSRA for both mathematics and science students. A one-way ANOVA was also used to determine the ability of each learning environment scale to differentiate between the perceptions of students in the different mathematics and science classrooms (Section 4.2.4).

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

An item analysis was conducted for the 58 items in the learning environment and attitude scales based on the CLES, WIHIC, and TOSRA in order to check if removing any of those items would improve the internal consistency reliability and/or factorial validity of the scales. Item analysis was conducted separately for data gathered from the mathematics and science students. Items having a low item-remainder correlation were removed and excluded from subsequent analyses for both the mathematics and science samples. As there were a total of eight items that met this criterion for removal, Items 3, 6, 7, 8, and 10 were removed from the CLES scales and Items 29, 31, and 34 were removed from the WIHIC scales. All of the items from the attitude scale modeled on the TOSRA remained. From the original 58 items, 50 items were kept in the same eight-factor structure: Personal Relevance, Critical Voice, Shared Control, Teacher Support, Involvement, Investigation, Cooperation, and Attitude.

To examine the internal structure of the remaining 50 items of the learning environment scales based on the CLES and WIHIC and an attitude scale modeled on the TOSRA, the data collected from the mathematics and science students were subjected to principal components factor analysis followed by varimax rotation. The individual student scores were used as the unit of analysis. The factor loadings, percentage of variance, and eigenvalue of each learning environment scale and the one attitude scale are reported separately for mathematics and science in Table 4.1.

There are 800 possible factor loadings (50 items x 8 scales x 2 subjects = 800) for both the mathematics and science samples (see Table 4.1). The criteria used to retain an item were that it must have a factor loading of 0.40 and above with its *a priori* scale and below 0.40 with each of the other scales. As shown in Table 4.1, the majority of the items have a factor loading of 0.40 or above on their *a priori* scale and no other scale for each of the 800 cases.

Table 4.1 Factor Loadings for Learning Environment Scales Based on the CLES and WIHIC and an Attitude Scale Modeled on the TOSRA for Mathematics and Science Students

	Factor Loadings															
Item No.	Personal Relevance		Critical Voice		Shared Control		Teacher Support		Involve ment		Investi- gation		Coop- eration		Attit- tude	
	Math	Sci.	Math	Sci.	Math	Sci.	Math	Sci.	Math	Sci.	Math	Sci.	Math	Sci.	Math	Sci.
1	0.73	0.75														
2	0.71	0.72														
4	0.67	0.73														
5	0.78	0.72														
9			0.64	0.60												
11			0.74	0.73												
12			0.78	0.75												
13					0.68	0.71										
14					0.65	0.72										
15					0.73	0.76										
16					0.72	0.75										
17					0.76	0.80										
18					0.61	0.63										
19							0.52	0.58								
20							0.53	0.71								
21							0.60	0.72								
22							0.49	0.58								
23							0.66	0.67								
24							0.73	0.75								
25							0.60	0.65								
26							0.56	0.59								
27									0.64	0.56						
28									0.66	0.61						
30									0.41	0.44						
32									0.55	0.62			0.41			
33									0.40	0.56			0.50			
35											0.59	0.63				
36									0.41		0.60	0.69				
37											0.74	0.73				
38											0.60	0.64				
39											0.70	0.72				
40											0.72	0.72				
41											0.74	0.74				
42											0.64	0.60				
43													0.69	0.70		
44													0.65	0.58		
45													0.61	0.63		
46													0.50	0.46		
47													0.58	0.64		
48													0.77	0.72		
49													0.75	0.75		
50													0.67	0.61		
51															0.73	0.77
52															0.75	0.79
53															0.79	0.79
54															0.79	0.82
55															0.84	0.85
56															0.78	0.75
57															0.76	0.83
58															0.76	0.78
%Vari- ance	3.33	4.03	2.35	2.46	4.21	4.63	4.49	5.99	2.85	2.80	6.60	7.53	5.81	4.28	30.60	28.63
Eigen- value	1.7	2.0	1.2	1.2	2.1	2.3	2.3	3.0	1.4	1.4	3.3	3.8	2.9	2.1	15.3	14.3

Factor loadings smaller than 0.40 have been omitted.

The mathematics sample consisted of *N*= 372 students from 19 classes in one middle school in Miami-Dade County, Florida.

The science sample consisted of *N*=387 students from 19 classes in one middle school in Miami-Dade County, Florida.

Items 3, 6, 7, 8, 10, 29, 31, and 34 were omitted for both samples.

There are only three cases in which an item loads at least 0.40 on its *a priori* scale and on another scale. For the Involvement scale for the mathematics sample, Items 32 and 33 each have a loading of 0.40 and above on its *a priori* scale and the Cooperation scale (see Table 4.1). For the Investigation scale for the mathematics sample, Item 36 loads at least 0.40 on its *a priori* scale and the Involvement scale (see Table 4.1). Therefore, the 50-item version of the questionnaire containing learning environment scales based on the CLES (3 scales with 3–6 items in each) and the WIHIC (4 scales with 5–8 items in each) and one eight-item attitude scale modeled on the TOSRA was accepted. Thus, the *a priori* eight-factor structure of the final version was replicated, with all items having a factor loading of at least 0.40 on their a priori scale and lower than 0.40 on the other scales, with only three exceptions (see Table 4.1).

The percentage of variance for the mathematics student sample (*N*=372) for the eight scales ranges from 2.35% to 30.60%, summing up a total of 60.24% variance for all eight scales combined (see Table 4.1). The eigenvalues for the eight different scales range from 1.2 to 15.3 (see Table 4.1) for mathematics.

For the science student sample (*N*=387), the percentage of variance for the eight scales ranges from 2.46% to 28.63%, summing up a total of 60.35% variance (see Table 4.1). The eigenvalues for the science student sample range from 1.2 to 14.3 for the eight scales. Overall, the percentage of variance and eigenvalue results shown in Table 4.1 suggest that the questionnaire containing learning environment scales based on the CLES and WIHIC and an attitude scale modeled on the TOSRA has a similar factor structure when used with either the mathematics or science middle-school students who participated in the present research study.

The factor analysis results reported in this section strongly support the factor structure of the 50-item questionnaire containing learning environment scales based on the CLES (3 scales with 3–6 items in each) and the WIHIC (4 scales with 5–8 items in each) and one eight-item attitude scale modeled on the TOSRA.

4.2.2 Internal Consistency Reliability of Learning Environment Scales Based on the CLES and WIHIC and an Attitude Scale Modeled on the TOSRA

To check whether every item in each scale assesses a similar construct, the internal consistency reliability was used. The index of scale internal consistency used was the Cronbach alpha coefficient. Table 4.2 shows the Cronbach alpha coefficient for each of the eight scales (namely, three scales based on the CLES, four scales based on the WIHIC, and one attitude scale modeled on the TOSRA) using two units of analysis (individual and class mean) separately for mathematics and science student samples. When using the individual student scores as the unit of analysis, the alpha coefficient for the eight different scales ranges from 0.69 to 0.94 for the mathematics student sample and from 0.59 to 0.99 for the science student sample. When using the class mean as the unit of analysis, the alpha coefficient for the eight different scales ranges from 0.70 to 0.94 for the mathematics student sample and from 0.73 to 0.98 for the science student sample (see Table 4.2). The alpha reliabilities for all eight scales using two units of analysis are similar for both the mathematics and science student samples (see Table 4.2). These results suggest that all eight scales are reliable when used to measure students' perceptions of both the mathematics and science classroom learning environments.

Table 4.2 Internal Consistency (Alpha Reliability Coefficient) and Discriminant Validity (Mean Correlation with Other Scales) for two Units of Analysis and Ability to Differentiate Between Classrooms (ANOVA Results) for Learning Environment and Attitude Scales Based on the CLES, WIHIC, and TOSRA for Mathematics and Science Students

Scale	No of Items	Unit of Analysis	Alpha Reliability		Mean Correlation with Other Scales		ANOVA Results Eta^2	
			Math	Science	Math	Science	Math	Science
Learning Environment								
Personal Relevance	4	Student	0.77	0.78	0.32	0.30	0.14**	0.06
		Class	0.86	0.75	0.47	0.16		
Critical Voice	3	Student	0.69	0.70	0.30	0.34	0.08*	0.14**
		Class	0.59	0.90	0.33	0.42		
Shared Control	6	Student	0.84	0.86	0.38	0.35	0.12**	0.09**
		Class	0.93	0.90	0.60	0.31		
Teacher Support	8	Student	0.87	0.88	0.51	0.46	0.17**	0.12**
		Class	0.95	0.94	0.65	0.49		
Involvement	5	Student	0.82	0.80	0.50	0.46	0.13**	0.07
		Class	0.91	0.73	0.64	0.43		
Investigation	8	Student	0.89	0.89	0.46	0.44	0.11**	0.06
		Class	0.95	0.95	0.54	0.52		
Cooperation	8	Student	0.86	0.83	0.41	0.33	0.16**	0.09**
		Class	0.94	0.89	0.56	0.22		
Attitudes								
Enjoyment of my Mathematics/ Science Class	8	Student	0.94	0.94	0.41	0.38		
		Class	0.99	0.98	0.57	0.43		

The mathematics sample consisted of *N*= 372 students from 19 classes in one middle school in Miami-Dade County, Florida.
The science sample consisted of *N*=387 students from 19 classes in one middle school in Miami-Dade County, Florida.
*p<0.05, **p<0.01
Eta^2 is the ratio of between to total sums of square and represents the proportion of variance accounted for by class membership
Items 3, 6, 7, 8, 10, 29, 31, and 34 were omitted for both samples.

Overall, the results reported in this section suggest that the learning environment scales based on the CLES and WIHIC and the one attitude scale modeled on the TOSRA are reliable when used with this sample of middle-school mathematics and science students in Miami-Dade County, Florida.

One study, also conducted in Miami-Dade County, Florida, found modified English and Spanish versions of the Personal Relevance and Critical Voice scales of the CLES to be reliable when used with elementary-school students (Peiro & Fraser, 2005). In that particular study, the alpha reliabilities ranged from 0.79 to 0.95 for both scales with the individual or the class mean as the units of analysis. In addition, the Personal Relevance, Critical Voice, and/or Shared Control scales from the CLES displayed satisfactory internal consistency reliability in other studies conducted with secondary-school students in Korea (Kim et al., 1999), Australia and Taiwan (Aldridge et al., 2000), South Africa (Aldridge et al., 2004), and the United States (Dryden & Fraser, 1996, 1998; Johnson & McClure, 2004; Nix et al., 2005).

The WIHIC scales that I validated in my study (namely, Teacher Support, Involvement, Investigation, and Cooperation) were also found to have satisfactory internal consistency reliability in past learning environment studies (Adamski et al., 2005; Allen & Fraser, 2007; Dorman, 2003; Chionh & Fraser, in press; Helding & Fraser, 2005; Khoo & Fraser, 2008; MacDowell-Goggin & Fraser, 2004; Margianti et al., 2004; Pickett & Fraser, 2004; Riah & Fraser, 1998; Robinson & Fraser, 2003; Soto-Rodriguez & Fraser, 2004; Zandvliet & Fraser, 2005).

The original, modified, and/or translated versions of the Enjoyment of Science Lessons scale from the TOSRA, which was the one used to create the one attitude scale for my study, were found to have satisfactory internal consistency reliability in a variety of research studies conducted among both science (Allen & Fraser, 2007; Helding & Fraser, 2005; MacDowell-Goggin & Fraser, 2004; Martin-Dunlop & Fraser; 2008; Peiro & Fraser, 2005; Soto-Rodriguez & Fraser, 2004; Wong & Fraser, 1996) and mathematics (Castillo, Peiro, & Fraser, 2005; Raaflaub & Fraser, 2003; Spinner & Fraser, 2005; Taylor, 2004) students in numerous contexts, especially.

Thus, my results replicate those of past research studies that have used the original, modified and/or translated versions of the Enjoyment of Science Lessons scale.

4.2.3 Discriminant Validity of Learning Environment Scales Based on the CLES and WIHIC and an Attitude Scale Modeled on the TOSRA

To check whether each of the learning environment scales and the one attitude scale measures a distinct construct, the discriminant validity was calculated for each of the eight scales. The mean correlation of a scale with other scales was the convenient index used to determine discriminant validity (see results in Table 4.2). When the individual student scores were used as the unit of analysis, the mean correlation of a scale with other scales ranged from 0.30 to 0.51 (mathematics student sample) and from 0.30 to 0.46 (science student sample) for different scales. When the class mean was used as the unit of analysis, the mean correlation of a scale with other scales ranged from 0.33 to 0.65 (mathematics student sample) and from 0.16 to 0.52 (science student sample) for different scales. The values shown in Table 4.2 suggest some overlap between raw scores on the learning environment scales based on the CLES and WIHIC and one attitude scale modeled on the TOSRA. Nevertheless, the factor analysis reported previously in Table 4.1 attests to the independence of factor scores on the eight CLES, WIHIC, and TOSRA scales.

4.2.4 Ability of the Learning Environment Scales Based on the CLES and WIHIC to Differentiate between Classrooms

One-way ANOVA was used to determine the ability of each learning environment scale to differentiate significantly between the perceptions of the mathematics and science students from the different classrooms. For each ANOVA, scores on one of the learning environment scales constituted the dependent variable and class membership was the independent variable. ANOVA results for each of the seven learning environment scales (Personal Relevance, Critical Voice, Shared Control, Teacher Support, Involvement, Investigation, and Cooperation) are reported in Table 4.2. The eta^2 statistic, which is a measure of the degree of association between class membership and the dependent variable for each of the learning environment scales ranges from 0.08 to 0.17 for the mathematics student sample and from 0.06 to 0.14 for the science student sample (see Table 4.2). All seven WIHIC scales were able to differentiate significantly ($p<0.05$) between classes for the mathematics student sample. For the science student sample, four of the seven learning environment scales (namely, Critical Voice, Shared Control, Teacher Support, and Cooperation) were able to differentiate significantly ($p<0.01$) between classes. Overall, the ANOVA results provide further evidence that the learning environment scales based on the CLES and WIHIC are valid.

My results replicate past research studies, which have consistently found that scales from the CLES are able to differentiate significantly ($p<0.05$) between students' perceptions in different classrooms (Aldridge et al., 2004; Aldridge et al., 2000; Johnson & McClure, 2004; Kim et al., 1999; Nix et al., 2005) and the WIHIC (Aldridge & Fraser, 2000; Allen & Fraser, 2007; Khoo & Fraser, 2008).

4.3 Results for Effectiveness of the Alliance+ Model for the Whole Sample in Terms of Classroom Learning Environment and Attitudes

4.3.1 Pre-Empting the Possibility of Instruction x Subject Interactions

At the outset, it is important to emphasize that Section 4.3 focuses on the overall effectiveness of Alliance+ for the whole sample of the students of mathematics and science teachers combined. Therefore, it is quite possible that any findings for the combined sample might not necessarily apply equally well to the separate subsamples of mathematics and science teachers. For this reason, Section 4.4 reports another set of analyses concerning the differential effectiveness of Alliance+ for the students of mathematics and science teachers. Consequently, the results for the whole sample reported in the present section might need to be modified later in the light of findings about differential effectiveness reported later in Section 4.4.

4.3.2 MANOVA and Effect Sizes

The Alliance+ professional development program was created in an attempt to integrate computer technology into mathematics and science curricula. The mathematics and science teachers who were trained under the Alliance+ project attended ten workshops at which they were taught principles of web development, cooperative learning, and PowerPoint presentation and were given access to online collaborative units around the world. They were also taught techniques to improve their classroom learning environment. An extension of the Alliance+ project consisted of encouraging teachers and students to design projects that would be displayed online to share with other teachers and students around the world.

The Alliance+ professional development program actually began in 1998 and was implemented for five years. During a four-year span, a multimethod research approach including experimental, qualitative, quantitative and historical techniques was used to evaluate the effectiveness of the Alliance+ project (Biggs & Fraser, 2006). Data gathered from 530 teachers from 53 middle schools within a year of participation in the project were generally positive (Yepes-Baraya & Biggs, 2001). During interviews, a pattern emerged in which teachers voiced their excitement and firm belief in the program. As one teacher put it: "The internet resources add tremendous excitement and motivation for the students…I think it dramatically increases the opportunities for self-directive learning." Based on observations conducted in science classrooms, it was noted that most teachers were implementing a constructivist approach in their science lessons and that typically students were highly involved in learning, cooperated with each other, and participated in making decisions about media and resources. Furthermore, results from interviews with students suggested that the constructivist lessons that teachers had learned from the workshops generally were being implemented in the classrooms, which made students feel they were allowed more choices of an educational nature. Students also frequently reported feeling more interested in the subject after the teachers implemented lessons that were constructivist in nature. In addition, many students and teachers alike were eager and willing to participate in online activities suggested by the Alliance+ training team (Yepes-Baraya & Biggs, 2001). For a detailed description of the Alliance+ professional development program and more information regarding earlier evaluation phases of the program, (refer to Section 1.3).

Because it is important to investigate the long-term effect of any innovative program, I chose to evaluate the effectiveness of the Alliance+ professional development model two years after the program had ended. It was evaluated in terms of mathematics and science Alliance+ teachers' students' perceptions of their classroom learning environment and their attitudes towards science/mathematics. That became the main objective of my doctoral research study, and the results are reported in the present section of this thesis.

As previously discussed in Section 4.2, the Questionnaire about my Science Class (see Appendix 3) and the Questionnaire about my Mathematics Class (see Appendix 4), each containing scales based on the CLES, WIHIC, and TOSRA, were utilized to assess the classroom environment perceptions and attitudes to science/mathematics of 759 mathematics/science students in 38 classes in one middle school in Miami-Dade County, Florida.

Although the main sample consisted of 759 students, it was divided into two separate samples to answer the research question for this part of the study. One sample (N=495) was composed of the students who were taught by two mathematics and two science teachers who had participated in the Alliance+ professional development program. The other sample (N=264) consisted of the students who were taught by one mathematics and two science teachers who had not participate in the Alliance+ professional development program. This comparison between an experimental group (students of teachers who participated in the Alliance+ training) and a control group (students of teachers who did not participate in the Alliance+ training) provides a strong research design. This type of design, known as causal-comparative, is helpful in establishing cause-effect relationships when an experimental design cannot be used (Dunham, 1988).

The data gathered were statistically analyzed to answer the following research question:

Research Question #2

> *Is the Alliance+ professional development model effective in terms of middle-school students':*
>
> e) *perceptions of classroom learning environment*
>
> f) *attitudes to science/mathematics?*

A MANOVA was the statistical analysis used to determine whether differences existed between teachers who had participated in the Alliance+ professional development program and teachers who had not participated in terms of their students' perceptions of the learning environment and their attitudes towards science/mathematics. The dependent variables consisted of the seven learning environment scales based on the CLES and WIHIC and the one attitude scale modeled on the TOSRA, and the independent variable used was the method of teacher training (Alliance+ or non-Alliance+). Because the MANOVA produced statistically significant results using Wilks' lambda criterion, the univariate ANOVA results were interpreted for each of the eight dependent variables as shown in Table 4.3.

As reported in Table 4.3, the MANOVA results show that the F ratio was statistically significant ($p<0.05$) for two out of the seven learning environment scales (namely, Teacher Support and Cooperation) and the one attitude scale. However, nonsignificant differences were found between the two groups for the other five learning environment scales (namely, Personal Relevance, Critical Voice, Shared Control, Involvement, and Investigation).

Table 4.3 Average Item Mean, Average Item Standard Deviation and Difference between Alliance+ and Non-Alliance+ Teachers (Effect Size and MANOVA Results) for Mathematics and Science Students' Scores on Learning Environment and Attitude Scales

Scale	Average Item Mean[a]		Average Item Standard Deviation		Difference	
	Alliance+	Non-Alliance+	Alliance+	Non-Alliance+	Effect Size	*F*
Learning Environment						
Personal Relevance	3.04	2.96	1.07	0.99	0.08	0.73
Critical Voice	3.35	3.51	1.11	1.02	-0.15	3.60
Shared Control	2.11	2.14	0.94	0.95	-0.03	0.11
Teacher Support	3.09	3.34	1.00	0.89	-0.26	11.17**
Involvement	2.97	2.98	1.02	0.99	-0.01	0.01
Investigation	2.96	3.05	0.95	0.92	-0.10	1.61
Cooperation	3.35	3.20	0.91	0.87	0.17	4.92*
Attitudes	3.23	3.46	1.17	1.03	-0.21	7.38**

*p<0.05, **p<0.01

The sample consisted of 759 students in 19 mathematics/science classes (495 students taught by four teachers who participated in the Alliance+ professional development model and 264 students taught by three teachers who did not participate in the Alliance+ professional development model).

Items 3, 6, 7, 8, and 10 were omitted from the CLES scales.

Items 29, 31, and 34 were omitted from the WIHIC scales.

[a] Average item mean=Scale mean divided by the number of items in that scale.

Although MANOVA results provide important information about the statistical significance of differences between two groups, it is also essential to determine the magnitude of these differences and their educational importance by calculating effect sizes (the difference between means expressed in standard deviation units). To determine the effect size for a scale, the difference between the mean of the two groups (students taught by the Alliance+ teachers and students taught by non-Alliance+ teachers) was divided by the pooled standard deviation. Thus, as recommended by Thompson (1998), the effect size for each learning environment and attitude scale was also calculated (see Table 4.3). According to Cohen (1988), effect sizes range from small (0.10) to medium (0.25) to large (0.40). The effect sizes displayed in Table 4.3 confirm the MANOVA results in that the magnitudes of the differences between the two samples (students taught by Alliance+ teachers and students taught by non-Alliance+ teachers) for the three scales that were statistically significant (namely, Teacher Support, Cooperation, and Attitude to Science/Mathematics) are modest (ranging from 0.17 to 0.26 standard deviations). These magnitudes suggest that there are some educationally noteworthy differences between the two groups of students. The students who were taught by the non-Alliance+ teachers perceived higher levels of teachers support in their classroom environment and reported more positive attitudes to science/mathematics than the students who were taught by the Alliance+ teachers. However, the students who were taught by the Alliance+ teachers perceived higher levels of cooperation in their classroom environment than the other group of students did.

To allow simple comparison of the average scores on the different scales, the average item mean (scale mean divided by the number of items in that scale) and average item standard deviation for each learning environment and attitude scale are reported in Table 4.3 for the students taught by the Alliance+ teachers and the students taught by the non-Alliance+ teachers. Furthermore, Figure 4.1 graphically demonstrates the differences between the two groups of students in terms of mean scores on each learning environment and attitude scale. A pattern that is evident is that the students of the non-Alliance+ teachers generally had higher scores on the learning environment scales (with the exception of Personal Relevance and Cooperation) and the one attitude scale than did the students of the Alliance+ teachers (see Table 4.3 and Figure 4.1). Nevertheless, the magnitudes of these differences tend to be relatively small for most scales.

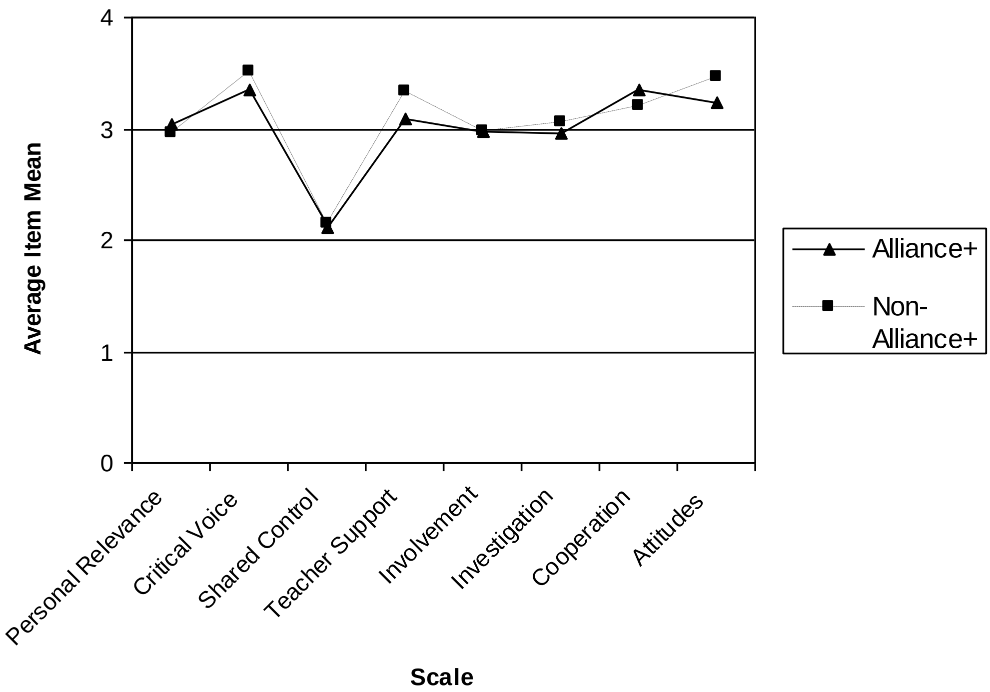

Figure 4.1 Differences between Alliance+ and Non-Alliance+ Teachers' Students' Scores on the Learning Environment and Attitude Scales (*N*=759)

Overall, these results suggest that the non-Alliance+ teachers were more effective than the Alliance+ teachers in providing a learning environment in which students perceived significantly higher levels of teacher support and were more effective in promoting positive attitudes towards science/mathematics among their students. However, these results also suggest that the Alliance+ teachers were more successful than the non-Alliance+ teachers in providing the students with more opportunities to cooperate with each other during science/mathematics lessons.

4.3.3 Using Qualitative Interviews to Clarify Survey Findings

Because it was important to gain some insight into the quantitative findings reported in this section, a small group of Alliance+ teachers was informally interviewed to get their perspectives on the long-lasting effects of their participation in the project (see Section 3.6.2). The teachers were interviewed as a group for two reasons. First, this was consistent with the guidelines of the original study undertaken at the conclusion of the Alliance+ program when interviews were held in focus-group meetings. The second reason was a combination of time restraints and administrative support. Because the administration had given tight timelines for conducting the research, group interviews fitted within the time allotment. The following questions were asked. “What were your positive or negative experiences when you implemented what you learned from the Alliance $^{+}$ project?” “At the beginning, how did you feel about implementing the activities from the Alliance+ project? Did your reactions change? If so, when and how?” “At the beginning, how did your students react to the activities that you implemented from the Alliance^{+} project? Did their reactions change? If so, how?”

During the interviews, teachers admitted they had been enthusiastic about implementing the technology in their lessons and using constructivist activities with their students when they first began the training. They also stated that most students became highly interested in the subject when being taught with the Alliance+ techniques. The interviewees said that their enthusiasm about the project and willingness to participate in activities first began to dwindle after the workshop trainers lost contact with them and stopped providing any guidance. Furthermore, these teachers had difficulty in obtaining follow-up support from their administrators. For instance, they were not provided the resources, such as materials for hands-on activities and computers, needed to implement the Alliance+ model effectively in their classrooms. For example, a very important resource for the

Alliance+ project is a computer with connectivity to the Internet because the whole purpose of the program is to stimulate the integration of technology into classroom lessons. During the interviews, most of the teachers said they had completed hands-on projects with their students, but that they hadn't been able to share them online with other classes around the world because they didn't have working computers and/or Internet access available in their classrooms.

As previously reported in this section, the non-Alliance+ teachers were more effective in promoting positive student attitudes toward science/mathematics and providing more teacher support to their students than the Alliance+ teachers were. An explanation for this is that the Alliance+ teachers' inability to implement the Alliance+ model consistently and effectively might have contributed to their students' less positive attitudes towards science/mathematics. Furthermore, the lack of administrative support might have caused these teachers to become less motivated when teaching the science/mathematics lessons, which might have led to their students perceiving these teachers as less supportive. One teacher's lack of motivation was clear from his interview comments: "I spent my time at the workshops, and I came back to the school really excited about trying out everything I had learned. But, then I had to face reality. I wasn't given any computers that had been promised by the principal. I tried using the Internet at the computer laboratory, but it was always filled with students from other classrooms. Finally, I just gave up. I was so disappointed." This pattern of negative comments from Alliance+ teachers continued during the interviews. These qualitative findings are tentative, though, because I was not able to interview non-Alliance+ teachers in order to really get a clearer picture as to why their students perceived more teacher support and reported more favorable attitudes than the Alliance+ teachers' students did.

When the Alliance+ teachers were asked if they had continued to implement the lessons that they had learned during the training, their responses varied. However, a pattern was apparent in that they all agreed that, although not consistently, they were still using some of the constructivist techniques in their lessons. They attributed this inconsistency to the fact that they must adhere to the fixed curriculum given by the district, which leaves them with very little freedom to be creative in their instruction. The continuing implementation of constructivist techniques in the mathematics/science lessons might explain why the Alliance+ teachers' students perceived higher levels of cooperation during mathematics/science lessons than did the students of the non-Alliance+ teachers.

Although the qualitative research component involving a small number of teacher interviews provided some valuable insights, its scope was quite limited. In future research, a more extensive and intensive qualitative component would be desirable.

As noted at the commencement of Section 4.3, the results for the one-way ANOVAs for the combined sample of mathematics and science teachers reported in Table 4.3 possibly might be misleading or invalid if the Alliance+ model is differentially effective for mathematics and science teachers. Consequently, the next section (Section 4.4) reports the results of two-way ANOVAs for the possible differential effectiveness of Alliance+ for different school subjects. Once the results for differential effectiveness are reported and interpreted in Section 4.4, the findings for the combined sample (Section 4.3) will be reconsidered.

4.4 Differential Effectiveness of the Alliance+ Professional Development Model for Mathematics and Science Teachers

Lubin (1961) notes that, in the presence of a disordinal interaction, any comparison of two instructional methods “may be meaningless” (p. 817). Consequently, it was essential in my study to revisit the comparisons of Alliance+ and non-Alliance+ teachers in Table 4.3 for the entire sample to check whether Alliance+ was differentially effective for mathematics and science teachers. In attempting to detect differential effectiveness, the presence of disordinal instruction x subject interactions was investigated using MANOVA.

Whereas Section 4.3 reported the effectiveness of the Alliance+ professional development program in terms of classroom environment and attitudes to science/mathematics for the complete sample of science and mathematics teachers, this section focuses on the differential effectiveness of the Alliance+ model for mathematics and science teachers using the same criteria. The sample used for this portion of the study was the same as the one used in Section 4.3 (i.e., 759 students in 19 mathematics/science classes). From the 759 students, 495 students were taught by two mathematics and two science teachers who participated in the Alliance+ professional development program and 264 students were taught by one mathematics and two science teachers who did not participate in the training.

The data gathered from the student sample were statistically analyzed to answer the following research question:

Research Question #3

> *Is the Alliance+ professional development model differentially effective for mathematics and science teachers in terms of middle-school students':*
>
> *e) perceptions of classroom learning environment*
>
> *f) attitudes to science/mathematics?*

Statistical analysis consisted of a two-way MANOVA in which the seven learning environment scales based on the CLES and WIHIC and the one attitude scale modeled on the TOSRA were used as the set of dependent variables. The two independent variables were a two-level instruction variable (Alliance+ or non-Alliance+) and a two-level subject variable (mathematics or science). The two-way instruction x subject interaction provided information about the differential effectiveness of Alliance+ for mathematics and science teachers.

Because the multivariate test yielded a statistically significant interaction for the set of dependent variable as a whole using Wilks' lamba criterion, the univariate ANOVA results were interpreted separately for each dependent variable. The last column in Table 4.4 shows the ANOVA results for each learning environment scale and the one attitude scale for the two-way interaction (instruction x subject). As shown in Table 4.4, statistically significant interactions (p<0.05) occurred for three scales (namely, Critical Voice, Teacher Support, and Cooperation). The significant interactions are also illustrated graphically for Teacher Support (Figure 4.2), Cooperation (Figure 4.3), and Critical Voice (Figure 4.4).

The effect size (the difference between means expressed in standard deviation units) was also calculated separately for mathematics and science for each learning environment and attitude scale to provide information about the magnitudes of the differences between the two samples (students taught by Alliance+ teachers and students taught by non-Alliance+ teachers) and are reported in the next-to-last column in Table 4.4.

Table 4.3 indicates a significant difference between Alliance+ and non-Alliance+ teachers in terms of Teacher Support and Cooperation for the combined sample of mathematics and science teachers. However, the existence of a significant interaction for these two scales in Table 4.4 means that the original interpretation of results is misleading and that a valid interpretation requires that results must be examined separately for mathematics and science teachers. This is elaborated upon below.

As shown in Table 4.4 and illustrated in Figure 4.2, a significant interaction occurred for the Teacher Support scale. Figure 4.2 shows that the difference in Teacher Support scores between the Alliance+ and non-Alliance+ teachers is negligible for mathematics teachers but is large for science teachers. As shown in Table 4.4, the effect size for differences between Alliance+ and non-Alliance+ teachers is large for science (0.51 standard deviations) but small for mathematics (0.03 standard deviations). The non-Alliance+ teachers were more effective than the Alliance+ teachers in terms of Teacher Support for science, but not for mathematics.

Table 4.4 Average Item mean, Average Item Standard Deviation, and Difference between Alliance+ and Non-Alliance+ Teachers (Effect Size) for Mathematics and Science, and MANOVA Results for Differential Effectiveness of Alliance+ for Mathematics and Science Teachers According to their Students' Scores on Learning Environment and Attitude Scales

Scale	Subject	Average Item Mean[a]		Average Item Standard Deviation		Difference between Alliance+ and Non-Alliance+	Instruction x Subject Interaction
		Alliance+	Non-Alliance+	Alliance+	Non-Alliance+	Effect Size	*F*
Learning Environment							
Personal Relevance	Math	2.59	2.63	1.04	0.93	-0.04	1.94
	Science	3.46	3.29	0.92	0.93	0.18	
Critical Voice	Math	3.53	3.38	1.08	1.11	0.14	14.04**
	Science	3.18	3.64	1.11	0.91	-0.46	
Shared Control	Math	2.18	2.11	0.96	0.97	0.07	1.76
	Science	2.04	2.16	0.92	0.93	-0.13	
Teacher Support	Math	3.19	3.22	1.01	0.93	-0.03	8.20**
	Science	3.00	3.46	0.97	0.83	-0.51	
Involvement	Math	3.01	2.91	1.07	1.02	0.10	1.94
	Science	2.94	3.06	0.97	0.95	-0.13	
Investigation	Math	2.91	3.05	0.96	0.96	-0.15	0.48
	Science	3.00	3.04	0.94	0.87	-0.04	
Cooperation	Math	3.32	3.03	0.99	0.88	0.31	4.02*
	Science	3.38	3.37	0.84	0.83	0.01	
Attitudes	Math	3.10	3.39	1.17	1.13	-0.25	0.51
	Science	3.35	3.52	1.16	0.93	-0.16	

*$p<0.05$, **$p<0.01$
The sample consisted of 759 students in 19 mathematics/science classes (495 students taught by two mathematics and two science teachers who participated in the Alliance+ professional development model and 264 students taught by one mathematics and two science teachers who did not participate in the Alliance+ professional development model).
Items 3, 6, 7, 8, and 10 were omitted from the CLES scales.
Items 29, 31, and 34 were omitted from the WIHIC scales.
[a] Average item mean=Scale mean divided by the number of items in that scale.

As shown in Table 4.4 and illustrated in Figure 4.3, another significant interaction occurred for the Cooperation scale. Figure 4.3 shows that the difference in Cooperation scores between the Alliance+ and non-Alliance+ teachers is negligible for science teachers but is large for mathematics teachers. As shown in Table 4.4, the effect size for differences between Alliance+ and non-Alliance+ teachers is large for mathematics (0.31 standard deviations) but small for science (0.01 standard deviations). Alliance+ teachers were more effective than non-Alliance+ teachers in terms of Cooperation for mathematics, but not for science.

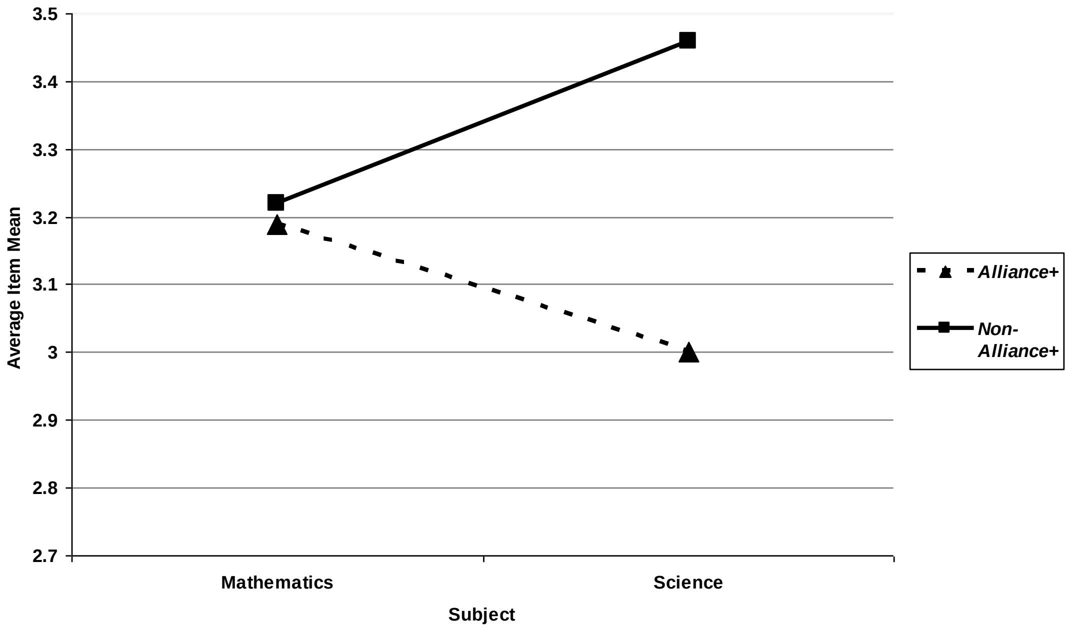

Figure 4.2 Two-Way Instruction x Subject Interaction for Teacher Support

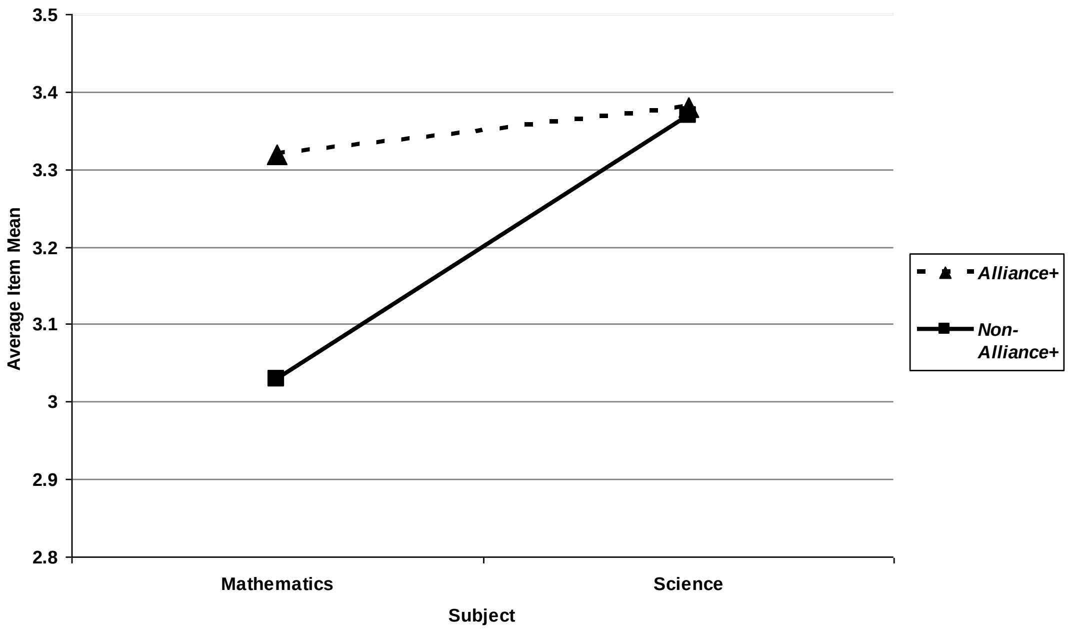

Figure 4.3 Two-Way Instruction x Subject Interaction for Cooperation

Table 4.3 suggests that Alliance+ and non-Alliance+ teachers do not differ significantly in terms of Critical Voice for the combined sample of mathematics and science teachers. However, the presence of an interaction in Table 4.4 suggests that the original interpretation is misleading and that a valid interpretation requires examining results separately for mathematics and science teachers.

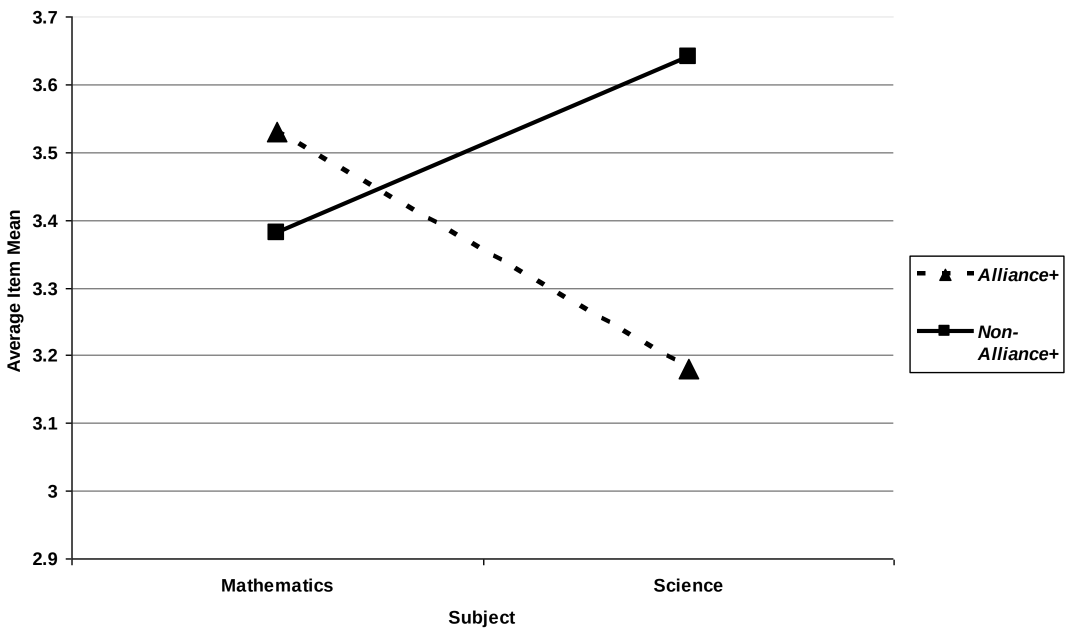

Figure 4.4 Two-Way Instruction x Subject Interaction for Critical Voice

As reported in Table 4.4 and illustrated in Figure 4.4, a significant interaction occurred for the Critical Voice scale. Figure 4.4 shows that the difference in Cooperation scores between the Alliance+ and non-Alliance+ teachers is relatively small for mathematics teachers but is large for science teachers. As shown in Table 4.4, the effect size for differences between Alliance+ and non-Alliance+ teachers is large for science (0.46 standard deviations with higher scores for non-Alliance+ teachers) but small for mathematics (0.14 standard deviations with higher scores for Alliance+ teachers). For Critical Voice, non-Alliance+ teachers were considerably more effective than the Alliance+ teachers for science, but Alliance+ teachers were a little bit more effective for mathematics.

Table 4.3 indicates nonsignificant differences between Alliance+ and non-Alliance+ teachers in terms of Personal Relevance, Shared Control, Involvement, and Investigation for the combined sample of mathematics and science teachers. The absence of a significant interaction in Table 4.4 for each of these scales confirms that this result is applicable to either mathematics or science teachers.

Table 4.3 also indicates that non-Alliance+ teachers are more effective than Alliance+ teachers in terms of students' attitudes for the whole sample of mathematics and science teachers. The absence of a significant interaction in Table 4.4 confirms that this results is valid and can be applied either to mathematics or science teachers.

Overall, the results reported in Section 4.4 suggest that Alliance+ was differentially effective for mathematics and science for three of the eight learning environment and attitude scales (Cooperation, Critical Voice, and Teacher Support). In terms of Cooperation, Alliance+ teachers were more effective than non-Alliance+ teachers for mathematics, but comparable in effectiveness to non-Alliance+ teachers for science. For Critical Voice, Alliance+ teachers were slightly more effective than non-Alliance+ teachers for mathematics, but considerably less effective than non-Alliance+ teachers for science. In terms of Teacher Support, Alliance+ teachers were less effective than non-Alliance+ teachers for science, but comparable in effectiveness to non-Alliance+ teachers for mathematics.

As pre-empted in Section 4.3, it is possible that the comparison of Alliance+ and non-Alliance+ teachers for the total sample (Table 4.3) potentially could be misleading if the analyses reported in Table 4.4 revealed that alliance+ was differentially effective for mathematics and science teachers. The overall pattern of findings emerging from Sections 4.3 and 4.4 combined can be summarized as follows:

- Alliance+ and non-Alliance+ teachers were comparably effective in terms of Student Cohesiveness, Shared Control, Involvement, Integration, and Attitudes (Table 4.3).
- The interpretation of the results for overall differences between Alliance+ and non-Alliance+ teachers in Table 4.3 are misleading for Critical Voice, Teacher Support, and Cooperation because of the presence of instruction x subject interactions for these three scales.
- Relative to non-Alliance+ teachers, Alliance+ teachers were more effective in terms of Cooperation, but less effective in terms of Critical Voice and Teacher Support.

4.5 Associations between Students' Perceptions of Classroom Learning Environment and Attitudes to Science/Mathematics

The data gathered from 759 middle-school students (372 mathematics students and 387 science students) responded to the Questionnaire about my Science Class (see Appendix 3) and the Questionnaire about my Mathematics Class (see Appendix 4), each containing scales based on the CLES, WIHIC, and TOSRA (see Section 4.2 for further information about the questionnaires) were statistically analyzed to determine associations between students' perceptions of their classroom learning environment and their attitudes toward science/mathematics. The relevant research question was:

Research Question #4

> *Are there associations between students' attitudes to science/mathematics and their perceptions of classroom learning environment?*

To answer Research Question #4, simple correlation and multiple regression analyses were performed for two units of analysis (individual and class mean), and results are reported in Table 4.5. The simple correlation describes the bivariate association between each of the seven learning environment scales and the attitude outcome. The standardized regression weight (β) describes the association between a particular learning environment scale and an outcome when all other learning environment scales are controlled.

A positive and statistically significant correlation ($p<0.05$) emerged between all seven learning environment scales based on the CLES and WIHIC and both Enjoyment of Mathematics Class and Enjoyment of Science Class using the individual as the unit of analysis (see Table 4.5). For the class mean as the unit of analysis, a positive and statistically significant correlation ($p<0.05$) existed between six of the learning environment scales (namely, Personal Relevance, Shared Control, Teacher Support, Involvement, Investigation, and Cooperation) and Enjoyment of Mathematics Class, and between the three learning environment scales of Critical Voice, Teacher Support, and Investigation and the Enjoyment of Science Class scale.

Table 4.5 shows the multiple correlation (R) between the group of seven learning environment scales and Enjoyment of Mathematics Class and Enjoyment of Science Class for two units of analysis (individual and class mean). The results show that the multiple correlation is significant ($p<0.05$) for both Enjoyment of Mathematics Class and Enjoyment of Science Class at both the individual level (R=0.65 and 0.59) and the class mean level (R=0.84 and 0.86).

Table 4.5 Simple Correlation and Multiple Regression Analyses for Associations Between Attitudes and Learning Environment for Two Units of Analysis

Scale	Unit of Analysis	Simple Correlation		Standardized Regression Coefficient	
		Enjoyment of Mathematics Class	Enjoyment of Science Class	Enjoyment of Mathematics Class	Enjoyment of Science Class
Personal Relevance	Student	0.33**	0.31**	0.10*	0.11*
	Class	0.68**	0.31	0.17	0.32
Critical Voice	Student	0.21**	0.43**	0.08	0.20**
	Class	0.12	0.72**	0.19	0.12
Shared Control	Student	0.30**	0.29**	0.02	0.00
	Class	0.60**	0.37	0.18	0.02
Teacher Support	Student	0.57**	0.52**	0.36**	0.29**
	Class	0.79**	0.66**	0.53	0.72
Involvement	Student	0.51**	0.40**	0.17**	0.02
	Class	0.68**	0.24	0.34	0.89
Investigation	Student	0.48**	0.40**	0.10	0.10
	Class	0.54*	0.57*	0.15	0.44
Cooperation	Student	0.44**	0.33**	0.12*	0.10*
	Class	0.56*	0.13	0.10	0.40
Multiple Correlation, *R*	Student			0.65**	0.59**
	Class			0.84*	0.86**

The mathematics sample consisted of N= 372 students from 19 classes in one middle school in Miami-Dade County, Florida.
The science sample consisted of N=387 students from 19 classes in one middle school in Miami-Dade County, Florida.
*$p<0.05$, **$p<0.01$
Items 3, 6, 7, 8, 10, 29, 31, and 34 were omitted for both samples.

In order to identify which individual learning environment scales are most strongly related to each of the attitudinal outcomes, when all other learning environment scales are mutually controlled, the standardized regression coefficients (β) were examined. Table 4.5 shows that Personal Relevance, Teacher Support, Involvement and Cooperation were positive, significant, and independent predictors of Enjoyment of Mathematics Class when controlling for all other learning environment scales and using the individual student as the unit of analysis. In addition, Personal Relevance, Critical Voice, Teacher Support, and Cooperation were positive, significant, and independent predictors of Enjoyment of Science Class using the individual student as the unit of analysis. No significant, independent predictors of either attitudinal outcome (Enjoyment of Mathematics Class and Enjoyment of Science Class) were found when using the class mean as the unit of analysis.

Overall, the results reported in this section indicate that statistically significant associations exist between students' attitudes towards science/mathematics and their perceptions of the classroom learning environment. The relationships are more consistent for the Personal Relevance, Teacher Support, and Cooperation scales. Furthermore, it is noteworthy that all statistically significant associations found are in the positive direction, thus suggesting that a positive classroom environment is linked with better student attitudes towards science/mathematics. These findings replicate those in previous learning environment studies, which showed positive and statistically significant relationships between students' perceptions of their classroom learning environment and their attitudes towards science/mathematics (Aldridge & Fraser, 2000; Allen & Fraser, 2007; Henderson et al., 2000; Kim et al., 1999; Margianti et al., 2004; Martin-Dunlop & Fraser, 2008).

4.6 Summary of Analyses and Results

This chapter reported the analyses and results for the four research questions investigated in my study, which focused on: the validity and reliability of learning environment scales based on the CLES and WIHIC and an attitude scale modeled on the TOSRA among middle-school students; the effectiveness of the Alliance+ professional development model in terms of middle-school teachers' students' perceptions of their learning environment and their attitudes towards science/mathematics; the differential effectiveness of the Alliance+ model for science and mathematics teachers' students based on their perceptions of the classroom learning environment and their attitudes towards science/mathematics; and environment-attitude associations.

Scales chosen from the Contructivist Learning Environment Survey (CLES) and the What Is Happening In this Class? (WIHIC) questionnaires, as well as one scale modeled on the Test Of Science-Related Attitudes (TOSRA) questionnaire, were modified and validated. Later, they were used to assess students' perceptions of their classroom learning environment and their attitudes towards science/mathematics so that Research Question 2–4 could be answered.

Data collected from 759 students (372 mathematics students in 19 classes and 387 science students in 19 classes) in one middle school in Miami-Dade County, Florida were statistically analyzed to answer the research questions of the present study, which were delineated in Section 1.6. First, to determine the validity and reliability of the learning environment scales based on the CLES (namely, Personal Relevance, Critical Voice, and Shared Control) and WIHIC (namely, Teacher Support, Involvement, Investigation, and Cooperation) and the one attitude scale modeled on the TOSRA (namely, Enjoyment of Lessons), the data were statistically analyzed to determine factor structure, internal consistency reliability, and ability of the learning environment scales to differentiate between classrooms.

Item analysis was conducted for the 58-item questionnaire containing the learning environment and attitude scales based on the CLES, WIHIC, and TOSRA. Eight items were removed from the questionnaire because they were found to be faulty. For the revised 50-item version of the questionnaire, a factor analysis was conducted, which revealed that all items had a factor loading of at least 0.40 on their *a priori* scale and no other scale, with the exception of three items in the Involvement and Investigation scales. The original eight-factor structure was replicated. The total proportion of variance accounted for was over 60% for either the mathematics or science student sample for the final 50-item version of the questionnaire containing scales from the CLES, WIHIC, and TOSRA.

When internal consistency reliability analysis was conducted for all eight scales, the alpha reliability coefficients for the mathematics and science samples ranged from 0.59 to 0.99 for the different learning environment and attitude scales using either the individual or class mean as the unit of analysis. Results for the discriminant validity (mean correlation of a scale with other scales) of each learning environment and attitude scale for the mathematics and science student samples ranged from 0.16 to 0.65 using the individual and class mean as the units of analysis. This suggests that the eight scales were fairly independent from each other, although some overlap exists. One-way ANOVAs demonstrated that, for the mathematics student sample, all seven learning environment scales based on the CLES and WIHIC were able to differentiate significantly ($p<0.05$) between the perceptions of the students in the different classrooms. For the science student sample, four of the seven learning environment scales (namely, Critical Voice, Shared Control, Teacher Support, and Cooperation) were able to differentiate significantly ($p<0.01$) between classes.

Overall, the results supported the validity and reliability of the learning environment scales based on the CLES and WIHIC and the one attitude scale modeled on the TOSRA for assessing perceptions of the classroom environment and attitudes towards science/mathematics among middle-school students in Miami-Dade County, Florida.

The next step consisted of using the data gathered with the validated instruments to evaluate the effectiveness of the Alliance+ professional development model in terms of teachers' students' perceptions of the classroom learning environment and their attitudes towards science/mathematics. The data were statistically analyzed using a one-way MANOVA. Also, effect sizes were calculated. The ANOVA for individual scales was statistically significant ($p<0.05$) for two of the seven learning environment scales (namely, Teacher Support and Cooperation) and the one attitude scale. The effect sizes for the scales for which statistically significant differences were found ranged from 0.17 to 0.26 standard deviations, suggesting modest magnitudes of differences. Overall, it was found that non-Alliance+ teachers were more effective than Alliance+ teachers in providing a positive learning environment in which the students perceived more teacher support and in promoting positive attitudes towards science/mathematics. On the other hand, Alliance+ teachers were more successful than the non-Alliance+ teachers in promoting more cooperation among students during the science/mathematics lessons.

In an attempt to get a clearer understanding of the quantitative data, the Alliance+ teachers were briefly interviewed to get their perspectives about the implementation of the Alliance+ model in their classrooms. During interviews, it was found that the quantitative results in favor of the non-Alliance+ teachers possibly could be due to the insufficient level of support provided by school administrators, the lack of follow-up support from Alliance+ trainers, and the lack of resources that were necessary for teachers to implement the project successfully.

Another goal of my study was to evaluate the differential effectiveness of the Alliance+ model for mathematics and science teachers in terms of their students' perceptions of the classroom learning environment and attitudes towards science/mathematics. A two-way MANOVA was conducted using the same data previously gathered. The results suggest that the Alliance+ professional development model was differentially effective for the mathematics and science teachers in terms of three learning environment scales (namely, Teacher Support, Cooperation, and Critical Voice), but not in terms of students' attitudes to science. In terms of Cooperation, Alliance+ teachers were more effective than non-Alliance+ teachers for mathematics, but comparable in effectiveness to non-Alliance+ teachers for science. For Critical Voice, Alliance+ teachers were slightly more effective than non-Alliance+ teachers for mathematics, but considerably less effective than non-Alliance+ teachers for science. In terms of Teacher Support, Alliance+ were less effective than non-Alliance+ teachers for science, but comparable in effectiveness to non-Alliance+ teachers for mathematics.

The data were also analyzed using simple correlation and multiple regression analyses at two units of analysis (individual and class mean) to determine whether associations existed between students' perceptions of the learning environment and attitudes towards science/mathematics. A positive and statistically significant

(p<0.05) correlation was found between each of the seven learning environment scales based on the CLES and WIHIC and Enjoyment of Mathematics/Science with the student as the unit of analysis. Also, at the student level of analysis, Personal Relevance, Teacher Support, Involvement, and Cooperation were significant independent predictors of Enjoyment of Mathematics Class, and Personal Relevance, Critical Voice, Teacher Support, and Cooperation were positive, significant, and independent predictors of Enjoyment of Science.

A discussion of the findings, distinctive contributions, limitations, and future directions of the present research study is found in Chapter 5.

Chapter 5

CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction to Chapter 5

Traditional methods of teaching subject matter are transforming rapidly. It has become more common for school programs to demand the use the Internet as an extension of the classroom as part of the curriculum. According to the American Council on Education, the U.S. must prepare teachers to better meet the challenges of this growing trend (Boggs, 2000). Thus, professional development programs that train teachers to implement technology into classroom lessons are extremely important (CEO Forum on Education & Technology, 1999). The present study evaluated the effectiveness of an innovative professional development program that integrates technology into mathematics and science education.

My study is significant because it evaluated the effectiveness of a professional development program, Alliance+, which was monetarily supported at the state and local levels and had only been evaluated immediately following its implementation. Follow-up research on the effectiveness of the Alliance+ had never been conducted until now.

This study is also important because it contributes to the field of learning environments research. I validated learning environment scales based on Constructivist Learning Environment Survey (CLES) and the What Is Happening In this Class? (WIHIC) questionnaires amongst middle-school students in Miami-Dade County, Florida. Additionally, my study adds to two past lines of learning environments research: evaluation of educational innovations and outcome-environment associations.

This chapter provides a summary of the thesis (Section 5.2) and a discussion of the major findings (Section 5.3), distinctive contributions (Section 5.4), and limitations (Section 5.5) of my research study. Finally, future directions of the present research study are discussed in Section 5.6.

5.2 Summary of Thesis

My study represents unique research in the areas involving learning environments and learner attitudes as it relates to a professional development program that integrates technology into mathematics/science lessons. Four overriding questions governed my study:

Research Question # 1

> *Are learning environment scales based on the CLES and WIHIC and an attitude scale based on TOSRA valid when used with this sample of middle-school students?*

Research Question #2

> *Is the Alliance+ professional development model effective in terms of middle-school students':*
>
> *a) perceptions of classroom learning environment*
>
> *b) attitudes to science/mathematics?*

Research Question #3

Is the Alliance+ professional development model differentially effective for mathematics and science teachers in terms of middle-school students':

a) perceptions of classroom learning environment

b) attitudes to science/mathematics?

Research Question #4

Are there associations between students' attitudes to science/mathematics and their perceptions of classroom learning environment?

Chapter 1 of this thesis gave a concise statement of the main purpose of the study as being to evaluate a design for improved teacher professional development for middle-school teachers in terms of their students' classroom environment perceptions and attitudes towards mathematics and science after the teachers had undergone professional development training. Chapter 1 also provided the rationale, background, and purpose for this study.

Chapter 2 provided a review of literature regarding the main areas of study. It began by providing a historical account of the field of learning environments, beginning in the 1960s with the work of various theorists and researchers such as Walberg and Moos (Moos & Houts, 1968; Walberg & Anderson, 1968). The evolution of the field through the past 30 years was also discussed at the beginning of Chapter 2.

Section 2.3 discussed the development, validation, and utilization of the eight learning environment instruments that, thus far have facilitated data collection for learning environments studies. A description of the eight learning environment questionaires was also provided with an extra focus on the development and validation of the Constructivist Learning Environment Survey (CLES) and the What Is Happening In this Class? (WIHIC) questionnaires.

Section 2.4 discussed the lines of learning environments research that emerged as the field progressed, with an emphasis on learning environments studies that have evaluated various educational innovations and investigated outcome-environment associations.

Section 2.5 provided a discussion about studies dealing with learners' attitudes and the characteristics, validation, and use of the Test Of Science-Related Attitudes (TOSRA). Section 2.6 discussed the history of computer usage in the classroom during the past 60 years. Finally, Section 2.7 provided a discussion of a variety of grant projects that facilitated the integration of technology into the classrooms.

Chapter 3 was devoted to describing the methodology undertaken to investigate the research questions of the present study. Section 3.2 was devoted to delineating my study's research questions along with an explanation of how the research questions emerged. Section 3.3 provided detailed information about the school where the data were collected. The school is located in a lower-class to middle-class neighborhood in the city of Miami Gardens within Miami-Dade County, Florida. It is designated by the Florida Department of Education as a School Improvement Zone (SIZ) school using three criteria: low academic performance for three years; located in a neighborhood in which low performance is widespread; and limited leadership capacity.

Section 3.4 described the study sample. The total teacher sample for this study consisted of seven science/mathematics teachers. Four teachers had participated in the Alliance+ project (experimental group) and three had not participated in the Alliance+ project (control group). The student sample consisted of 759 students (372 mathematics students in 19 classes and 387 science students in 19 classes).

Section 3.5 discussed the selection and modification of the instruments used in my study. Scales from the Constructivist Learning Environment Survey (CLES) and the What Is Happening In this Class? (WIHIC) were chosen to assess students' perceptions of the classroom learning environment. I chose the Personal Relevance, Critical Voice, and Shared Control scales from the CLES and the Teacher Support, Involvement, Investigation, and Cooperation scales from the WIHIC. Minor modifications, such as changing the wording to assess both science and mathematics learning environments, were made to the items in each of the learning environment scales. To assess students' attitudes towards science/mathematics, an attitude scale modeled on the Test Of Science-Related Attitudes (TOSRA) was created. The Enjoyment of Science Lessons scale was chosen from the TOSRA, and only eight of the 10 items in that scale were used. Modifications were made, such as rewording the items to measure enjoyment of the science/mathematics class, changing the title of the scale to Enjoyment of my Science/Mathematics Class, and rephrasing negatively-worded items in a positive manner. The learning environment scales and the one attitude scale were merged into two instruments titled Questionnaire About My Science Class and Questionnaire About My Mathematics Class in order to gather data from the mathematics and science student samples separately.

Section 3.6 described the steps undertaken to collect the quantitative and qualitative data in this study. Combining quantitative and qualitative methods of data collection in a research study has been supported frequently by researchers (Fraser, 1999; Fraser & Tobin, 1991; Tobin & Fraser, 1998). The quantitative data were collected via the questionnaires, and the qualitative data were collected via teacher interviews. Careful steps were taken to ensure that the data were collected in a valid manner. Section 3.7 discussed the procedures undertaken in preparing the data for input and analysis, as well as the data-analysis procedures, including the types of statistical analyses chosen to answer the research questions.

Chapter 4 reported the analyses and results of quantitative and qualitative data collected to answer the research questions in my study. To provide information about the validity and reliability of the modified learning environment scales based on the CLES and WIHIC and the modified attitude scale modeled on the TOSRA, statistical analyses were conducted. Item analysis for the 58 items in the learning environment and attitude scales based on the CLES, WIHIC, and TOSRA revealed eight faulty items from the learning environment scales, which were removed from subsequent data analyses. The remaining 50 items in the *a priori* eight-factor structure were subjected to principal components factor analysis followed by varimax rotation. Further validity and reliability analyses consisted of determining the learning environment and/or attitude scales' internal consistency reliability, discriminant validity, and ability to differentiate between the perceptions of students in the different classrooms.

After the learning environment and attitude scales had been validated, the same data were statistically analyzed with a MANOVA to determine whether differences existed between teachers who had participated in the Alliance+ professional development program and teachers who had not participated in terms of their students' perceptions of the learning environment and their attitudes towards science/mathematics. To gain insight into the MANOVA results reported, the Alliance+ teachers were interviewed to get their perspectives on the long-lasting effects of their participation in the project. In addition, a two-way MANOVA was conducted to determine the differential effectiveness of the Alliance+ model for mathematics and science teachers. Finally, to determine if associations existed between students' attitudes towards science/mathematics and their perceptions of the classroom learning environment, the data were also statistically analyzed using simple correlation and multiple regression analyses. All of the results for the statistical analyses were reported in Chapter 4, and the major findings are discussed in Section 5.3 below.

5.3 Findings of the Study

Under the following headings, I provide a discussion of the major findings of this study:

- Findings for the Validity and Reliability of the Learning Environment Scales Based on the CLES and WIHIC and an Attitude Scale Based on the TOSRA (Section 5.3.1);
- Findings for the Effectiveness of the Alliance+ Model in Terms of Classroom Learning Environment and Attitudes (Section 5.3.2);

- Findings for Differential Effectiveness of the Alliance+ Professional Development Model for Mathematics and Science Teachers (Section 5.3.3);
- Findings for Associations between Students' Perceptions of Classroom Learning Environment and Attitudes to Science/Mathematics (Section 5.3.4).

5.3.1 Findings for the Validity and Reliability of the Learning Environment Scales Based on the CLES and WIHIC and an Attitude Scale Based on the TOSRA

Data gathered from 759 students (372 mathematics students in 19 classes and 387 science students in 19 classes) in one middle school in Miami-Dade County, Florida were statistically analyzed to determine the validity and reliability of the learning environment scales based on three CLES scales, four WIHIC scales and one attitude scale modeled on the TOSRA in terms of factor structure, internal consistency reliability, discriminant validity and ability to differentiate between classrooms using one-way ANOVA. A single factor analysis encompasses the same learning environment scales and one attitude scale.

Reported below are the findings based on results of statistical analyses:

Finding 1: The a priori *factor structure for the revised questionnaire containing seven learning environment scales and on attitude scale was replicated for 50 of the original 58 items. Nearly all of the remaining 50 items had a factor loading of 0.40 or above on their* a priori *scale and less than 0.40 on each of the other seven scales, thus demonstrating strong factorial validity.*

Finding 2: The internal consistency reliability estimate (Cronbach alpha coefficient) for each of the eight scales for the mathematics and student samples, using both the *individual and the class mean as the unit of analysis, was high and above 0.59 for all scales.*

Finding 3: Although discriminant validity analyses revealed some overlap between raw scores on the learning environment and attitude scales, the factor analysis results attested to the independence of factor scores on these scales.

Finding 4: All seven WIHIC scales were able to differentiate significantly between classes for the mathematics student sample. For the science student sample, four of the seven learning environment scales (namely, Critical Voice, Shared Control, Teacher Support, and Cooperation) were able to differentiate significantly between classes.

Overall, it was found that the learning environment scales based on the CLES and WIHIC and the one attitude scale modeled on the TOSRA were reliable when used with middle-school mathematics and science students in Miami-Dade County, Florida. These findings are consistent with past validation studies for the CLES (Aldridge et al., 2000; Kim et al., 1999; Nix et al., 2005), the WIHIC (Chionh & Fraser, in press; Khoo & Fraser, 2008; Zandvliet & Fraser, 2005), and the TOSRA (Allen & Fraser, 2007; Martin-Dunlop & Fraser; 2008; Wong & Fraser, 1996).

5.3.2 Findings for the Effectiveness of the Alliance+ Model in Terms of Classroom Learning Environment and Attitudes

A MANOVA was used to determine whether differences existed between teachers who had participated in the Alliance+ professional development program and teachers who had not participated in terms of their students' perceptions of the learning environment and their attitudes towards science/mathematics. The dependent variables consisted of the seven learning environment scales based on the CLES and WIHIC and the one attitude scale modeled on the TOSRA, and the independent variable used was the method of teacher training (Alliance+ or non-Alliance+). Because the MANOVA produced statistically significant results using Wilks' lambda criterion, the univariate ANOVA results were interpreted for each of the eight dependent variables. Findings based on these results are listed below:

Finding 5: Statistically significant differences between Alliance+ and non-Alliance+ teachers were found for two out of the seven learning environment scales (namely, Teacher Support and Cooperation) and the one attitude scale. But, effect sizes were modest and ranged from 0.17 to 0.26 standard deviations for these scales. (However, these results for Teacher Support and Cooperation should be interpreted cautiously because of the presence of the instruction x subject interactions for these scales summarized in Section 5.3.3.)

Finding 6: The students who were taught by the non-Alliance+ teachers perceived higher levels of teachers support in their classroom environment and reported more positive attitudes to science/mathematics than the students who were taught by the Alliance+ teachers. However, the students who were taught by the Alliance+ teachers perceived higher levels of cooperation in their classroom environment than the other group of students did.

Overall, these results suggest that the non-Alliance+ teachers were more effective than the Alliance+ teachers in providing a learning environment in which students perceived significantly higher levels of teacher support and were more effective in promoting positive attitudes towards science/mathematics among their students. However, these results also suggest that the Alliance+ teachers were more successful than the non-Alliance+ teachers in providing the students with more opportunities to cooperate with each other during science/mathematics lessons. To gain some insight into the quantitative findings reported in this section, the Alliance+ teachers were interviewed to get their perspectives on the long-lasting effects of their participation in the project. The qualitative findings are discussed below:

Finding 7: At the beginning of the training, teachers and students had been enthusiastic about implementing the technology in the classroom, but enthusiasm dwindled after the workshop trainers lost contact with Alliance+ teachers.

Finding 8: Alliance+ teachers had difficulty in obtaining follow-up support from their administrators and lacked resources to implement the Alliance+ model effectively in their classrooms.

Quantitative results showed that the non-Alliance+ teachers were more effective in promoting positive student attitudes toward science/mathematics and providing more teacher support to their students than the Alliance+ teachers were. A possible explanation for this could be that the Alliance+ teachers' inability to implement the Alliance+ model consistently and effectively might have contributed to their students' less positive attitudes towards science/mathematics. Also, the lack of administrative support might have caused these teachers to become less motivated when teaching the science/mathematics lessons, which might have led to their students perceiving these teachers as less supportive.

Quantitative results also showed that the Alliance+ teachers' students perceived higher levels of cooperation during mathematics/science lessons than did the students of the non-Alliance+ teachers. It was found through conversations with the Alliance+ teachers that they had continued to implement constructivist techniques in the mathematics/science lessons as they had learned to do so at the Alliance+ training. This might explain why the Alliance+ teachers' students perceived higher levels of cooperation in the classroom learning environment than did the students of the non-Alliance+ teachers did.

5.3.3 Findings for Differential Effectiveness of the Alliance+ Professional Development Model for Mathematics and Science Teachers

The same data were statistically analyzed to investigate differential effectiveness of the Alliance+ model for mathematics and science teachers in terms of students' perceptions of the classroom learning environment and their attitudes towards mathematics/science. The findings are discussed below:

Finding 9: The non-Alliance+ teachers were more effective than the Alliance+ teachers in terms of Teacher Support for science, but not for mathematics.

Finding 10: Alliance+ teachers were more effective than non-Alliance+ teachers in terms of Cooperation for mathematics, but not for science.

Finding 11: For Critical Voice, non-Alliance+ teachers were considerably more effective than the Alliance+ teachers for science, but Alliance+ teachers were a little bit more effective for mathematics.

5.3.4 Findings for Associations between Students' Perceptions of Classroom Learning Environment and Attitudes to Science/Mathematics

The data gathered were statistically analyzed using simple correlation and multiple regression analyses, calculated at two units of analysis (individual and class means), to determine whether associations exist between students' attitudes to mathematics/science and their perceptions of the classroom learning environment. The findings based on the results of these statistical analyses are reported below:

Finding 12: A positive and statistically significant correlation emerged between each of the seven learning environment scales and both Enjoyment of Mathematics Class and Enjoyment of Science Class using the individual as the unit of analysis.

Finding 13: For the class mean as the unit of analysis, a positive and statistically significant correlation existed between six of the learning environment scales (namely, Personal Relevance, Shared Control, Teacher Support, Involvement, Investigation, and Cooperation) and Enjoyment of Mathematics Class and between the three learning environment scales of Critical Voice, Teacher Support, and Investigation and the Enjoyment of Science Class scale.

Finding 14: The multiple correlation was statistically significant for seven environment scales for both Enjoyment of Mathematics Class and Enjoyment of Science Class at both the individual and class mean levels.

Finding 15: For the individual student as the unit of analysis, Personal Relevance, Teacher Support, Involvement and Cooperation were all positive, significant, and independent predictors of Enjoyment of Mathematics Class.

Finding 16: Personal Relevance, Critical Voice, Teacher Support, and Cooperation were positive, significant, and independent predictors of Enjoyment of Science Class using the individual student as the unit of analysis.

Overall, it was found that statistically significant associations existed between students' attitudes towards science/mathematics and their perceptions of the classroom learning environment. The relationships were more consistent for the Personal Relevance, Teacher Support, and Cooperation scales. Furthermore, it is noteworthy that all statistically significant associations found were in the positive direction, thus suggesting that a positive classroom environment is linked with better student attitudes towards science/mathematics. These findings replicate those in previous learning environment studies, which showed positive and statistically significant relationships between students' perceptions of their classroom learning environment and their attitudes towards science/mathematics (Allen & Fraser, 2007; Margianti et al., 2004; Martin-Dunlop & Fraser, 2008; Spinner & Fraser, 2005).

5.4 Distinctive Contributions of This Study

Miami-Dade County Public Schools (M-DCPS) teachers and administrators have high expectations of all students. By promoting positive attitudes and encouraging the students to excel in mathematics and science, these expectations can be met. This study is educationally important in that it identified a model that has the potential to assist others in directing the best methods to facilitate the advancement of technology in the middle-school classroom. A deeper insight into the challenges facing instructors from an inside view could give curriculum writers, professional workshop developers, software programmers, and teachers a chance to develop and implement constructivist learning environments and curriculum that supports learning in a more relevant manner and to enhance retention.

From the viewpoint of the field of classroom learning environment, my research is noteworthy in that it attempted to evaluate the effectiveness of teacher professional development partly in terms of the quality of the classroom environments created by these teachers at their schools. Furthermore, two questionnaires containing learning environment scales from the CLES and WIHIC and an attitude scale modeled on the TOSRA were created and validated. These questionnaires could be of eventual use for future researchers in the field of learning environments.

This research on the Alliance+ project involving integrating technology into the classroom is likely to be beneficial in future professional development projects and for training for middle-school teachers. The findings show the needs and desires of middle-school teachers in reference to integrating technology into their daily curriculum. This study makes the argument that middle-school teachers, trainers, and developers need training activities and environments to advance, excite and make mathematics and science more meaningful to students. The study shows a need for further follow-up of professional development participants and for administrative support. The results imply that professional development workshops are not the key ingredients of success as much as the perceptions and attitudes of the teachers. The teachers' attitudes are improved by good working conditions, support and the openness of curriculum and administrators.

The results of this research will be presented to the Stevens Institute of Technology and the principals of the Alliance+ project for further development of the Alliance+ project. The Alliance+ project has begun training in South America and is looking to expand its international presence. The findings of this research will aid in improving the tools and methods of the ongoing efforts of Stevens Institute and Alliance+ to integrate technology into the curriculum. The results of this research will be shared through journal publications and conference presentations in the hope of assisting other professional development personnel to create worthwhile and long-lasting programs for training middle-school teachers on the integration of technology into the curriculum.

5.5 Limitations of This Study

There are a few limitations that made the completion of this study difficult. First, the mobility ratio of educators in a school system as big as M-DCPS made it difficult to track down a large number of teachers who had participated in the Alliance+ project.

The study group originally consisted of 160 mathematics and science teachers who completed the training. Two years later, only a little more than one-third of those participants were still employed as middle-school teachers in the school system. Therefore only one-third of the original participants in the Alliance+ professional development project could form the population for the part of the study involving assessment of teachers' students' attitudes and perceptions of classroom environment. If it would have been possible to have included most Alliance+ participants, there would have been a larger sample from various areas of the county. Instead, I was limited to only the teachers in one school, which might not be representative of other schools in the district. Therefore, when applying the findings of this study to other schools, one must be careful.

Second, in my study I was only able to interview Alliance+ participant teachers when I gathered the qualitative data. This poses a limitation because it was not possible to gather the opinions form the non-participants to make comparisons. Had I been able to gather the opinions of the non-Alliance+ teachers, it would have given me more insight into why they were more successful than the Alliance+ teachers in some aspects of providing a more positive learning environment. Therefore, as noted in Section 3.6.2, the qualitative results reported in Chapter 4 should be taken as limited and tentative, and interviews with both groups of teachers and their students should be conducted in any future research that evaluates the effectiveness of the Alliance+ project.

Third, most Alliance+ teachers admitted that they did not continue to implement the strategies learned during the training with fidelity due to the lack of follow-up support. Thus, this is a limitation because it is difficult to determine if the Alliance+ project would have been more effective than what my findings show if the support had been provided. This is very important to take into consideration when determining further extension of the Alliance+ professional development program. According to the findings of my study, follow-up support to the teachers should to be a component of the Alliance+ if we want to see better results.

5.6 Recommendations for Further Research

This study suggests avenues for future research projects. Further studies into the integration of technology into the classroom should be undertaken at various grade levels. For other professional development programs, the attitudes and classroom environment perceptions of students and teachers should be compared to those found in this study. Future replications of my research also should focus on how long lasting and to what level implementation is still taking place.

Relative to the quantitative component of my study, the qualitative component of my research was limited in scope to interviewing four Alliance+ teachers (but no students and no non-Alliance+ teachers). Therefore, future studies should involve more extensive use of qualitative methods than was possible in my investigation.

In my study, the criteria of effectiveness in evaluating Alliance+ were learning environment and student attitudes. In future research, however, student achievement should be included because it would be pertinent to see if it improved following teachers' participation in a professional development program.

It would be desirable to conduct a future study in a district where there is strong administration support of the program. One of the limitations of my study was lack of support from administration and teachers' reluctance to participate because of district curriculum restraints. A study in a district with more flexibility and support could provide new insights into the effectiveness of Alliance +.

Ideally future research would involve larger and more diverse populations of students and teachers. This research was on a small scale and involved a mainly Hispanic population. Using a larger group of students from various cultures would increase the generalizability of findings.

Another area of research suggested by my study would involve a comparision of other academic areas. Whereas my study involved mathematics and science classes only, similar research should involve English and reading and other subjects. Further studies also could span teacher and students at a variety of educational levels (middle-school, elementary and higher-education).

5.7 Concluding Remarks

Professional development opportunities are imperative for educators if they are to grow professionally and to keep up with new methodologies such as integrating technology into curricula. The Alliance+ professional development program is one such important opportunity for educators to hone their skills. However, I have come to the conclusion, after having conducted this research, that no professional development program is effective if it doesn't provide a component of follow-up and support for educators once they return to their classrooms. There must be a connection between what has been taught during the professional development program and how it is later implemented in the actual participants' school classrooms.

As I have learned during the time that I conducted this study, the field of learning environments is worth researching. Because students spend most of their time in the classroom, we must pay attention to how they feel within that environment. Most professional development programs are usually evaluated in terms of the effect they have on students' academic achievement. However, researchers should be encouraged also to evaluate programs in terms of how they help to improve the classroom learning environments and attitudes of students. Thus, I recommend further research in this area.

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Appendix 1

Permission Letter for School Principal

November 30, 2006

Ms. XXXXXX XXXXXXXX
Principal
XXXXX Middle School
XXXXXXXXXXXXXXX
Miami, FL XXXXX

Dear Ms. XXXXXX:

I am a former Miami-Dade County Public Schools teacher and Alliance+ trainer currently working on my doctoral dissertation at Curtin University in Australia. My area of interest is to better understand what teachers need from professional development experiences and to investigate the long term effect of teacher workshops in the classroom. For this, I designed a survey to measure students' personal state of contentment or discontentment with their science and mathematics class experiences. I'm hoping that such measure will allow me to better understand how teachers change their classroom environments after having participated in professional development experiences.

I am at the stage where I need to collect data from a wide sample of practicing science and mathematics teachers who either have or have not experienced the Alliance+ training. My records indicate that five teachers, currently working at your school site, have participated in the Alliance+ training. Thus, your school was chosen for participation in the study. Although I have received district permission to conduct the study, your approval is necessary.

I've noted that on your staff, you have three mathematics and two science teachers who have participated in the Alliance+ training: XXXXXX, XXXXXX, XXXXXX, XXXXXX, and XXXXXXX. If possible, I would like their classes to receive the survey as well as the classes of several other mathematics and science teachers who have not participated in the Alliance+ training.

Thank you in advance for your consideration of my project. If you would please e-mail your permission to my Research Assistant, XXXXXXXX, at XXXXXXXX. If you have any further questions, please contact XXXXXXX by calling XXXXXXX. You may also contact me, Ellyn Biggs, at XXXXXXXX.

Sincerely,
Ellyn Biggs

Appendix 2

Permission Letter for Parents

Parent Release Form for Research Survey

conducted in partial fulfillment of the requirement for the degree of Doctor of Sciences at Curtin University of Technology.

I, Ellyn Biggs, will be conducting a research study at XXXXXX Middle School as part of my doctoral thesis for Curtin University. The purpose of this Parent Release Form is to inform you of your child's participation in my study. I ascertain that the students' names and personal information will remain anonymous and that all data collected will be destroyed at the end of the study. The following is a description of the research study:

Purpose: To assess students' perceptions of their science or mathematics learning environments and their attitudes toward mathematics or science in order to investigate the effectiveness of teacher professional workshops.

Data to be collected: Students will answer the following questionnaires: Constructivist Learning Environment Survey, What Is Happening In this Class?, and Test Of Science-Related Attitude.

Projected Timeline: The study will be conducted during February 2007. The questionnaires will be administered only once during the study. The approximate amount of time that it will take for students to answer each questionnaire is 15 to 20 minutes. **Individuals Responsible for Research**: Ellyn Biggs XXXXXXXX or XXXXXXX

If you do not wish for your child to participate in this study, then please return the bottom portion of this form to your child's teacher by February 12, 2007.

-

I do not allow my child to participate in the present study.

Student's Name: ______________________________

Mathematics Teacher: _________________________

Science Teacher: _______________________

Parent's Signature: ____________________________ Date: ____________________

Appendix 3

Questionnaire about my Science Class

The questionnaire in Appendix 3 consists of modified versions of scales from the Constructivist Learning Environment Survey (CLES, Taylor & Fraser, 1991), the What Is Happening In this Class? (WIHIC, Fraser, McRobbie, & Fisher, 1996), and the Test Of Science-Related Attitudes (TOSRA, Fraser, 1981) and is discussed in this thesis in Sections 2.3.2, 2.3.3, 2.5, and 3.5. It was modified and used in my study and included in this thesis with the permission of the authors.

Science Class Teacher ____________ Period______

Questionnaire about my Science Class

Directions for Students: This questionnaire contains statements about this science class. Think about how well each statement describes what this class is like for you.

Draw a circle around:

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

Be sure to give an answer for all questions. If you change your mind about an answer, just cross it out and circle another.

Some statements in this questionnaire are fairly similar to other statements. Don't worry about this. Simply give your opinion about all statements.

PRACTICE EXAMPLE:

Suppose you were given the statement: 'I choose my partners for group discussion.' You would need to decide whether you choose your partners 'Almost Never', 'Seldom', 'Sometimes', 'Often', or 'Almost Always'. If you selected 'Often' then you would circle the number 4 on your questionnaire.

Learning about the world	Almost Never	Seldom	Some -times	Often	Almost Always
In this science class…					
1. I learn about the world outside of school.	1	2	3	4	5
2. My new learning starts with problems about the world outside of school.	1	2	3	4	5
3. I learn how science can be part of my out-of-school life.	1	2	3	4	5
In this science class…					
4. I get a better understanding of the world outside of school.	1	2	3	4	5
5. I learn interesting things about the world outside of school.	1	2	3	4	5
6. What I learn has nothing to do with my out-of-school life.	1	2	3	4	5

Learning to speak out	Almost Never	Seldom	Some -times	Often	Almost Always
In this science class…					
7. It's OK for me to ask the teacher "Why do I have to learn this?"	1	2	3	4	5
8. It's OK for me to question the way I'm being taught.	1	2	3	4	5
9. It's Ok for me to complain about teaching activities that are confusing.	1	2	3	4	5
In this science class…					
10. It's Ok for me to complain about anything that prevents me from learning.	1	2	3	4	5
11. It's OK for me to express my opinion.	1	2	3	4	5
12. It's OK for me to speak up for my rights.	1	2	3	4	5
Learning to learn	Almost Never	Seldom	Some -times	Often	Almost Always
In this science class…					
13. I help the teacher to plan what I am going to learn.	1	2	3	4	5
14. I help the teacher to decide how well I am learning.	1	2	3	4	5
15. I help the teacher to decide which activities are best for me.	1	2	3	4	5
In this science class...					
16. I help the teacher to decide how much time I spend on learning activities.	1	2	3	4	5
17. I help the teacher to decide which activities I do.	1	2	3	4	5
18. I help the teacher to assess my learning.	1	2	3	4	5
Teacher Support	Almost Never	Seldom	Some -times	Often	Almost Always
In this science class…					
19. The teacher takes a personal interest in me.	1	2	3	4	5
20. The teacher goes out of his/her way to help me.	1	2	3	4	5
21. The teacher considers my feelings.	1	2	3	4	5
22. The teacher helps me when I have trouble with the work.	1	2	3	4	5
In this science class…					
23. The teacher talks with me.	1	2	3	4	5
24. The teacher is interested in my problems.	1	2	3	4	5
25. The teacher moves about the class to talk with me.	1	2	3	4	5
26. The teacher's questions help me to understand.	1	2	3	4	5

Involvement	Almost Never	Seldom	Some -times	Often	Almost Always
In this science class…					
27. I discuss my ideas.	1	2	3	4	5
28. I give my opinions during class discussions.	1	2	3	4	5
29. The teacher asks me questions.	1	2	3	4	5
30. My ideas and suggestions are used during classroom discussions.	1	2	3	4	5
In this science class…					
31. I ask the teacher questions.	1	2	3	4	5
32. I explain my ideas to other students.	1	2	3	4	5
33. Students discuss with me how to go about solving problems.	1	2	3	4	5
34. I am asked to explain how I solve problems.	1	2	3	4	5
Investigation	Almost Never	Seldom	Some -times	Often	Almost Always
In this science class…					
35. I carry out investigations to test my ideas.	1	2	3	4	5
36. I am asked to think about the evidence for statements.	1	2	3	4	5
37. I carry out investigations to answer questions coming from discussions.	1	2	3	4	5
38. I explain the meaning of statements, diagrams, and graphs.	1	2	3	4	5
In this science class…					
39. I carry out investigations to answer questions which puzzle me.	1	2	3	4	5
40. I carry out investigations to answer the teacher’s questions.	1	2	3	4	5
41. I find out answers to questions by doing investigations.	1	2	3	4	5
42. I solve problems by using information obtained from my own investigations.	1	2	3	4	5
Cooperation	Almost Never	Seldom	Some -times	Often	Almost Always
In this science class…					
43. I cooperate with other students when doing assignment work.	1	2	3	4	5
44. I share my books and resources with other students when doing assignments.	1	2	3	4	5
45. When I work in groups, there is teamwork.	1	2	3	4	5
46. I work with other students on projects.	1	2	3	4	5
In this science class…					
47. I learn from other students.	1	2	3	4	5
48. I work with other students.	1	2	3	4	5
49. I cooperate with other students on class activities.	1	2	3	4	5
50. Students work with me to achieve class goals.	1	2	3	4	5

Enjoyment of my Science Class		Almost Never	Seldom	Some -times	Often	Almost Always
51.	Science lessons in this class are fun.	1	2	3	4	5
52.	I like the science lessons in this class.	1	2	3	4	5
53.	School should have more science classes like this one.	1	2	3	4	5
54.	This science class is one of the most interesting school subjects.	1	2	3	4	5
55.	I really enjoy going to this science class.	1	2	3	4	5
56.	The material covered in this science class is interesting.	1	2	3	4	5
57.	I look forward to this science class.	1	2	3	4	5
58.	I would enjoy school more if there were more science classes like this one.	1	2	3	4	5

Appendix 4

Questionnaire about my Mathematics Class

The questionnaire in Appendix 4 consists of modified versions of scales from the Constructivist Learning Environment Survey (CLES, Taylor & Fraser, 1991), the What Is Happening In this Class? (WIHIC, Fraser, McRobbie, & Fisher, 1996), and the Test Of Science-Related Attitudes (TOSRA, Fraser, 1981) and is discussed in this thesis in Sections 2.3.2, 2.3.3, 2.5, and 3.5.It was modified and used in my study and included in this thesis with the permission of the authors.

Mathematics Class Teacher ____________ Period______

Questionnaire about my Mathematics Class

Directions for Students: This questionnaire contains statements about this mathematics class. Think about how well each statement describes what this class is like for you.

Draw a circle around:

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

Be sure to give an answer for all questions. If you change your mind about an answer, just cross it out and circle another.

Some statements in this questionnaire are fairly similar to other statements. Don't worry about this. Simply give your opinion about all statements.

PRACTICE EXAMPLE:

Suppose you were given the statement: 'I choose my partners for group discussion.' You would need to decide whether you choose your partners 'Almost Never', 'Seldom', 'Sometimes', 'Often', or 'Almost Always'. If you selected 'Often' then you would circle the number 4 on your questionnaire.

Learning about the world	Almost Never	Seldom	Some times	Often	Almost Always
In this mathematics class…					
1. I learn about the world outside of school.	1	2	3	4	5
2. My new learning starts with problems about the world outside of school.	1	2	3	4	5
3. I learn how mathematics can be part of my out-of-school life.	1	2	3	4	5
In this mathematics class…					
4. I get a better understanding of the world outside of school.	1	2	3	4	5
5. I learn interesting things about the world outside of school.	1	2	3	4	5
6. What I learn has nothing to do with my out-of-school life.	1	2	3	4	5

Learning to speak out	Almost Never	Seldom	Some - times	Often	Almost Always
In this mathematics class…					
7. It's OK for me to ask the teacher "Why do I have to learn this?"	1	2	3	4	5
8. It's OK for me to question the way I'm being taught.	1	2	3	4	5
9. It's Ok for me to complain about teaching activities that are confusing.	1	2	3	4	5
In this mathematics class…					
10. It's Ok for me to complain about anything that prevents me from learning.	1	2	3	4	5
11. It's OK for me to express my opinion.	1	2	3	4	5
12. It's OK for me to speak up for my rights.	1	2	3	4	5
Learning to learn	Almost Never	Seldom	Some - times	Often	Almost Always
In this mathematics class…					
13. I help the teacher to plan what I am going to learn.	1	2	3	4	5
14. I help the teacher to decide how well I am learning.	1	2	3	4	5
15. I help the teacher to decide which activities are best for me.	1	2	3	4	5
In this mathematics class...					
16. I help the teacher to decide how much time I spend on learning activities.	1	2	3	4	5
17. I help the teacher to decide which activities I do.	1	2	3	4	5
18. I help the teacher to assess my learning.	1	2	3	4	5
Teacher Support	Almost Never	Seldom	Some - times	Often	Almost Always
In this mathematics class…					
19. The teacher takes a personal interest in me.	1	2	3	4	5
20. The teacher goes out of his/her way to help me.	1	2	3	4	5
21. The teacher considers my feelings.	1	2	3	4	5
22. The teacher helps me when I have trouble with the work.	1	2	3	4	5
In this mathematics class…					
23. The teacher talks with me.	1	2	3	4	5
24. The teacher is interested in my problems.	1	2	3	4	5
25. The teacher moves about the class to talk with me.	1	2	3	4	5
26. The teacher's questions help me to understand.	1	2	3	4	5

Involvement	Almost Never	Seldom	Some - times	Often	Almost Always
In this mathematics class…					
27. I discuss my ideas.	1	2	3	4	5
28. I give my opinions during class discussions.	1	2	3	4	5
29. The teacher asks me questions.	1	2	3	4	5
30. My ideas and suggestions are used during classroom discussions.	1	2	3	4	5
In this mathematics class…					
31. I ask the teacher questions.	1	2	3	4	5
32. I explain my ideas to other students.	1	2	3	4	5
33. Students discuss with me how to go about solving problems.	1	2	3	4	5
34. I am asked to explain how I solve problems.	1	2	3	4	5
Investigation	Almost Never	Seldom	Some - times	Often	Almost Always
In this mathematics class…					
35. I carry out investigations to test my ideas.	1	2	3	4	5
36. I am asked to think about the evidence for statements.	1	2	3	4	5
37. I carry out investigations to answer questions coming from discussions.	1	2	3	4	5
38. I explain the meaning of statements, diagrams, and graphs.	1	2	3	4	5
In this mathematics class…					
39. I carry out investigations to answer questions which puzzle me.	1	2	3	4	5
40. I carry out investigations to answer the teacher's questions.	1	2	3	4	5
41. I find out answers to questions by doing investigations.	1	2	3	4	5
42. I solve problems by using information obtained from my own investigations.	1	2	3	4	5
Cooperation	Almost Never	Seldom	Some - times	Often	Almost Always
In this mathematics class…					
43. I cooperate with other students when doing assignment work.	1	2	3	4	5
44. I share my books and resources with other students when doing assignments.	1	2	3	4	5
45. When I work in groups, there is teamwork.	1	2	3	4	5
46. I work with other students on projects.	1	2	3	4	5
In this mathematics class…					
47. I learn from other students.	1	2	3	4	5
48. I work with other students.	1	2	3	4	5
49. I cooperate with other students on class activities.	1	2	3	4	5
50. Students work with me to achieve class goals.	1	2	3	4	5

Enjoyment of my Mathematics Class		Almost Never	Seldom	Some - times	Often	Almost Always
51.	Mathematics lessons in this class are fun.	1	2	3	4	5
52.	I like the mathematics lessons in this class.	1	2	3	4	5
53.	School should have more mathematics classes like this one.	1	2	3	4	5
54.	This mathematics class is one of the most interesting school subjects.	1	2	3	4	5
55.	I really enjoy going to this mathematics class.	1	2	3	4	5
56.	The material covered in this mathematics class is interesting.	1	2	3	4	5
57.	I look forward to this mathematics class.	1	2	3	4	5
58.	I would enjoy school more if there were more mathematics classes like this one.	1	2	3	4	5