Science and Mathematics Education Centre

Learning Environments of Beginning Algebra Students: Compulsory Adolescent vs. Voluntary Adult Classes

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Declaration

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

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

Signature: *Tiffany Fraser*

Date: April 5, 2011

Abstract

The main purpose of this study was to investigate differences between adolescents and adults enrolled in beginning algebra courses in terms of their perceptions of preferred and actual learning environment and their attitudes toward mathematics. In addition, I investigated the validity of the learning environment and attitude questionnaires, as well as associations between the learning environment and attitudes among high-school and community-college students in Fresno County in California. A sample of 750 students from 38 classes in five high schools and two community colleges were involved. The learning environment was assessed with three scales (Teacher Support, Investigation, and Task Orientation) from the actual and preferred forms of the What Is Happening In this Class? (WIHIC), whereas students' attitudes were assessed with two scales (Value of Mathematics and Self Confidence) from the Attitudes Toward Mathematics Inventory (ATMI).

Principal axis factoring with varimax rotation and Kaiser normalization supported a strong facture structure for a 24-item three-scale version of the actual or preferred forms of the WIHIC and for a 25-item two-scale version of the ATMI. The total percentage of variance accounted for by the three WIHIC scales was nearly 60% for the preferred form and just over 60% for the actual form, and by the two ATMI scales was roughly 56%. The alpha reliability coefficient for every WIHIC and ATMI scale was at least 0.88, therefore demonstrating strong internal consistency for all scales.

MANOVA and effect sizes were used to provide information about the statistical significance and magnitude of the differences between high-school and college students' scores separately for each WIHIC and ATMI scale. For the WIHIC environment scales, between-group differences were statistically significant for actual Teacher Support (effect size of 0.24 standard deviations), actual Task Orientation (effect size of 0.70 standard deviations), and all preferred environment scales (effect sizes ranging from 0.36 to 0.78 standard deviations. For the ATMI, differences between groups were statistically significant for Value of Mathematics and associated with an effect size of 0.50 standard deviations. Differences between high-school students and community-college students were statistically nonsignificant for the ATMI scale of Self Confidence (with a small effect size of 0.18 standard deviations). Relative to high-school students, college students preferred more teacher support, involvement and focus on classroom tasks, perceived a greater level of teacher support and personal dedication to classroom activities, and reported higher ratings for the value in mathematics.

Finally, the use of simple correlation and multiple regression analyses demonstrated positive associations between students' attitudes toward mathematics and the learning environment. The simple correlation was statistically significant between each WIHIC scale (Teacher Support, Involvement and Task Orientation) and each ATMI scale (Value of Mathematics and Self Confidence) with the student as the unit of analysis, and between the ATMI scale of Value of Mathematics and the WIHIC scales of Teacher Support and Task Orientation and between Self Confidence and Involvement. The multiple regression analyses showed that the WIHIC scale of Task Orientation was a significant independent predictor of Value

of Mathematics at both the individual and class level of analysis, and that Involvement and Task Orientation were significant independent predictors of Self Confidence when the student was used as the level of analysis. The direction of every significant correlation and regression coefficient was positive, suggesting that a greater emphasis on the three learning environment scales of Teacher Support, Involvement and Task Orientation was related to higher Value of Mathematics and Self Confidence scores.

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Chapter 1

INTRODUCTION

The man ignorant of mathematics will be increasingly limited in his grasp of the main forces of civilization. ~John Kemeny (1926–1992)

Mathematics is an important component of any comprehensive education. Businesses, institutions of higher learning, and local, national and international governments are investing in mathematics education because of its importance to a knowledgeable workforce, many technical professions and to civilization as a whole. "Mathematically proficient students are also able to compare the effectiveness of two plausible arguments, distinguish correct logic or reasoning from that which is flawed, and – if there is a flaw in an argument – explain what it is" (Common Core State Standards Initiative, 2010).

1.1   Overview

This chapter provides the reader with the context of the study in Section 1.2, followed by the statement of the problem in Section 1.3. I identify the rationale for my study in Section 1.4 and its significance in Section 1.5. Section 1.6 delineates the three Research Questions and Section 1.7 provides the reader with an overview of the thesis.

1.2   Context of the Study

The California Department of Education has defined the expectations for successful completion of a beginning algebra course by creating a state-adopted set of frameworks and providing a state-wide standardized examination for beginning

algebra at the end of 8th grade (Curriculum Development and Supplemental Materials Commission State of California, 2005). Many students enrolled in a beginning algebra course in high school or college are below grade level.

At the time when this research was conducted, roughly 20% of the students in the State Center Community College District were enrolled in a beginning algebra course and over half of all students enrolled in a mathematics class were in a course at the algebra level or below (SCCCD Department of Institutional Research, 2011). With these kinds of numbers, the question arises as to why so many students are still needing to take beginning algebra at the community college. It was obvious to me that there exists a critical need to know more about these students' algebra experiences prior to entering college and their algebra experiences during college.

1.3   Statement of the Problem

Comparing the Mathematics Content Standards for California Public Schools (Curriculum Development and Supplemental Materials Commission State of California, 2005) and the recommended College Algebra Standards prepared by the American Mathematical Association of Two Year Colleges (Agras, 2005) reveals that the curriculum is similar at the two levels (see Appendix A). It is reasonable that the recommended college algebra standards are similar to the public school standards, because beginning algebra is not a college-level course.

Because the core algebraic curriculum is the same in both settings, I decided to focus my research on aspects that could be different: the learning environments and students' attitudes toward mathematics. General adolescent development theories and adult learning theories, as well as personal experience, suggest that the students

at these two levels are not as similar as their respective course content. Adolescents are dependent on the teacher for direction, have relatively limited life experience and look to society (curriculum standards) for what to learn and the order in which it should be learned, while adults integrate new knowledge with previous experience, want to learn what they believe that they need to know, and want to take an active role in the learning experience (Knowles, 1980; Reece & Walker, 1997; Rogers, 2001; Woolhouse, Jones, & Rees, 2001). Therefore, it became a point of curiosity to me as to how, or if, the two groups differ in these regards. Do high school and college students perceive their respective learning environments differently? And how do the attitudes toward mathematics differ between the two levels of students? My study investigated differences between adolescents in a compulsory beginning algebra course in high school and adults voluntarily taking a course at the same level at a community college.

1.4   Rationale for the Study

A common measure used to describe student success is some form of achievement score or a combination of scores. It can be a local measure such as a course grade or a broader measure, such as California's Academic Performance Index (API), of the academic performance and growth of K – 12 schools on a variety of academic measures, or a global measure such as the Trends in International Mathematics and Science Study (TIMSS, International Association for the Evaluation of Educational Achievement, 2009). No such achievement measure currently exists that covers beginning algebra at both the high-school and community-college level.

Rather than create a standard measure of achievement to use across the age levels, I chose to use measures related to learning environment and students' attitudes toward mathematics. Past research has shown that student attitudes affect the learning environment and that a more positive learning environment contributes to greater student achievement (Fraser, 1998b, 2001, in press). A study conducted by Yara (2009) with 1542 secondary students in Nigeria revealed that teacher support and involvement (traits addressed by learning environment research) are related to more positive attitudes. Wubbels and Levy (1993) affirmed the significance of teacher behavior in influencing students' attitudes, which can be linked with improved achievement. Consonant with previous research, a study with 449 students from a large urban school district in the USA indicated that both engagement in school (a trait of the learning environment) and students' perceptions of their own academic competence (self-confidence) influenced achievement in mathematics for high school students (Akey, 2006).

1.5   Significance of the Study

The findings from my study are significant because they have the potential to provide insights into and influence current and future research and practice related to the mathematics classroom environment in high schools and community colleges. My study could indicate that elements of the learning environment can influence students' attitudes toward mathematics. Together with research conducted in other settings, and research that focuses on other aspects of the mathematics classroom, teachers need to carefully decide how they can shape the learning environment to best suit the students.

Future researchers are likely to be interested in my finding about whether the WIHIC and the ATMI were valid and reliable when used with high-school and community-college students taking a beginning algebra class in Fresno County. This study could guide future research into learning environment and/or attitudes toward mathematics in California, in high schools or in community colleges.

My study adds to the richness of learning environment studies with a primary focus on the mathematics classroom (e.g. Chionh & Fraser, 2009; Dorman, 2001; Kilgour, 2006; Majeed, Fraser, & Aldridge, 2002; Mink & Fraser, 2005; Moldavan, 2007; Ogbuehi & Fraser, 2007; Spinner & Fraser, 2005). Of the relatively few learning environment studies that have focused specifically in on mathematics classes, none of this small group of learning environment studies has involved two different age groups taking the same mathematics course.

1.6   Research Questions

1.   Are modified versions of the following questionnaires valid when used with beginning algebra students:

   (a) Preferred Form of the What Is Happening In this Class (WIHIC)?

   (b) Actual form of the What Is Happening In this Class (WIHIC)?

   (c) Attitudes Toward Mathematics Inventory (ATMI)?

2.   Are there differences between adolescents and adults in a beginning algebra course in terms of:

   (a) Preferred learning environment?

   (b) Perceived learning environment?

   (c) Attitudes toward mathematics?

3. Are there associations between the learning environment of beginning algebra classes and students' attitudes toward mathematics?

1.7 Overview of the Thesis

Chapter 1 provides the reader with the context of the study and a statement of the problem. Also included were the rationale and the significance of the study. The chapter concluded by identifying the three research questions.

Chapter 2 provides a review of the related literature and describes each of the instruments used in gathering data for the study. The early work and history of learning environment research is summarized, beginning in the 1960s with the research of Walberg and Moos (Moos, 1974a; Walberg & Anderson, 1968) and leading up to the many recent applications of learning environment research (Fraser, 2007). Details about the development, validity and reliability of eight of the learning environment instruments that have historical or contemporary significance are provided within the chapter. Two instruments are of historical significance, namely, the Learning Environment Inventory (LEI, Walberg & Anderson, 1968) and the Classroom Environment Scale (CES, Moos & Trickett, 1974). Additional instruments were developed for more specialized environments, such as the Individualized Classroom Environment Questionnaire (ICEQ, Rentoul & Fraser, 1979), the College and University Classroom Environment Questionnaire (CUCEI, Fraser & Treagust, 1986) and the Science Laboratory Environment Inventory (SLEI, Fraser, Giddings, & McRobbie, 1992). Special attention is paid to the development and application of the What Is Happening In this Class? (WIHIC) questionnaire which was chosen for collecting learning environment data in this study.

Chapter 2 also reviews literature about the history of studying students' attitudes toward mathematics and the development and validation of several surveys designed to collect data on students' attitudes toward mathematics. Because the Attitudes Toward Mathematics Inventory (ATMI) was chosen for my study, much of the discussion relates to the development, validation and application of the ATMI. In addition, a review of past research related to learning environments is included. Of particular interest is past research involving the WIHIC and the ATMI. Although no previous research has combined the use of these two instruments, plenty of earlier studies reported the reliability and validity of the instruments.

Chapter 3 is devoted to describing the research methods followed in investigating the three research questions. Included in the discussion of my quantitative research methods are the data sources in terms of the role of the participants, the sample used and the population from which it was drawn. The data were collected from 383 high-school students and 367 community-college students enrolled in a typical beginning algebra

Chapter 4 reports the analysis of the quantitative data gathered to answer the three research questions in this study. The factor structure and reliability of the instruments are reported as well as a comparison of the high-school and college students in terms of preferred learning environment, actual learning environment and attitudes. Finally, associations between attitudes and the learning environment are analyzed and reported.

Further discussion of my study is provided in chapter 5. The study and its main findings are summarized. Implications for improving classroom learning

environments in high-school and college beginning algebra classes are presented, as well as limitations and suggestions for further study.

Following chapter five, documents related to my study can be found in the appendices. Appendix A contains the content standards for the California public schools for beginning algebra, followed by beginning algebra standards for the college level. Appendix B contains the Information Sheet and Consent Forms used by the volunteer participants. Finally, Appendix C contains parts I and II of the questionnaire used to collect data.

Chapter 2

REVIEW OF THE LITERATURE

2.1   Introduction

Students taking beginning algebra in California public schools range from being middle-school students in 7th or 8th grade, to high-school students in 9th to 12th grade, and to undertaking lower-division coursework for college or university.   The mathematics framework for California public schools suggests that beginning algebra is an 8th grade topic. Students in high school or college taking beginning algebra are considered to be behind grade level. Yet, nearly 60% of the mathematics courses taught in the community-college district where I teach are below college level. The curriculum for beginning algebra is quite similar at the various school levels, but the students are not. Adolescents tend to be busy building an identity for themselves and matching it up against their peers.   They are notorious for being distracted by their surroundings and being far more interested in their social life than their academic life. Adult learners function at a 'need to know' level, bring years of experience to the course and generally prefer a more learner-centered approach (Knowles, 1990). As I moved from teaching at the high school to the college, I began to be curious about how my students perceived the learning environments in high-school and community-college beginning algebra classes.

Learning environment research recognizes that the student is at a good vantage point to describe the regular activities of the classroom. From age five until age 18 years, most Americans make a career of being a student. For nearly 19 years, students make a regular practice of attending classes, getting to know teachers, classmates and the

school system, and they soon begin to be aware of what is happening around them and to them and what they prefer in a learning environment.

For this study, it is important to understand the history, development and research applications of learning environment instruments, as well as research on student attitudes toward mathematics. Together these two topics provide the researcher with a new window into beginning algebra classrooms and the students within. Plenty of research has been conducted in the areas of learning environments and student attitudes toward mathematics, but never have two different age groups been compared with respect to learning environment and attitudes toward mathematics for similar disciplines.

This chapter begins with a review of the history and development of learning environment research (Section 2.2), Section 2.3 examines the development of learning environment instruments, with special attention paid to the development, validation and application of the What Is Happening In this Class? questionnaire used in my study (Section 2.4), and finally Section 2.5 focuses on student attitudes toward mathematics.

2.2   History and Development of Learning Environment Research

Learning environment research focuses on the shared perceptions of the students and the teachers in a particular classroom environment. The notion that a distinct classroom environment exists began as early as the 1930s, when Kurt Lewin (1936) launched the idea that personal behavior is the result of the interaction between the individual and his or her environment. Murray (1938) expanded this idea by considering additional effects within the system, namely, that an individual's

behavior is affected internally by characteristics of personality and externally by the environment itself. Murray proposed a needs-press model that allows analogous representation of personal and environment in common terms.

Following Murray's model, Getzels and Thelen (1960) put forward a model for the class as a social system that suggests that the interaction of personality, expectations and the environment predicts behaviors including student outcomes. Stern (1970) formulated a theory of person-environment congruence in which complementary combinations of personal needs and environmental press enhance student outcomes. Later, Doyle (1979) proposed that the classroom be viewed from an ecological viewpoint, hence placing strong emphasis on the inter-relationships and communications among all members in the classroom community. In the 1960s, Getzels and Thelen, and then later in the 1980s, Wubbels, Brekelmans and Hermans (1987) all suggested that teacher-student interaction is a powerful force that can play a major role in influencing the cognitive and affective development of students. Wubbels and Levy (1993) reaffirmed the significance of teacher behavior in classrooms, particularly how this can influence students' motivation, which can be linked with improved achievement. Individual performance is only one side of the learning process if we consider learning as a result of interaction with the environment (Allodi, 2007).

Herbert Walberg and Gary Anderson's (1968) work with Harvard Project Physics experimental course led to the development of the Learning Environment Inventory (LEI). The LEI was developed to asses students' perceptions of their learning environment during the research and evaluation phase of the Harvard Project Physics. Simultaneously at Stanford University, Rudolf Moos began developing the

first of his social climate scales, which led to the development of the Classroom Environment Scale (Fisher & Fraser, 1983; Moos, 1974b, 1979; Moos & Trickett, 1974; Trickett & Moos, 1973).

The study of learning environments has a theoretical base in the studies of a variety of human environments conducted by Rudolf Moos. Based on extensive empirical research, Moos (1974a, 1974b) concluded that such environments could be described in terms of three general categories, referred to as dimensions. The Relationship Dimension describes the degree of student attentiveness, interest, and participation in class activities, as well as the concern and friendship students feel for one another, and the amount of help, trust and friendship the teacher shows for students. The Personal Development Dimension measures the emphasis on completing planned activities and staying on the subject matter, as well as how much the students compete with one another for grades and recognition, and how hard it is to achieve good grades. The System Maintenance and Change Dimension assesses the emphasis on students behaving in an orderly and polite manner, the organization of assignments and activities, rule clarity and consequences, as well as how strict the teacher is and how much students contribute to planning classroom activities. The development of the Classroom Environment Scale (CES) linked Moos' work in other human environments to school settings (Moos & Trickett, 1974; Trickett & Quinlan, 1979).

The development and use of learning environment instruments has become more prevalent since the LEI and CES were developed for use in the USA in the late 1960s (Moos, 1979; Walberg & Anderson, 1968). The LEI has since been translated into many languages as the research has grown internationally. Moos' three dimensions

have continued to influence the development of learning environment questionnaire. Walberg's and Moos' work in the field led to the birth of the journal *Learning Environments Research: An International Journal* and books on learning environment, such as Fraser's (1986) *Classroom Environments* and Fisher and Khine's (2006) *Contemporary Approaches to Research on Learning Environments: Worldviews*.   As well, the American Educational Research Association (AERA) established a very successful Special Interest Group (SIG) on Learning Environments in 1984 and this group sponsored an annual monograph (Fraser, 1986; Waxman & Ellett, 1990).

Two further programs of learning environment research emerged, one in the Netherlands led by Theo Wubbels (1993), and one in Australia led by Barry Fraser (1981b). The Questionnaire on Teacher Interaction (QTI) grew out of Wubbels' research and focused on the nature and quality of interpersonal relationships between students and teachers (Wubbels, 1993; Wubbels & Brekelmans, 1998).   Fraser and his colleagues began programmatic research, which first focused on student-centered classrooms and involved the use of the Individualized Classroom Environment Questionnaire (Fraser, 1990; Rentoul & Fraser, 1979).

The use of students' perceptions of classroom environments as predictor variables has established consistent relationships between the nature of the classroom environment and student cognitive and affective outcomes (Fraser, 2007; Goh & Fraser, 1998). Although the concept of classroom environment is subtle, much progress has been made in conceptualizing, measuring and analyzing it, and mapping its effects on students (Fraser, 2007; Wubbels & Brekelmans, 1998). Numerous studies have shown that students' classroom environment perceptions, relative to

students' background characteristics, are more closely associated with learning outcomes (Fraser, 2002).

2.3   Development of Learning Environment Research Instruments

The field of learning environments is blessed with the availability of a variety of economical, valid and widely-applicable questionnaires that have been developed and used for assessing students' perceptions of classroom environment (Fraser, 2002; Wubbels & Brekelmans, 1998). Few fields of education can boast of the existence of such a rich array of validated and robust instruments which have been used in so many research applications (Aldridge & Fraser, 2000).

Students are at a good vantage point to make judgments about classrooms because they have encountered many different learning environments and have had enough time in the class to form accurate impressions (Fraser, 2001). Even if teachers are inconsistent in their behavior, they usually project a consistent image of the long-standing attributes of a classroom environment. A distinctive feature of most of the instruments is that they not only have a form to measure perceptions of actual or experienced classroom environment, but also another form to measure perceptions of preferred or ideal classroom environment (Wubbels & Brekelmans, 1998).

Learning environment research has many and varied applications. According to Fraser (1998a), past research can be identified as focusing on one or more categories: (1) associations between student outcomes and environment (Chionh & Fraser, 2009; Dorman, 2001; Majeed, Fraser, & Aldridge, 2002; Quek, Wong, & Fraser, 2005), (2) evaluation of educational innovations (Lightburn & Fraser, 2007; Mink & Fraser, 2005; Spinner & Fraser, 2005), (3) differences between students' and teachers'

perceptions of the same classrooms (Fisher & Fraser, 1983; Kilgour, 2006; Maor & Fraser, 1996; Sinclair & Fraser, 2002), (4) whether students achieve better when in their preferred environments (Fraser & Fisher, 1983) , (5) teachers practical attempts to improve their classroom climates (Aldridge, Fraser, & Sebela, 2004; Sinclair & Fraser, 2002), (6) combining qualitative and quantitative methods (Martin-Dunlop & Fraser, 2008; Ogbuehi & Fraser, 2007; Spinner & Fraser, 2005), (7) school psychology (Burden, 1993; Sink & Spencer, 2005), (8) links between educational environments (Dorman, Fraser, & McRobbie, 1997; Jegede, Fraser, & Fisher, 1995; Marjoribanks, 1991), (9) cross-national studies (Aldridge & Fraser, 2000; Aldridge, Fraser, Taylor, & Chen, 2000; Fraser, Aldridge, & Adolphe, 2010), (10) transition from primary to secondary education (Ferguson & Fraser, 1999), and (11) teacher education (Martin-Dunlop & Fraser, 2008).

The following sections review literature about the development and use of learning environment instruments. The first reviews some historically significant questionnaires (Section 2.3.1), followed by the My Class Inventory (MCI) survey (Section 2.3.2) and the Questionnaire on Teacher Interaction (QTI, Section 2.3.3). The section continues with instruments that focus on more particular learning environments such as the Science Laboratory Environment (SLEI, Section 2.3.4) and the Constructivist Learning Environment Survey (CLES, Section 2.3.5). The section concludes with a brief discussion of some additional instruments (2.3.6) that were designed for specific learning environments such as parochial schools, computer laboratories and distance learning classrooms. Table 2.1 summarizes several learning environment instruments and classifies each scale according to Moos' scheme.

2.3.1 Historically-Significant Questionnaires

This section provides some background on four historically significant questionnaires. Section 2.3.1.1 describes the history of the Learning Environment Inventory (LEI) and the Classroom Environment Scale (CES). Sections 2.3.1.2 and 2.3.1.3 provide background on the Individualized Classroom Environment Questionnaire (ICEQ) and the College and University Classroom Environment Inventory (CUCEI), respectively.

2.3.1.1 Learning Environment Inventory (LEI) and Classroom Environment Scale (CES)

The LEI and the CES were developed in the United States in the late 1960s. Walberg developed the Learning Environment Inventory (LEI) to assess students' perceptions of their learning environments during his research and evaluation of Harvard Project Physics (Walberg & Anderson, 1968). The Classroom Environment Scale (CES) grew out of Moos' development of a theory to sort human environment dimensions into three areas: Relationship Dimension, Personal Development Dimension and System Maintenance and Change Dimension. The creation of the CES allowed researchers to study the learning environment according to these three dimensions as they relate specifically to schools (1974a, 1974b).

As research grew internationally, Walberg's (1968) Learning Environment Inventory (LEI) and Moos and Trickett's (1974) Classroom Environment Scale (CES) were translated into other languages. A study in Rajasthan, India validated a Hindi version of the LEI with 166 groups of students in 83 general science classes and 134 similar students in 67 social studies classes (Walberg, Singh, & Rasher, 1977). In Indonesia, Paige (1979) investigated associations between elementary students' attitudes and

the scales of the two learning environment instruments. The CES and LEI became trusted instruments because of their reliability and predictive validity. A couple of other historically important questionnaires, in addition to the CES and LEI, are considered below.

2.3.1.2   *Individualized Classroom Environment Questionnaire (ICEQ)*

Rentoul and Fraser (1979) initially developed the Individualized Classroom Environment Questionnaire (ICEQ) to distinguish individualized classrooms from conventional ones. The questionnaire was shaped by the literature on individualized and inquiry-based learning. The final version has 50 items equally divided among five scales.

The ICEQ has been found to be valid and reliable in several settings in several countries (Fraser, 1990). Rentoul and Fraser's (1979) initial study was conducted with 225 junior high students in 15 classes in Sydney, Australia. In the Netherlands, Wierstra (1984) analyzed data from 398 15–16 year old students in nine classes. Fraser, Nash and Fisher's (1983) further validation involved 116 grade 8 and 9 science classes in Tasmania.

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

Until the 1980s, very few learning environment studies had been undertaken in colleges or universities that paralleled the work in the primary and secondary schools. As a result, the College and University Classroom Environment Inventory (CUCEI) was developed for use in small classes (seminars) with fewer than 30 students. The CUCEI contains seven scales with seven items each (Fraser &

Treagust, 1986) and was validated with a sample of 536 alterative high-school students in 45 classes with 106 teachers in Australia.

Table 2.1 Scales from 11 Learning Environment Instruments for Educational Settings Classified According to Moos' Scheme

Instrument	Date Developed & Authors	Items per Scale	Scales Classified According to Moos' Scheme		
			Relationship Dimensions	Personal Development Dimensions	System Maintenance and Change Dimensions
Learning Environment Inventory (LEI)	1968 Walberg & Anderson	7	Cohesiveness Friction Favouritism Cliqueness Satisfaction Apathy	Speed Difficulty Competitiveness	Diversity Formality Material Environment Goal Direction Disorganisations Democracy
Classroom Environment Scale (CES)	1974 Moos	10	Involvement Affiliation Teacher Support	Task Orientation Competition	Order and Organisation Rule Clarity Teacher Control Innovation
Individualised Classroom Environment Questionnaire (ICEQ)	1979 Rentoul & Fraser	10	Personalisation Participation	Independence Investigation	Differentiation
College and University Classroom Environment Inventory (CUCEI)	1986 Fraser & Treagust	10	Personalisation Involvement Student Cohesiveness Satisfaction	Task Orientation	Innovation Individualisation
Questionnaire on Teacher Interaction (QTI)	1990 Creton, Hermans, & Wubbels	8 –10	Leadership Helpful/Friendly Understanding Student Responsibility and Freedom Uncertain Dissatisfied Admonishing Strict		
Science Laboratory Environment Inventory (SLEI)	1995 Fraser, Giddings & McRobbie	7	Student Cohesiveness	Open-Endedness Integration	Rule Clarity Material Environment
Constructivist Learning Environment Survey (CLES)	1995 Taylor, Dawson & Fraser	7	Personal Relevance Uncertainty	Critical Voice Shared Control	Student Negotiation
What Is Happening In this Class? (WIHIC)	1996 Fraser, McRobbie & Fisher	8	Student Cohesiveness Teacher Support Involvement	Investigation Task Orientation Cooperation	Equity
Web-Based Learning Environment Instrument (WEBLEI)	2003 Chang & Fisher	4	Access Response	Interaction	Results
Technology-Rich Outcomes-Focused Learning Environment Inventory (TROFLEI)	2004 Aldridge, Dorman, & Fraser	10	Student Cohesiveness Teacher Support Involvement Young Adult Ethos	Task Orientation Investigation Cooperation Differentiation	Equity Computer Usage
Place-based And Constructivist Learning Environment (PLACES)	2007 Zandvliet	5	Cohesiveness Student Involvement	Environmental Interaction Critical Voice Open-Endedness	Integration Student Negotiation Shared Control

Adapted from Fraser (1998a)

An action-research study of preservice teachers and their elementary school students' perceptions of the classroom learning environment was conducted at Queensland University of Technology (Yarrow, Millwater, & Fraser, 1997). The CUCEI was administered to 536 adult students from 45 classes who were returning to school to complete their education. Data showed that these students perceived their classes as having greater involvement, satisfaction, innovation, and individualization than the control group.

In an evaluative study using both student perceptions of classroom environment and teacher perceptions of school environment within the same study, Fraser, Williamson and Tobin (1987) focused on a specific type of alternative high school in Australia called 'Senior Colleges' which catered for adult learners who were returning to complete their schooling. A sample of 536 students from 45 classes were administered the CUCEI. Student data revealed that, when compared to a control group, the alternative high school students perceived their classes as having greater involvement, satisfaction, innovation, and individualisation.

2.3.2   My Class Inventory (MCI)

The My Class Inventory (MCI) was created as a simplified form of the LEI for use with younger students (Fisher & Fraser, 1981). Originally written for children aged 8–12 years, it has also been successfully used with middle school students (Goh & Fraser, 2000; Majeed, Fraser, & Aldridge, 2002). Fraser and O'Brien (1985) deviated from the previous studies of elementary classrooms involving either systematic observation or naturalistic inquiry and case study, by focusing on student and teacher perceptions of the classroom environment. The short form of the MCI

was administered to 758 grade 3 students in 32 classes in eight schools in the suburbs of Sydney, Australia. Alpha coefficients for the actual and preferred form were reported to be satisfactory and the short form of the MCI demonstrated good discriminant validity (Fraser & O'Brien, 1985).

Four features make the MCI different from the LEI. First, the MCI contains only five of the LEI's original 15 scales. This reduces some of the issues of student fatigue when used with younger students. Second, the wording has been adjusted to improve readability. Third, students respond using a Yes/No format rather than the four-point format and, fourth, students circle those responses directly on the questionnaire itself, rather than transferring their responses to a separate scoring sheet.

In research conducted by Goh and Fraser (2000) among 1512 elementary mathematics students from schools in Singapore, a widely-applicable and convenient questionnaire for assessing perceptions of the classroom climate at the elementary-school level was validated. A short form of the MCI was validated by Fraser and O'Brien (1985) with a sample of 758 grade 3 students from 32 classrooms in eight schools in the suburbs of Sydney.

Although intended for use with younger students, the readability of the instrument led Majeed, Fraser and Aldridge (2002) to use the MCI in a study of lower secondary mathematics in Brunei Darussalam. Analysis of data from a sample of 1565 students from 81 classes in 15 government secondary schools revealed a satisfactory factor structure for a refined, three-scale version of the MCI, as well as satisfactory reliability and discriminant validity. A noteworthy aspect of the study is that the

factorial validity of the MCI had not been previously established in studies in other countries.

Other studies involving the MCI have been recently conducted in the United States. Mink and Fraser's (2005) study in Florida involving 120 grade 5 students revealed that MCI scales exhibited satisfactory internal consistency reliability and discriminant validity. Prior research was replicated in that students' satisfaction was greater in classrooms with a more positive learning environment. In Washington state, Sink and Spencer (2005) examined the reliability and factorial validity of the MCI-short form in a study with more than 2800 upper-elementary students. A revised version of the MCI-SF consisting of 18 items was found to be valid. In Texas, 588 grade 3–5 grade students were participants in a study in which the MCI was used to evaluate the effectiveness of educational alternatives in science. Various analyses supported the factorial validity and reliability of the MCI with this sample (Scott Houston, Fraser, & Ledbetter, 2008).

2.3.3   *Questionnaire on Teacher Interaction (QTI)*

The Questionnaire on Teacher Interaction (QTI) grew out of research originating in the Netherlands and focused on the nature and quality of interpersonal relationships between students and teachers (Wubbels, 1993; Wubbels & Brekelmans, 1998). Although research began at the senior high level, cross-validation and comparative work has been completed at various levels in the United States (Wubbels & Levy, 1993) and throughout the world. In Singapore, Goh and Fraser (1998) administered the QTI to 1512 elementary students in a government school, leading to the validation of the QTI as a widely-applicable and convenient questionnaire for

assessing teacher interpersonal behavior. Another notable study in Singapore involving 497 gifted and non-gifted secondary-school chemistry students supported the reliability and validity of the QTI (Quek, Wong, & Fraser, 2005).

In a study in Korea, a Korean translation of the QTI was found to be valid and reliable when administered to 543 students in 12 Korean schools (Kim, Fisher, & Fraser, 2000). Lee, Fisher and Fraser (2003) also administered the QTI to 439 senior high school students in Korea and confirmed its validity using the pattern of scale of intercorrelations and internal consistency. Satisfactory reliability was reported for different QTI scales using both the individual and the class mean as the units of analysis.

When an elementary version of the QTI was translated into Standard Malay, statistical analyses revealed that it was valid and reliable with 3104 elementary students in 136 classrooms in Brunei (Scott & Fisher, 2004). In Indonesia, the validity of the QTI was reported when used with 422 private university students in 12 classrooms (Fraser, Aldridge, & Soerjaningsih, 2010). A sample of 674 students from 24 classes in grades 9–11 participated in a study in Turkey conducted by Telli, den Brok and Cakiroglu (2007).

The Principal Interaction Questionnaire, based on the QTI, was developed and validated in Australia to measure principals' interpersonal behavior with their teaching staff. The study was conducted by Fisher and Cresswell (1998) throughout Australia where it was completed by the principal and 20 teachers from each of 56 schools.

2.3.4   Science Laboratory Environment Inventory (SLEI)

Several learning environment instruments assess unique classroom settings. For example, the Science Laboratory Environment Inventory (SLEI) was developed to suit the nature of the laboratory classroom (Fraser, Giddings, & McRobbie, 1992, 1995). The instrument was validated with an impressive cross-national sample of 5447 students. The students in the sample came from 269 senior high school and university classes in six countries. It was then cross-validated with 1594 senior high-school students in 92 classes in Australia. The SLEI contains five seven-item scales. Scales include items that measure the integration of information from lecture to laboratory and the scale of open-endedness. Through a variety of applications, the SLEI displayed evidence of its usefulness. It was revealed that science laboratory classes are dominated by closed-ended activities.

The SLEI (along with the QTI) were used to study associations between students' perceptions of their biology teachers' interpersonal behavior and their laboratory learning environments in Tasmania, Australia. A sample of 489 students from 28 senior-high biology classes in eight schools completed the questionnaires. Statistical analyses supported the validity and reliability of both instruments when used with senior-high biology students (Henderson, Fisher, & Fraser, 2000).

The main purpose of a study conducted in Miami, Florida was to evaluate the use of anthropometric activities in terms of student outcomes and classroom environment (SLEI). The sample consisted of 761 biology students in 25 classes from a suburban public high school. Data analyses supported the SLEI's factorial validity, internal

consistency reliability and ability to differentiate between classrooms (Lightburn &
Fraser, 2007).

A Korean translation of the SLEI was validated with 439 senior-high students in
Korea. Of the 439 students, 99 were science-independent stream students, 195 were
science-oriented stream students, and 145 were humanities stream students. Factorial
validity and internal consistency reliability of the SLEI were confirmed for the
Korean version (Fraser & Lee, 2009).

Based on the SLEI, the Computer Laboratory Environment Inventory (CLEI) was
developed by Newby and Fisher (1997) to measure student perceptions of aspects of
their laboratory environment: Student Cohesiveness, Open-Endedness, Integration,
Technology Adequacy and Laboratory Availability. Newby and Fisher demonstrated
that the CLEI was a valid and reliable instrument.

Two studies in secondary-school chemistry classes in Singapore used another
modification of the SLEI, the Chemistry Laboratory Environment Inventory (CLEI).
The first study involved 1,592 students in co-educational government schools and the
second involved 497 gifted and non-gifted grade 10 students in independent schools.
Both studies provided strong support for the validity of the CLEI when used with
students in Singapore (Quek, Wong, & Fraser, 2005; Wong & Fraser, 1996).

2.3.5   *Constructivist Learning Environment Survey (CLES)*

The Constructivist Learning Environment Survey (CLES) was developed to assist
researchers and teachers to measure the degree to which a classroom's environment
is consistent with a constructivist epistemology (P. C. Taylor, Fraser, & Fisher,

1997). A constructivist classroom is concerned with a sense-making process that involves active negotiation and consensus building. Taylor and colleagues established the plausibility of the CLES in small-scale, classroom-based qualitative studies, whereas statistical analyses of data from large-scale studies in the USA and Australia revealed a robust and reliable instrument. After several administrations and modifications to the CLES, the six-item CLES scales have satisfactory internal consistency and factorial validity.

In a cross-national study, the CLES was validated with English and Chinese versions in Taiwan and Australia. The participants in the study were 1081 high-school students from 50 classes in Australia and 1879 students from 50 classes in Taiwan. Data analyses supported each scale's internal consistency reliability, factor structure and ability to differentiate between classrooms (Aldridge et al., 2000).

The CLES was administered in IsiZulu to 1864 mathematics students in 43 classes in South Africa. The primary focus of the study was to assist South African teachers to become more reflective in their daily mathematics teaching. The CLES was administered at the beginning of the study and again at the end of a 12-week intervention phase to assist the teachers at improving the constructivist orientation of their classroom learning environments. The CLES proved to be valid and reliable for use in South Africa (Aldridge, Fraser, & Sebela, 2004).

Modified English and Spanish versions of the CLES were used along with an attitude survey instrument in a study in the USA. Analyses supported a sound factor structure and internal consistency reliability when used with 739 grade K–3 students in Miami, Florida. The study revealed strong, positive and significant relationships

between the science classroom environment and students' attitudes toward science (Peiro & Fraser, 2008).

The CLES was administered to a sample of 544 two-year college students in Florida. The study investigated age, gender and ethnicity as determinants of classroom environment, as well as the effects of classroom environment on student attitudes. Data analyses supported the CLES's factorial validity, internal consistency reliability, and its ability to differentiate between classrooms in this community-college setting (Tulloch, 2011).

A new form of the CLES was reported as valid and useful for use with students in Texas. The CLES-CS (comparative student) form was developed to evaluate the impact of an innovative teacher development program based on the Integrated Science Learning Environment (ISLE) model. Data were collected from 1,079 students in 59 classrooms in north Texas. The factor structure, internal consistency reliability, discriminant validity and ability to differentiate between classrooms were supported (Nix, Fraser, & Ledbetter, 2005).

2.3.6   Additional Instruments

The Web-based Learning Environment Instrument (WEBLEI) was designed by Chang and Fisher (2003) to capture students' perceptions of a web-based learning environment. The instrument assesses four dimensions (namely Emancipatory Activities, Co-participatory Activities, Qualia, and Information Structure and Design Activities) of the web-based learning environment. Alpha reliability coefficients

supported the validity of WEBLEI scales, while the means of the four core aspects demonstrated that the concept of online learning was well received by students.

A recent classroom environment instrument called the Technology-Rich Outcomes-Focused Learning Environment Inventory (TROFLEI) was developed and validated for actual and preferred forms by Aldridge, Dorman and Fraser (2004). The 80-item instrument assesses 10 classroom dimensions: Student Cohesiveness, Teacher Support, Involvement, Investigation, Task Orientation, Cooperation, Equity, Differentiation, Computer Usage, and Young Adult Ethos (Aldridge & Fraser, 2008). Seven of these scales are from the What Is Happening In this Class? (WIHIC) instrument reviewed in Section 2.4. Factor analyses supported the 10 scale *a priori* structure of the instrument. Multitrait-multimethod modeling with the 10 scales as traits and the two forms of the instrument supported the construct validity of the TROFLEI. Data obtained from 1249 high-school students in Western Australia and Tasmania who responded to the actual and preferred forms of the TROFLEI provided information about the validity of the questionnaire (Aldridge, Dorman & Fraser, 2004). The development and validity of the TROFLEI is the subject of a book by Aldridge and Fraser (2008).

Zandvliet (2007) conducted a case study which employed a learning environment approach and developed a specialized instrument called the Place-based And Constructivist Learning Environment Survey (PLACES). Seven scales from other instruments were combined to form the new instrument. PLACES measures Student Cohesion, Integration, Involvement, Teacher Support, Cooperation, Open-Endedness, and Environment Interaction. The case study yielded interesting insights, while instrument development efforts led to the creation of a robust tool for the

evaluation of learning environments in place-based and environmental education settings.

Additional instruments have been developed for use in specific learning environments such as parochial schools, computer laboratories, action research, distance-education courses, online learning, and interactive classrooms (Chang & Fisher, 2003; Dorman & Fraser, 1996; Henderson & Reid, 2000; Jegede, Fraser, & Fisher, 1995; Sinclair & Fraser, 2002).

Although there are advantages in having a variety of instruments developed to assess specific dimensions of the learning environment (see Table 2.1), the What Is Happening In this Class? (WIHIC) brings together new scales with some of the most salient scales from other instruments. The WIHIC has been used around the world in various educational settings at the elementary, middle-school, high-school and college levels. The WIHIC has emerged as the most widely-used learning environment instrument in the past decade. Literature relevant to the WIHIC is reviewed in Section 2.4 in more detail than the other instruments because I used three scales from it for my study.

2.4   What Is Happening In this Class? (WIHIC)

Because the What Is Happening In this Class? was the learning environment questionnaire selected for use in my study, it is considered here in detail. The WIHIC instrument contains seven scales that measure perceptions across the three dimensions proposed by Moos (1974a): Relationship Dimension (scales of Teacher Support, Student Cohesiveness, and Involvement), Personal Development Dimension

(scales of Investigation, Task Orientation, and Cooperation), and the Systems Maintenance and Change Dimension (scale of Equity).

This section is divided into four subsections. The first describes the rationale for selecting the WIHIC for this study (2.4.1). The following section (2.4.2) provides the reader with an overview of the WIHIC, noting that it went through several stages of field testing and refinement (Fraser, Fisher, & McRobbie, 1996) and has proven to be valid and reliable in several contexts. Section 2.4.3 reports studies that have validated the WIHIC, as well as a number of its salient applications in various countries. The final section (2.4.4) reports the strengths and weaknesses of the WIHIC.

2.4.1   *Selection of the WIHIC*

The WIHIC was chosen for my study because it is a relatively recent instrument designed for use in any classroom environment context. It combines the best features of earlier instruments and includes dimensions of contemporary relevance (Chua, Wong, & Chen, 2000). The scales of Teacher Support, Involvement, and Task Orientation were selected because they were considered to be particularly pertinent to my study. Another reason why the WIHIC was used is that it has separate actual and preferred forms, which allows students to provide the researcher with perceptions of their current learning environment in addition to their ideal learning environment. Collecting actual and preferred data allows the researcher to measure any difference between the two. Research suggests that students perform better and are more likely to achieve their academic goals when the actual learning environment

is more closely aligned with students' preferred learning environment (Fraser & Fisher, 1983).

2.4.2   Description of the WIHIC

The WHIC was initially developed by Fraser, Fisher and McRobbie (1996) and combines scales from past questionnaires with contemporary dimensions to bring parsimony to the field of learning environments (Aldridge & Fraser, 2000). Seven dimensions of the classroom environment are measured: Student Cohesiveness (extent to which students know, help, and are supportive of one another), Teacher Support (extent to which the teacher helps, befriends, trusts, and shows interest in students), Involvement (extent to which students have attentive interest, participate in discussions, perform additional work, and enjoy the class),   Investigation (emphasis on the skills and processes of inquiry and their use in problem solving and investigation), Task Orientation (extent to which it is important to complete activities planned and to stay on the subject matter), Cooperation (extent to which students cooperate rather than compete with one another on learning tasks), and Equity (extent to which students are treated equally by the teacher).

The WIHIC has a class form (which assesses a student's perceptions of the class as a whole) and a personal form (which assesses a student's personal perceptions of his or her role in the classroom). The personal form is more suited for investigations of the classroom environment perceptions of within-class subgroups (e.g., different genders or ethnic groups) or for the construction of case studies of individual students (Sinclair & Fraser, 2002). My study used the personal form to collect data from 750 high school and college beginning algebra students.

Students generally fill out the preferred form near the beginning of the research and near the beginning of the course. The preferred forms are concerned with goals and value orientations and measure perceptions of the classroom environment ideally liked or preferred by the student. Later, once the students are more familiar with the environment, the actual form can be given to gather data as to what students perceive is happening in their current environment. Although item wording is similar for actual and preferred forms, slightly different instructions for answering each are used. For example, an item in the actual form such as "there is a clear set of rules for students to follow" would be changed in the preferred form to "there would be a clear set of rules for students to follow". Each item of the WIHIC uses a five-point frequency response format (Almost Never, Seldom, Sometimes, Often, Almost Always) (Dorman, 2003). Typical items are "I discuss ideas in class" (Involvement), and "I work with other students on projects in this class" (Cooperation) (Fraser, Fisher, & McRobbie, 1996). My study employed both the preferred and actual forms of the questionnaire.

2.4.3   *Validation and Application of WIHIC*

Statistical analysis, extensive interviewing of students about their views of their classroom environments in general, and the wording and salience of individual items and their questionnaire responses, were used to refine the original 90-item, 9-scale version of the WIHIC. Data were collected from 355 students in 17 high-school mathematics and science classrooms in five Australian schools. Data underwent principal components factor analysis followed by varimax rotation, along with item analysis and estimation of internal consistency (Cronbach alpha coefficient) and

discriminant validity (mean correlation of each scale with the other scales) (Fraser, Fisher, & McRobbie, 1996).

Only 54 items in seven scales survived these procedures. This set of items was expanded to 80 items in eight scales for the field testing of the second version of the WIHIC, which involved 50 junior high school science classes in Australia and 50 classes in Taiwan (Aldridge, Fraser, & Huang, 1999). The scales of Autonomy/Independence and Understanding did not hold up in principal components factor analysis followed by varimax rotation.

The final form of the WIHIC contains 7 scales with 8 items each and was validated with a sample of 2310 high school geography and mathematics students in Singapore (Chionh & Fraser, 2009). Associations between learning environment and three student outcomes of examination results, attitudes and self-esteem were investigated. Data analyses suggested that, when students perceived the classroom environment as more cohesive, higher examination scores were achieved. Self-esteem and attitudes were more favourable in classrooms perceived as having more teacher support, task orientation and equity.

A review of past research involving the validation and use of the WIHIC is organized below according to the continent where it was conducted. The first section (2.4.3.1) describes research conducted on a cross-national platform. Following that, examples of studies are reviewed from Australia (2.4.3.2), Africa (2.4.3.3), Asia (2.4.3.4), and North America (2.4.3.5).

2.4.3.1   Cross-National Research

In his presidential address at a NARST annual meeting, Fraser (1997) claimed that educational research which crosses national boundaries offers much promise for generating new insights for at least two reasons. First, there usually is greater variation in variables of interest (e.g. teaching methods, student attitudes) in a sample formed from multiple countries than from a one-country sample. Second, the taken-for-granted and familiar educational practices, beliefs and attitudes in one country can be exposed, made 'strange' and questioned when research involves two countries.

Dorman (2003) conducted a cross-national validation of the WIHIC among 3,980 grade 8, 10 and 12 students from Australia, the UK and Canada. Because it is a desirable characteristic of the WIHIC that it possesses an invariant factor structure for the grouping variables, Dorman considered the variables of country, grade level, and gender. If statistical tests indicate the factor structure is a good fit to the model, they enhance the utility of the scales as they provide evidence of the validity of the WIHIC for use with different populations (Dorman, 2003). The use of multi-sample analyses within structural equation modeling substantiated invariant factor structures for the three grouping variables.

Aldridge and colleagues validated the use of an English and Mandarin version of the WIHIC in junior high science classes in Australia and Taiwan (Aldridge & Fraser, 2000; Aldridge, Fraser, & Huang, 1999). The instrument was translated into Chinese and back translated into English by members who were not involved in the original translation. This cross-national study involved six Australian and seven Taiwanese researchers. The WIHIC was administered to 50 junior high school student science

classes in Taiwan (1879 students) and Australia (1081 students). The research involved comparison of classroom learning environments in the two countries, as well as an investigation of socio-cultural factors that influence the learning environment in each country. Data analysis supported the validity and reliability of the instrument in each country and revealed differences between the classrooms of the two countries. Data from the questionnaires guided the collection of qualitative data. Student responses to individual items were used to form an interview scheduled to clarify whether items had been interpreted consistently by students and to help to explain differences in questionnaires scale means between countries (Aldridge & Fraser, 2000).

A study conducted by Zandvliet and Fraser involved the use of internet technologies in 81 high-school classrooms in Australia and Canada. The study involved 1040 students. The learning environments in these 'technological settings' were explored using five scales of the actual form of the WIHIC, an ergonomic inventory, an ergonomic worksheet and an attitudes survey. Case studies were conducted in the second phase of the study. The five scales of the WIHIC used in this study demonstrated good reliability. The discriminant validity of the WIHIC scales demonstrated that the WIHIC scales measured distinct aspects of the psychosocial environment.

The psychosocial environment was assessed in a study of 1404 students in 81 classes in Australia and Canada by administering five scales selected and adapted from the WIHIC questionnaire (Zandvliet & Fraser, 2004). The actual, personal form of the WIHIC required students to respond to their personal perceptions of their actual

(shared) classroom environment (Zandvliet & Fraser, 2005).   The questionnaire exhibited good factorial validity and internal consistency reliability.

A cross-national study of secondary science classroom environments was conducted by Fraser, Aldridge and Adolphe (2010) in Australia and Indonesia. A modified version of the WIHIC was administered to 1161 students (567 students in 18 classes in Australia and 594 students in 19 classes in Indonesia). Principal components factor analysis with varimax rotation supported the validity of the modified version of the WIHIC in each language. Two-way MANOVA revealed some differences between countries and between sexes in students' perceptions of their classroom environments.   Simple correlation and multiple regression analyses revealed generally positive associations between the classroom environment and student attitudes to science in both countries.

2.4.3.2 Africa

In South Africa, Aldridge, Fraser and Ntuli (2009) examined the viability of using feedback from WIHIC to guide improvements in the teaching practices of inservice teachers undertaking a distance-education program. A primary school version of the WIHIC was administered to 1077 students in 31 classes to collect data to determine preferred and actual learning environments. Feedback about the differences between the learners' preferred and actual learning environments was used to create a 12-week intervention program. The study cross-validated an IsiZulu version of the WIHIC and supported the success of teachers using a learning environment questionnaire to guide improvements in their teaching. The WIHIC-Primary displayed satisfactory factorial validity, internal consistency reliability and supported the ability of the actual form of each scale to differentiate between classrooms.

Aldridge and colleagues developed the Outcomes-Based Learning Environment Questionnaire (OBLEQ, Aldridge, Laugksch, Seopa, & Fraser, 2006) to assess students' perceptions of their learning environment as a means of monitoring and guiding changes toward outcomes-based education. The questionnaire was validated with 2638 grade 8 science students from 50 classes in 50 schools in South Africa. The development of this new instrument drew heavily on scales from the WIHIC, but also extended past research by modifying existing scales and adding new scales to make the questionnaire more suitable for assessing outcomes-based learning environments.

2.4.3.3 Asia

An English version of WIHIC has been cross-validated in Brunei Darussalam with samples of 644 grade 10 chemistry students (Riah & Fraser, 1998) and 1188 Form 5 science students by (Khine & Fisher, 2001). Also, in these two studies, outcome-environment associations were established in Brunei for science attitudes and scales of the WIHIC.

Khine and Fisher (2001) used the WIHIC in Brunei to study the classroom environment and teachers cultural background in an Asian context. The study revealed the reliability and validity of the instrument and that the teachers from different cultural backgrounds created different types of learning environments. It also indicated that the WIHIC is a useful instrument with which to measure the effect of cultural background differences and as a basis for the identification and development of desirable teacher or student behaviors that will lead to a more effective learning environment.

Students' cultural backgrounds and their perceptions of their teacher's interpersonal behavior and classroom learning environment were investigated by Koul and Fisher (2005). When an English version of the WIHIC was used with a sample of 1,021 students in 31 classes in seven co-educational private schools in India, reliability, discriminant validity, and ANOVA results supported use of the WIHIC with confidence in further research in India. Statistical analyses showed that the Kashmiri group of students perceived their classroom environments and teacher interactions more positively than the other cultural groups in the study.

When an Indonesian translation of the WIHIC was used with university students in computing-related courses, its validity and usefulness were supported by Margianti, Fraser and Aldridge (2001) for samples of 2498 university students in 50 computing classes.

The WIHIC has also been translated into the Korean language and validated with a sample of 543 grade 8 science students in 12 schools (Kim, Fisher, & Fraser, 2000). The study also involved associations between students' attitudes to science and their perceptions of the classroom environment as assessed by the WIHIC and the QTI, as well as gender-related differences in the students' perceptions.

Chionh and Fraser's (2009) unusually comprehensive study in Singapore established associations between the WIHIC scales and three student outcomes (examination results, attitudes and self-esteem) among a large sample of 2,310 mathematics and geography students in 75 classes. Chionh and Fraser reported strong validity and reliability for both an actual and a preferred form of the WIHIC.

Khoo and Fraser (2008) used a modified version of the WIHIC when evaluating adult computer courses in Singapore with a sample of 250 adults attending computer courses in 23 classes in four Singaporean computing schools. Forty-six items in six scales were selected and adapted to make them suitable for use among adults attending computer courses in Singapore. When WIHIC was validated using factor analysis (principal components with varimax rotation), the Student Cohesiveness scale was lost altogether and a small number of items were deleted from other scales to improve the factor structure. Generally, students perceived their learning environments favorably in terms of the levels of Trainer Support, Task Orientation, and Equity.

Chua, Wong and Chen (2001) developed a Chinese-language version of the WIHIC based on the Taiwanese version of Aldridge, Fraser and Huang (1999). This is a bilingual instrument with every item presented in both English and Chinese. They followed detailed procedures in developing this Chinese version, which was cross validated with a sample of 1,460 students in 50 classes (Fraser, 2002).

A Taiwanese sample of 1,879 students in 50 classes responded to a Chinese version of the WIHIC that had undergone careful procedures of translation and back translation. Data analysis supported the reliability and factorial validity of the questionnaire, leading to the final form of the WIHIC containing seven eight-item scales (Aldridge & Fraser, 2000; Aldridge, Fraser, & Huang, 1999).

Researchers in Taiwan investigated gender differences in students' perceptions of their psychosocial environment and related variables (school membership, attendance, time spent doing homework, students' academic expectations, course

grade and course content). Data were collected from 644 middle school students. Three scales (Equity, Investigation and Cooperation) from the WIHIC were combined with scales from the Instructional Learning Environment Questionnaire and the Classroom Environment Scale and were validated for the study (Huang, 2003).

Parallel Arabic and English versions of the WIHIC were field tested with a sample of 763 college students in 82 classes in Dubai. The WIHIC exhibited sound factorial validity and internal consistency reliability for both the actual and preferred forms, and the actual form differentiated between classrooms (MacLeod & Fraser, 2010). Also, in Abu Dhabi, Afari, Aldridge, Fraser & Khine (in press) validated an Arabic version of the WIHIC among 352 college students in 33 classes in Abu Dhabi.

2.4.3.4 *Australia*

Dorman (2001) conducted research into associations between classroom psychosocial environment and academic efficacy. The WIHIC was used with a sample of 1055 mathematics students from Australian secondary schools who responded to an instrument that assessed 10 dimensions of the mathematics classroom environment. The study provided further validation for the WIHIC. Simple and multiple correlation analyses revealed positive and statistically significant associations between these classroom environment dimensions and academic efficacy.

A sample of 978 secondary students from Australia participated in a study that used the actual and preferred forms of the WIHIC. Separate confirmatory factor analyses for the actual and preferred forms supported the seven-scale *a priori* structure of the

instrument. The use of multitrait-multimethod modeling with the seven scales as traits and the two forms of the instruments as methods supported the WIHIC's construct validity (Dorman, 2008).

An interpretive study of a grade 8 classroom in Western Australia used the WIHIC questionnaire to investigate students' understandings of the nature of the classroom-learning environment. It was administered to all students in the class. The questionnaire consisted of 70 items which assessed seven dimensions of classroom environment (Wallace, Venville, & Chou, 2002). In order to focus attention was focused on students' understanding of aspects of four of the dimensions used in the questionnaire, three items were selected from each of the Teachers Support, Involvement, Cooperation and Equity scales as the basis for separate interviews with four students from the class.

Section 2.4.3.1 included a review of cross-national studies involving Australia and other countries that were conducted by Dorman (2003), Aldridge and Fraser (2000), Aldridge, Fraser and Huang (1999), Fraser, Aldridge and Adolphe (2010) and Zandvliet and Fraser (2004, 2005).

2.4.3.5   North America

In North Texas, Sinclair and Fraser (2002) validated the Elementary and Middle School Inventory of Classroom Environments (ICE), which is based on the WIHIC. The study used qualitative and quantitative methods to describe students' perceived and preferred classroom environment. The sample consisted of ten middle grade teachers and their 43 classes. The five scales of Cooperation, Teacher Support, Task Orientation, Involvement, and Equity were selected and the wording of items was

modified to maximize suitability for the primary and middle-school levels. Item responses were made more simple by selecting from a three-point scale consisting of Often, Sometimes and Seldom (compared with the WIHIC's original five point response scale ranging from Very Often to Almost Never) (Sinclair & Fraser, 2002).

An evaluation of a two-year mentoring program in science for elementary teachers drew on the field of learning environments. A sample of 573 primary grade students from seven classes in Florida responded to a modified version of the WIHIC questionnaire. Data collected from the study were used to assess student perceptions of classroom learning environment as a pretest and posttest. Data analyses supported the sound factorial validity of the WIHIC. Use of MANOVA and effect sizes supported the efficacy of the mentoring program (Pickett & Fraser, 2009).

The WIHIC questionnaire was modified for elementary students and their parents and administered to 520 students and 120 parents in South Florida. Data analyses supported the WIHIC's validity, reliability and ability to differentiate between classrooms. Results from the study reported that both parents and students preferred a more positive learning environment than was perceived (Allen & Fraser, 2007). In another study involving 172 kindergarten students and 78 parents in South Florida, Robinson and Fraser (in press) reported further validation information for a modified version of the WIHIC when used with very young students.

A study of middle school mathematics students in California focused on the effective use of an innovative teaching strategy for enhancing the classroom environment, students' attitudes, and conceptual development. A sample of 661 students from 22 classrooms in four inner-city schools validated modified forms of the Constructivist

Learning Environments Survey, WIHIC questionnaire, and Test of Mathematics Related Attitudes. Three scales from the WIHIC questionnaire were utilized: Involvement, Investigation and Task Orientation (Ogbuehi & Fraser, 2007).

Another study in California conducted with middle-school students investigated the effectiveness of increased allocated instructional time in algebra classes in terms of learning environment, achievement, and attitudes. Data were collected using five scales of the WIHIC (Teacher Support, Involvement, Investigation, Task Orientation, and Equity) along with scales from an attitude instrument and state achievement scores for 499 middle-school students from 22 classes. The WIHIC proved to have sound factor structure, internal reliability consistency and discriminant reliability when use with this sample (Azimioara, 2008).

A sample of 745 high-school students in California were the participants in the first study to investigate the connection between learning environments and the attitudes students hold toward their teachers. The study combined the study of learning environments, anxiety, and attitudes toward mathematics. All seven scales of the WIHIC along with four scales from the Test of Mathematics Related Attitudes (TOMRA) and two aspects of mathematics anxiety from the Revised Mathematics Anxiety Scale (RMARS) were combined in the instrument (B. A. Taylor, 2004). Overall, the WIHIC held up very well in the various validity, reliability, and factor analyses.

Data were collected from 525 female students from a large urban university in California (Martin-Dunlop & Fraser, 2008) participating in an innovative science class for pre-service elementary school teachers. The class aimed to improve

prospective elementary teachers' perceptions of laboratory learning environments and attitudes toward science. Ideas and perceptions based on previous science classes were collected using a combination of scales from the WIHIC, SLEI, and the Test of Science Related Attitudes (TOSRA) prior to the start of the course and compared to data collected at the end of the course. This study replicated with university students past research that attests to the validity of the WIHIC. The researchers found large and statistically significant difference between a previous science laboratory class and the innovative class being assessed.

The study conducted in California by den Brok, Fisher, Rickards and Bull (2006) used data collected from an administration of the WIHIC to 665 middle-school science students in 11 schools. The study included several background variables such as gender, socioeconomic status, ethnicity, and class size to examine their influence on Californian students' perceptions of their learning environment. This research provided further cross-validation of the WIHIC as a measure of student perceptions of seven aspects of the classroom environment.

Student perceptions of the classroom learning environment were assessed using the WIHIC together with a modified TOSRA and achievement data from 1434 middle school students in 71 classes from New York and seven additional states (Wolf & Fraser, 2008). This study compared inquiry and non-inquiry laboratory teaching in terms of students' perceptions of the classroom learning environment, attitudes toward science, and achievement. Learning environment and attitude scales were found to be valid and related to each other in this context (Wolf & Fraser, 2008).

In a study involving the use of the WIHIC in both the English and Spanish languages with a sample of 924 students in 38 grade 8 and 10 science classes in Florida, again the WIHIC was found to exhibit strong validity and reliability. Also the students of teachers with National Board Certification had more favorable classroom environment perceptions than the students of non-certified teachers (Helding & Fraser, in press).

2.4.4 Strengths and Weaknesses of the WIHIC

While the WIHIC has been used and validated in a number of countries, there are potential limitations to its use; the economy and frugality of such methodology can create inherent dangers (Wallace, Venville, & Chou, 2002). What is gained in simplicity can be lost in richness. But, more importantly, the aggregation of data around universal themes or constructs reflects particular assumptions about the nature of learning environments and the role of individuals in constructing the environment (Tobin & Fraser, 1998). In recent times, some of these assumptions about the universality of learning environment constructs have been called into question (Roth, 2000).

During the process of translation and back translation, researchers identified the strong points and pitfalls associated with using a questionnaire framed in a western context in a different culture (Aldridge & Fraser, 2000). Whether administered in the language in which it was originally written, or as a translation, studies that have followed questionnaires with interviews suggest that students interpreted items from the questionnaire in ways that were meaningful and relevant to their local environment. The participants in the research process (researchers, teachers and students) construct (and reconstruct) their own meanings based on their experiences

of the world and their notion of self (Wallace, Venville, & Chou, 2002). Meaning comes in multiple forms because each individual's experience is different and constantly in a state of flux (Eisner, 1993). This can lead to inconsistent interpretations of the questions.

Despite the accuracy of back translations in the case of the Chinese version, the questionnaire did not always capture the full or liberal meaning of the original questionnaire. For example, some questionnaire items were outside the realm of students' experiences because some Taiwanese students had not been involved in class discussions like their western peers, and therefore interpreted discussion as questioning (Aldridge & Fraser, 2000).

There is a risk here that the characteristics of a learning environment cannot be assessed or analyzed properly if the instruments used 1) are based on common-sense, 2) contain subjective questions, or 3) rely on intuition, any of which can easily lead to arbitrary or inconsistent evaluations. Teachers need their work to be supported by a definition of what a good learning environment is, to be refined and discussed on the basis of cumulative knowledge, and to have available relevant theories as for other psychosocial phenomena (Allodi, 2007).

Although much mention has been made above regarding some cautions about which researchers must be aware when using the What Is Happening In this Class? questionnaire, its strengths far outweighs the weaknesses. Researchers still have much to learn about the classroom learning environment and using the WIHIC provides an opportunity to do so.

Use of the WIHIC questionnaire can be justified in terms of its consistent validity and reliability in numerous studies in numerous countries. It has been validated in cross-national studies and been used in conjunction with qualitative measures to clarify the reasons for patterns and differences. The WIHIC incorporates scales that have been shown in previous studies to be significant predictors of outcomes. Its robust and reliable nature made it a logical choice for this study.

2.5   Student Attitudes Toward Mathematics

In addition to learning environment, student attitudes were another important variable in my study. Past research on learning environments has addressed questions about the associations between learning environment and students' attitudes (Fraser, 2001). A study conducted by Yara (2009) with 1542 secondary students in Nigeria revealed that teacher support and involvement (two elements measured by WIHIC) were related to more positive attitudes.

Section 2.5.1 reviews literature related to the history of research on student attitudes toward mathematics. Several of the instruments for measuring attitudes toward mathematics are described in Section 2.5.2. Because my study used the Attitudes Toward Mathematics Inventory (ATMI), Section 2.5.3 reviews literature on the development, validation and application of the ATMI.

2.5.1   *History of Research on Student Attitudes Toward Mathematics*

Our world is in a state of rapid growth in technology and science. It is critical, now more than ever, for students to be comfortable with mathematics, science, and technology. Schools and governmental bodies struggle with how to create fluency in

students for these areas. Studies of student attitudes toward mathematics have been under study since the 1970s (Melancon, Thompson, & Becnel, 1994), yet more understanding is needed about student attitudes toward mathematics to make educational efforts as successful as possible (Deeds, 1999). Research has shown that the attitudes of students significantly affect students' study of mathematics (Butty, 2001). A number of researchers have reported correlations above 0.40 between attitude toward mathematics and achievement in mathematics (Kloosterman, 1991; Minato, 1983; Minato & Yanase, 1984; Randhawa & Beamer, 1992).

Conventional wisdom and some research suggest that student attitudes toward mathematics affect their success. Students with negative attitudes toward mathematics can have performance problems based simply on anxiety (Tapia & Marsh, 2004). For almost three decades, there has been a recognition of the role of beliefs, as well as knowledge, on the cognitive process (Mason, 2003). Schoenfeld (1983) explained that a student's system of beliefs about mathematics directs them in their mathematical problem solving process. If a student believes that the process of mathematics is not useful in relation to one's personal goals, then many mental tools and information remain inaccessible to the student during the process (Schoenfeld, 1983). For example, if a student plans to excel at sports, with the intent of someday becoming a professional athlete, he/she might not see how the study of mathematics is relevant to this pursuit. If the study of mathematics is not perceived as valuable to this individual, some memory constructs could be weaker than those of classmates who value mathematics. Individuals are more likely to remember more about subjects that they value and/or in which they have an interest in (Schoenfeld, 1983). For this reason, I chose to include Value of Mathematics as one of the scales in my study.

Attitude generally refers to someone's basic like or dislike of a familiar subject (or object). Because attitude is an ambiguous construct (Hannula, 2002), it often gets discussed without a suitable, or agreed upon, definition. According to Aiken (1970), attitude is a "learned disposition or tendency on the part of an individual to respond positively or negatively to some object, situation, concept, or another person" (p. 551). Neale (1969) defined attitudes toward mathematics as a measure of "a liking or disliking of mathematics, a tendency to engage in or avoid mathematical activities, a belief that one is good or bad at mathematics, and a belief that mathematics is useful or useless" (p. 632). Attitude toward mathematics is described by Hannula as the degree of affect associated with mathematics.

Deeds (1999) measured attitudes in a study comparing science majors with non-science majors in terms of importance and usefulness. Less than 30% of non-science majors believed that mathematics and statistics are elements of good citizenship. Slightly more than one-third of science majors believed that mathematics and statistics are elements of good citizenship. Two-thirds of non-science majors saw a connection between mathematics and science in their future professions, yet only half believed it to be useful in everyday life. A majority of non-science majors felt that their mathematical skills were adequate or better. Three-fourths believed that mathematics is a vital part of a liberal arts education, yet less than half would take a mathematics class if it were not required (Deeds, 1999).

McLeod (1992) broke attitude into three components: emotional response, beliefs, and behavior. Hannula (2002) separated emotional responses into two separate components (emotion and cognition) to describe it as four evaluative processes: 1) emotions of the student while experiencing mathematics; 2) emotions that the student

associates with the concept of 'mathematics'; 3) evaluations of a situation that the student might experience as a consequence of mathematics; and 4) value of mathematics-related goals within the context of the student's overall goals. Attitudes, beliefs and emotions are major descriptors of the affective domain in mathematics education (McLeod, 1992).

Hannula suggests that emotion and cognition are two complementary aspects of the mind. Yet it is reasonable to separate them because cognition is neuron-based and emotions include other physiological actions; they can be thought of as two sides of the same coin. Attitudes are a representational system parallel to the system of cognition. Emotions are not only a consequence of cognitive processing, but they also affect cognitive processing by biasing attention and memory (Hannula, 2002).

Ma and Kishor (1997) synthesized 113 studies that used surveys in investigating the relationship between attitudes toward mathematics and achievement in mathematics. The research indicated that attitudes towards mathematics affect achievement in mathematics (Ma, 1997). Perhaps achievement in mathematics affects attitudes towards mathematics. Ma suggests that attitudes towards mathematics and achievement in mathematics form a reciprocal relationship with each contributing to the other. Ma found that high achievers were not always free of negative attitudes toward mathematics, and that those with positive attitudes were not consistently high achievers. There has been some success in promoting positive attitudes at the individual level (Hembree, 1990), but efforts at the whole-class level have often been unsuccessful (McLeod, 1992).

Emotions are a basic and fundamental process which underlie every form of expression whether consciously or subconsciously. While the student is not engaged in mathematical activity, the emotions are a result of prior experience and associations. If a student engages in evaluation of a mathematical process, there could be emotions related to expected consequences (Hannula, 2002). "It is impossible to separate the cognitive from the affective domains in any activity…The most important is that there is a cognitive component to every affective objective and an affective component to every cognitive objective" (Maker, 1982, p. 111).

Historically, attitudinal research has dealt primarily with anxiety or enjoyment of the subject matter. Aiken (1974) responded to a call from the National Assessment of Educational Progress to measure the objective of "recognizing the importance and relevance of mathematics to the individual and to society" by constructing scales designed to measure enjoyment of mathematics and the value of mathematics. Michaels and Forsyth (1977) and Sandman (1980) were among those who developed multidimensional attitude scales. The Dutton Scale was one of the first attitudinal instruments developed and it measured 'feelings' of prospective elementary school teachers toward arithmetic. Other researchers dealt exclusively with measuring mathematics anxiety using the Mathematics Anxiety Rating Scale (MARS, Richardson & Suinn, 1972), the Mathematics Anxiety Rating Scale – Revised (Plake & Parker, 1982), and the Mathematics Anxiety Questionnaire (Wigfield & Meece, 1988). In the sections that follow, literature related to several attitudinal assessment instruments is reviewed.

2.5.2   *Attitude Instruments*

The Fennema-Sherman Mathematics Attitude Scales (Fennema & Sherman, 1976) have been among the most widely-used measures of attitude (Melancon, Thompson, & Becnel, 1994). They have been used extensively to investigate attitudes toward mathematics and correlates of these attitudes (Mulhern & Rae, 1998).

The Fennema-Sherman Mathematics Attitude Scales were originally developed to study gender-related differences in mathematics achievement (Mulhern & Rae, 1998). The nine scales are 1) attitude toward success in mathematics; 2) mathematics as a male domain; 3) mother; 4) father; 5) teacher; 6) confidence in learning mathematics; 7) mathematics anxiety; 8) effectance motivation in mathematics; and 9) usefulness of mathematics (Fennema & Sherman, 1976). The scales can be used individually or in sets of two or more (Alexander & Martray, 1989; Drisko, 1993; Stricker, Rock, & Burton, 1993) and have been modified for different age groups (Elliot, 1990; Sherman, 1983).

While it has been a popular instrument, the Fennema-Sherman scales have been the focus of little or no reliability or validity research for many years (Suinn & Edwards, 1982). The integrity of the scores produced by the measure had not yet been established conclusively as late as 1988 (O'Neal, Ernest, McLean, & Templeton, 1988, November). However, in a 1994 study, Melancon and colleagues (1994) found that the results of the factor analysis generally favorable with regards to the validity of the scores from the Fennema-Sherman Scales when using primary school teachers as subjects.

Because the original instrument takes approximately 45 minutes to administer, Mulhern and Rae (1998) attempted to create a shortened form. They found six clearly identifiable scales. Mother and Father scales combined to Parent, Anxiety and Confidence became Mathematics-related Affect, and no single factor was clearly associated with the effectance motivation scale (Mulhern & Rae, 1998).

The Test of Science Related Attitudes (TOSRA) was designed to measure seven science-related attitudes among secondary science students: 1) Social implications of science, 2) Normality of scientists, 3) Attitude to scientific inquiry, 4) Adoption of scientific attitudes, 5) Enjoyment of science lessons, 6) Leisure interest in science and 7) Career interest in science (Fraser, 1981a). TOSRA has been field tested and applied in numerous studies and has shown to be valid and reliable (Aldridge, Fraser, & Huang, 1999; Fraser, 1981a; Fraser, Aldridge, & Adolphe, 2010). Researchers or educators can use TOSRA to monitor student progress toward achieving specific attitudinal goals. While it can be used to assess individuals, it is most effective when used to measure the progress or performance of groups of students. To measure changes in attitudes over time, TOSRA can be used as a pretest and a posttest (Fraser, 1981a; Fraser, Aldridge, & Adolphe, 2010; Martin-Dunlop & Fraser, 2008).

The predecessor to the TOSRA contained only five scales (Social implications of science, Attitude to scientific inquiry, Adoption of scientific attitudes, Enjoyment of science lessons and Leisure interest in science) based on Klopfer's (1971) classification scheme for attitudinal aims which distinguishes six categories: attitudes to science and scientists, attitude to inquiry, adoption of scientific attitudes like curiosity and open-mindedness, enjoyment of science learning experiences, interest in science apart from learning experiences, and interest in a career in science.

TOSRA is an extension and an improvement of the original battery of scales in four ways. Two new scales were added: Normality of scientists and Career interest in science. The previous battery had required three sets of directions and answering formats and that was simplified so that the TOSRA could be administered with one set of directions and one answering format. TOSRA was structured to contain the same number of items in each scale, whereas the previous format did not. In addition, the field-testing and validation of TOSRA was extended to involve students in years 7–10 rather than only year 7 students as had been the case previously.

While the TOSRA has been used to investigate associations between attitudes and achievement and between gender and attitudes, it has also been used to investigate associations between classroom environment and attitudes (Wong & Fraser, 1996). The TOSRA has been shown to have good internal consistency reliability and discriminant validity. The TOSRA was validated in junior and senior high schools Australia and in the United States (Khalili, 1987), and can be used to monitor progress in achieving attitudinal aims in specific areas, or to compare groups of students on particular attitudinal dimensions (Fraser, 1981a). In a cross-national study of learning environments and attitudes conducted with 1161 students in Australia and Indonesia, the TOSRA was found to be valid and reliable in both its Indonesian and English versions (Fraser, Aldridge, & Adolphe, 2010).

Several studies have used the TOSRA in a modified form to assess the attitudes of students in a mathematics class or to assess students' satisfaction with their learning environment (Ogbuehi & Fraser, 2007; Raaflaub & Fraser, 2002; Spinner & Fraser, 2005). The modified form is referred to as the Test of Mathematics Related Attitudes

(TOMRA). The same seven scales remain but the word 'mathematics' replaces the word 'science' in each item.

2.5.3   Attitudes Toward Mathematics Inventory (ATMI)

The Attitudes Toward Mathematics Inventory (ATMI) was designed to assess several the underlying dimension of attitudes toward mathematics (Tapia & Marsh, 2004). The original form had 49 items that assess confidence, anxiety, value, enjoyment, motivation and parent/teacher expectations (Tapia & Marsh, 2004). The ATMI was given to 545 high school students (male and female, grades 9–12) enrolled in mathematics classes. Responses were collected using a Likert-scale format with the following anchors: (1) strongly disagree, (2) disagree, (3) neutral, (4) agree, and (5) strongly agree. Twelve items were reverse scored. Students were tested at the beginning of the school year and retested four months later (Tapia & Marsh, 2004).

When Cronbach's alpha coefficient was used to test the internal consistency of the ATMI, a coefficient of 0.96 indicated a high degree of internal consistency. Of the 49 items, 40 had item-to-total correlations above 0.50, suggesting that most of the items contributed to the total. After deleting the nine items with an item-to-total correlation lower than 0.50, the value of the alpha coefficient reached 0.97 (Tapia & Marsh, 2004). After factor analysis was conducted on the data, four factors were retained which accounted for 55% of the variance. The four remaining factors were Self-confidence (15 items), Value of mathematics (10 items), Enjoyment (10 items) and Motivation (5 items). The 40-item inventory is estimated to take between 10 and 20 minutes to complete (Tapia & Marsh, 2004).

The ATMI has been used with younger students as well. Tapia and Marsh (2000) measured students' attitudes toward mathematics and identified the underlying dimension of the inventory by testing 262 middle school students in a bilingual college preparatory school (Tapia & Marsh, 2000). Ke (2008) used the ATMI with 160 fifth graders in a study of the application of cooperative, competitive, and individualistic goal structures in classroom use of computer mathematics games. The impact on students' mathematics performance was measured using a standards-based mathematics examination and the ATMI was used to assess the impact of the model on mathematics learning attitudes. A college population has also been studied using the ATMI. Tapia and Marsh undertook a study with 134 college-aged American students. Confirmatory analysis indicated that the four-factor model held up for American college students (Tapia & Marsh, 2002).

2.6   Summary

The main purpose of this study was to investigate differences between high-school and community-college beginning algebra students in terms of their perceptions of the actual learning environment, their preferred learning environment and their attitudes toward mathematics. In this chapter, literature related to this research project about the learning environment of beginning algebra students has been reviewed to provide a theoretical and methodological framework for this study. Two major areas of focus were reviewed because of their relevance to this study: learning environments research; and research related to students' attitudes toward mathematics.

Section 2.2 reviewed the historical background of learning environments research and this was followed in Section 2.3 with a description of several historically-

significant learning environment instruments, as well as some more-contemporary instruments. Subsections of Section 2.3 highlighted the development and use of specific learning environment instruments beginning with two historically-significant questionnaires, namely, the Learning Environment Inventory (LEI, Walberg & Anderson, 1968) and the Classroom Environment Scale, the Individualized Classroom Environment Questionnaire (ICEQ) and the College and University Classroom Environment Inventory (CUCEI). This was followed by the My Class Inventory (MCI, Fraser & O'Brien, 1985), the Questionnaire on Teacher Interaction (QTI, Wubbels, 1993), the Science Laboratory Environment Inventory (SLEI, Fraser, Giddings, & McRobbie, 1992), and the Constructivist Learning Environment Survey (CLES, P. C. Taylor, Fraser, & Fisher, 1997). A few additional learning environment instruments were reviewed.

An entire section (Section 2.4) was devoted to reviewing literature about the development, characteristics and validation of the What is Happening In this Class? (WIHIC) because it was used in my study of the differences between the perceptions that adolescents and adults hold of their beginning algebra learning environments. Subsections provided a justification for the selection of this instrument for use in this study, a review of literature related to the history and development of the instrument, its validation and application, and its benefits and limitations. Subsection 2.4.3 organized past research into (1) cross-national studies, (2) investigations in Australia, (3) research in Africa, (4) studies in Asia and (5) studies in North America.

In addition to investigating differences in learning environments between beginning algebra students in high school and college, differences in attitudes toward mathematics and associations between learning environments and attitude also were

investigated. Section 2.5 reviewed literature relating to students' attitudes toward mathematics. The past 30 years has seen many studies of student attitudes toward mathematics (Melancon, Thompson, & Becnel, 1994). Attitudes toward mathematics were included in this research to make it and other follow-up educational efforts as successful as possible. More research is needed about student attitudes toward mathematics because past studies have shown that the attitudes of students significantly affect their mathematics achievement (Butty, 2001).

Several instruments have been developed and validated to measure attitudes. The focus of the beginning of Section 2.5 was the history and development of early instruments assessing mathematics attitudes, such as the Fennema-Sherman Mathematics Attitude Scales (Fennema & Sherman, 1976) and a shortened form of the Fennema-Sherman Mathematics Attitude Scales used by Mulhern and Ray (1998). As well, the Test of Science-Related Attitudes (Fraser, 1981a) has been adapted to measure attitudes toward mathematics and renamed as the Test of Mathematics-Related Attitudes (TOMRA, Ogbuehi & Fraser, 2007).

The Attitudes Toward Mathematics Inventory (ATMI) was chosen for my study because of it its ease of use, its simplicity of language, and its proven validity and reliability (Tapia & Marsh, 2004). The section concluded with the history of the development, characteristics, and validation of the ATMI.

Chapter 3 provides a description of the methodology used to address the research questions and the context in which the research was conducted. Background, sample selection, instruments, research design, and administration of the questionnaires are described, followed by information about the data-analysis methods used. Chapter 4

reports data analyses and results for my study. Chapter 5 discusses the findings related to learning environment and student attitudes.

Chapter 3

RESEARCH METHODS

3.1   Introduction

Chapter 2 reviewed literature about the background and theoretical framework of my study, including literature related to learning environments research (Fraser, 1998a, 2002; Goh & Khine, 2002) and student attitudes toward mathematics (Aiken, 1970; Dutton, 1954; Fennema & Sherman, 1976; Ma, 1997; Tapia & Marsh, 2004). This chapter contains an explanation of my study's research design and its implementation.

My experience has shown that, while the course content of high-school and community-college beginning algebra courses are similar, the student populations are not. I spent the first nine years of my teaching career teaching high school mathematics at three different schools in Fresno County. Following that, I began teaching at a community college in the same county. It appears that college students are more involved in their academic choices and feel a vested interest in their own personal success. My experiences in the two situations began to raise questions in my mind about differences in the learning environments of high schools and community colleges and the attitudes that these groups of students have towards mathematics. Once educators have data to better explain the learning environment and the attitudes that our students have toward mathematics, I believe that we can begin to look for ways to improve mathematics education in Fresno County. Are high-school students less interested in the classroom, the teacher and the subject than college students? Are college students more task oriented and confident in their abilities? Could learning environment and attitude variables provide one explanation

for why so many community-college students are required to retake high-school level mathematics in college? These questions were the impetus for my research.

Fresno County, where I conducted my research, follows the Mathematics Framework for California public schools in Kindergarten to grade 12. The framework provides standards for grades K–7, followed by standards for beginning algebra. This implies that students who are taking beginning algebra in the ninth grade or later (community college certainly falls in this category) are behind grade level. Therefore, my study investigated two of the groups who are behind grade level (beginning algebra students in high schools and community colleges) using the criteria of learning environment and attitudes toward mathematics.

My study is significant because it is the first documented research that used learning environment instruments to assess and investigate students' preferred and actual perceptions of their beginning algebra classroom environments at both the high-school and community-college levels. Also, this is the first time that research has been conducted using the What is Happening In this Class? (WIHIC) questionnaire with an American sample of high-school and community-college students. Another unique feature is that students' attitudes towards mathematics were compared for the two age groups using the Attitudes Toward Mathematics Inventory (ATMI).

Given that students' perceptions of the learning environment have consistently been found to be related to achievement (Chionh & Fraser, 2009; Wolf & Fraser, 2008) and that their attitudes toward mathematics have also been shown to be related to achievement (Adamski, Peiro, & Fraser, 2000; Ma, 1997; Ma & Kishor, 1997; Mason, 2003; Tapia & Marsh, 2000; Yara, 2009), this study focused on associations

between learning environments and attitudes. Three research questions were identified for this exploratory study of the learning environments and attitudes of beginning algebra classes in high-schools and community-colleges in Fresno County:

1. Are modified versions of the following questionnaires valid when used with beginning algebra students:

    (a) Preferred Form of the What Is Happening In this Class (WIHIC)?

    (b) Actual form of the What Is Happening In this Class (WIHIC)?

    (c) Attitudes Toward Mathematics Inventory (ATMI)?

2. Are there differences between adolescents and adults in a beginning algebra course in terms of:

    (a) Preferred learning environment?

    (b) Perceived learning environment?

    (c) Attitudes toward mathematics?

3. Are there associations between the learning environment of beginning algebra classes and students' attitudes toward mathematics?

3.2 Research Methods

According to Fraser (1982), three common approaches to studying classroom environments are systematic observations, case studies and assessing student and teacher perceptions of the learning environment. I chose to focus on perceptual measures for this study. While the field of learning environment research is still relatively young, having only been initiated less than 40 years ago, Fraser and Walberg identified five major strengths of this approach as early as 1981. First,

paper-and-pencil instruments are more economical than classroom observation techniques that involve the expense of training outside observers. Second, perceptual measures are based on students' observation of several lessons over time, while observational data is generally limited to a few lessons from a small number of observations. Third, perceptual measures pool the observations of all of the students in the class, whereas observation techniques generally involve one perspective. Fourth, as students' perceptions are the determinants of student behavior, these can be more important than what the observer perceives as the real situation. Finally, perceptual measures of classroom environment have been found to account for more variance in student learning outcomes than variables that are directly observed (Fraser & Walberg, 1981).

3.3 Data Sources

In order for the results of this study to be meaningfully generalized to other samples, it is important to know the makeup of the sample and the population from which the sample was drawn. This section discusses my data sources in terms of the population (Section 3.3.1), sample size (Section 3.3.2) and the role of the participants (Section 3.3.3).

3.3.1 Population

Fresno County is located in the geographical center of California and can boast of great diversity and culture. Just over one-third of the county reports themselves as being 'white persons not Hispanic', nearly half of the county is Hispanic or Latino, and the remaining persons identify themselves as black, American Indian, Asian, Pacific Islander or being of mixed race. Twenty-one percent of the population is

foreign born and 40% speak a language other than English at home. Two-thirds of the population are high school graduates, while less than 20% have a Bachelor's degree or higher. Only 56% of the residents own homes and nearly 20% live below the poverty level (2008).

3.3.2   Sample Size

A convenience sample of 750 students from 38 classes in Fresno County participated in this comparison of the learning environment and attitudes of beginning algebra students in high school and community college. Over 2,000 participants were surveyed, but those who returned incomplete surveys or did not grant consent were not included in the study. Of the 750 students, 383 were high-school students ranging in age from 13 years to 18 years and 367 were attending a community-college with ages typically ranging from 17 to 40 years.

3.3.3   Participants and Procedure

In the semester prior to the administration of the questionnaires, I obtained permission from the principal of each participating school and the respective district administrators.   Teachers from those schools whose principals had granted permission were solicited for volunteers. I provided a brief explanation of the aims and expected outcomes of my research. A calendar of administration dates was generated to ensure that each participating class was visited at an appropriate time.

At the time of administration, the students were informed that completion of the questionnaire was purely voluntary and that they would not be disadvantaged in any way should they choose not to have their surveys included in the study. Students were informed of the confidentiality involved in the study, but were asked to put

their first name on each form of the questionnaire to enable matching, for the purposes of statistical analysis, of actual and preferred forms. Each student was given a summary of the research goals and a copy of the confidentiality agreement for themselves and their parents (Appendix B). The entire process took 15 minutes in each class. Following the survey administration and collection, teachers were able to resume their normal class activities.

In an effort to make the time dedicated to the survey meaningful for the participating teachers, I offered to return statistical summaries and graphs to each teacher based on their classes' actual and preferred responses on each item of the WIHIC and responses from the ATMI. Because responses for each individual item were not the main focus of the study, these graphs are not included in this report. In addition, each teacher was sent a Curtin University spiral notebook as a token of appreciation.

3.4   Instruments and Modifications

Scales from two previously-validated instruments were combined to form the questionnaire that was used for this study. These instruments measured students' perceptions of the learning environment and their attitudes toward mathematics, respectively. The questionnaire was divided into two parts and data were collected on two separate dates for each class. Part I of the questionnaire contained the scales of Teacher Support, Involvement and Task Orientation from the personal, preferred form of What Is Happening In this Class? (WIHIC, Fraser, Fisher, & McRobbie, 1996), as well as the scales of Value of Mathematics and Self Confidence from the Attitudes Toward Mathematics Inventory (ATMI, Tapia, 1996). Part II contained items from the same three scales of the personal, actual form of the WIHIC. Part I and II of the survey can be found in Appendix C.

This section offers a more detailed description of each of the instruments used in my study. Whereas Section 3.4.1 provides a description of the WIHIC, Section 3.4.2 describes the ATMI.

3.4.1   *What Is Happening In this Class?*

As detailed in Chapter 2, Section 2.3, the What Is Happening In this Class? (WIHIC) questionnaire was developed by Fraser, Fisher and McRobbie (1996) and combines scales from past questionnaires with contemporary dimensions to bring parsimony to the field of learning environments (Aldridge, Fraser & Huang, 1999). The WIHIC has two versions. It can be given in a class version that assesses a student's perceptions of the class as a whole, or as a personal version which assesses a student's personal perceptions of his or her role in the classroom (Fraser, 1998a). The personal version, which is more suited for investigations of the classroom environment perceptions from multiple perspectives to obtain a holistic picture, is what I chose to use. Each version of the WIHIC has a preferred form (which assesses a student's personal preferred role in the classroom) and an actual form (which assesses a student's personal perceptions of his or her role in the classroom) (Fraser, 1998b). Using both of the forms enabled me to compare high-school and college students in terms of their ideals as well as their perceptions of what is actually happening in their classes in answer to Research Question 2.

Another reason why the WIHIC was chosen for this study was because it has proven to be reliable and valid in a diverse range of classroom applications (Fraser, 1998a). Recent studies showing good factorial validity and internal consistency reliability using high-school mathematics students and the WIHIC were undertaken in Australia (Kilgour, 2006; Zandvliet & Fraser, 2005), Singapore (Chionh & Fraser, 2009), and

the USA (Ogbuehi & Fraser, 2007). School mathematics students were involved in a study using the WIHIC conducted by Aldridge, Fraser and Sebela (2004) in South Africa.

Using the WIHIC questionnaire, seven dimensions of the classroom environment can be measured: Student Cohesiveness (extent to which students know, help, and are supportive of one another), Teacher Support (extent to which the teacher helps, befriends, trusts, and shows interest in students), Involvement (extent to which students have attentive interest, participate in discussions, perform additional work, and enjoy the class), Investigation (emphasis on the skills and processes of inquiry and their use in problem solving and investigation), Task Orientation (extent to which it is important to complete activities planned and to stay on the subject matter), Cooperation (extent to which students cooperate rather than compete with one another on learning tasks), and Equity (extent to which students are treated equally by the teacher) (Aldridge, Fraser, & Huang, 1999).

Because of time constraints and respect for the teachers' and students' time, only three scales were chosen from the WIHIC. The scales of Teacher Support, Involvement and Task Orientation were chosen for my study. I see differences in the ways in which teachers are trained to support and involve students at each level. I have also observed a different degree of task orientation based on the maturity of the student. My experience and training as a high school teacher and my current position as a community college teacher led me to choose these three scales (eight items each) because they could provide the most salient data for comparing the two student samples.

Items in the WIHIC are worded in a similar fashion for the preferred and actual forms (the tense changes), but there are slightly different instructions for answering each. For example, an item in the actual form such as "there is a clear set of rules for students to follow" would be changed in the preferred form to "there would be a clear set of rules for students to follow" (Fraser, 1998a). Each item of the WIHIC uses a five-point frequency response scale of Almost Never, Seldom, Sometimes, Often, Almost Always (Dorman, 2003). Examples of other typical items are "The teacher's questions help me to understand" (Teacher Support), and "I explain my ideas to other students" (Involvement) (Fraser, 2002). Table 3.1 provides more examples of the differences in tense between the two forms.

Table 3.1   Scale Descriptions and Wording Differences for a Sample of Items from the WIHIC Preferred and Actual Forms

Scale	Scale Description The extent to which…	Sample Items	
		Preferred Form	Actual Form
Teacher Support	…the teacher helps, befriends, trusts and is interested in students.	The teacher would take a personal interest in me. The teacher would go out of his/her way to help me. The teacher would help me when I have trouble with the work.	The teacher takes a personal interest in me. The teacher goes out of his/her way to help me. The teacher helps me when I have trouble with the work.
Involvement	…students participate actively and attentively in class discussions and activities.	I would discuss ideas in class. The teacher would ask me questions. I would be asked to explain how I solve problems.	I discuss ideas in class. The teacher asks me questions. I am asked to explain how I solve problems.
Task Orientation	…is important to complete activities planned and to stay on the subject matter.	Getting a certain amount of work done would be important to me. I would know the goals for this class. I would know what I am trying to accomplish in this class.	Getting a certain amount of work done is important to me. I know the goals for this class. I know what I am trying to accomplish in this class.

3.4.2 *Attitudes Toward Mathematics Inventory*

Past research has shown that attitude is related to achievement (Dwyer, 1993; Gibbons, Kimmel, & O'Shea, 1997; Schunert, 1951; Yara, 2009). Gottfried (1985) claimed that students who value and enjoy mathematics have a higher level of achievement. It was one of my goals in this study to determine if associations exist between students' perceptions of the actual learning environment and their attitudes toward mathematics.

The ATMI was chosen for this study because it has shown to be valid and reliable for American students in middle schools (Ke, 2008; Tapia & Marsh, 2000), high schools (Schroeder, 2007; Tapia & Marsh, 2000, 2002, 2004) and for adults (Moldavan, 2007). The language of the ATMI is simple and easy to understand, making it appropriate to use with low-performing high-school and community-college students. It is also the most recently developed of the instruments designed to measure attitude.   While several instruments measure mathematics anxiety (Alexander & Martray, 1989; Hannafin, 1985; Plake & Parker, 1982), the ATMI goes beyond the scope of mathematics anxiety. In fact, Terwilliger and Titus (1995) found that positive attitudes toward mathematics are inversely related to mathematics anxiety (Tapia & Marsh, 2002). The language of the ATMI is appropriate for the local community, thus reducing some of the confusion that can be caused by the wording in other instruments.

Of the four scales included in the ATMI (Self-confidence, Value of mathematics, Enjoyment, and Motivation), only Value and Self Confidence were chosen for this study.   The Value of Mathematics scale measures students' beliefs about the usefulness, relevance and worth of mathematics in their lives now and in the future.

The Self Confidence scale measures students' confidence and self-concept of their performance in mathematics (Tapia & Marsh, 2004). I felt that these two factors would best expose the possible differences between beginning algebra students in high school and those in community college. I also wanted to know if there were any associations between these two attitude scales and the actual learning environments of beginning algebra students.

The ATMI uses a five-point Likert response format: Strongly Disagree (1), Disagree (2), Neutral (3), Agree (4) and Strongly Agree (5). For example, a student who responds to the statement "Mathematics is a very worthwhile and necessary subject" with the response of Strongly Agree feels that this statement aligns with his or her views relating to the Value of Mathematics. A typical statement from the scale of Self Confidence is "My mind goes blank and I am unable to think clearly when working with mathematics." A student responding to that statement with 'Strongly Disagree' feels that this statement does not accurately describe him or her and indicates a strong sense of self confidence.

3.5   Data Analysis

The data analyses that I performed were used to answer the three research questions described in Section 3.1. Validation information was generated for the WIHIC and ATMI for the use of these questionnaires in high-school and community-college classes. Differences between high-school and community-college students were investigated in terms of preferred and actual perceived learning environment and attitudes toward mathematics. Finally, associations between attitudes toward mathematics and the learning environment were explored.

First, Section 3.5.1 describes how the data were prepared for statistical analyses. To address the first research question, the validity and reliability of the two questionnaires (WIHIC and ATMI) were assessed in order to determine their suitability in my study. This is discussed further in section 3.5.2. Once the questionnaires were shown to be valid and reliable, I analyzed the data in search of difference between the two groups of beginning algebra students (Section 3.5.3). The third and final research question was addressed by computing simple correlation and multiple regression analyses as a means of investigating associations between the attitudes and learning environment scales (3.5.4).

3.5.1   *Preparation of the Data*

After the questionnaires were administered and collected from the 38 classes of students who participated in this study, each student's responses were checked. Because the survey was administered in two parts, surveys that were missing either part or had incomplete responses were eliminated from the data set. Responses from the remaining 750 questionnaires were entered directly into a database using Microsoft Excel by me or a trained assistant.

The responses of Almost Never/Strongly Disagree, Seldom/Disagree, Sometimes/Neutral, Often/Agree, and Almost Always/Strongly Agree were entered into the database as 1, 2, 3, 4, and 5, respectively. Nine items from the ATMI scale of Self Confidence were negatively worded and, therefore, reverse scored so that the larger numeric values corresponded to the more positive responses. Other important information such as the grade level, school, class and first name of the student were also entered directly from the questionnaire to the spreadsheet. The data were rechecked by the person who entered it and again by another individual. After all the

data were successfully entered and checked, they were uploaded into SPSS for statistical analyses. Consent forms and original questionnaires were stored in a locked file cabinet in my office.

3.5.2   *Validity and Reliability of Questionnaires*

To give credibility to my results and to answer the first research question concerning validity and reliability of the three learning environment scales from the WIHIC and the two attitude scales from the ATMI, several analyses were performed.   Data gathered from the 750 students were used to investigate the factor structure, reliability, discriminant validity, and ability to distinguish between different classes.

The internal structure of the 49 items was examined by performing a principal axis factoring with varimax rotation and Kaiser normalization. Factor analysis determines how well the items measure a single construct (Urdan, 2010). In other words, factor analysis basically tells the researcher which items go together. Statistical software performs factor analysis by continually reorganizing the items in the analysis into new factors and then rotating these factors away from each other to create as many meaningful, separate factors as possible. Principal axis factor analysis of the three scales of the WIHIC and two scales of the ATMI was used to check the *a priori* structure of each instrument. This allows researchers to know whether particular groups, or combinations of groups, differ from each other in their averages on the dependent variable. It was decided that items having a factor loading of at least 0.40 on their own scale and less than 0.40 on all other scales would be retained as recommended by Field (2005), Stevens (1992) and Thompson (2004).   Factor loadings indicate the strength of the relationship between an item and a construct. A larger factor loading suggests a stronger association. A stronger association means

that the researchers can have more confidence in the results. Factor analysis identified whether there was a need to remove any of the items from subsequent analyses. Factor loadings (a measure of correlation), percentage of variance, and eigenvalues are reported in Chapter 4.

The internal consistency reliability was calculated for each scale separately to check whether every item in each learning environment scale and each attitude scale assess a common construct. Reliability analysis determines how well the proposed organizational structure fits the set of data. Simply stated, reliability refers to consistency in measurement. The similarity of the responses indicates that the construct is being measured reliably. The most common reliability statistic is Cronbach's alpha coefficient (1951), which was calculated with both the individual and the class mean as the units of analysis. Alpha coefficients range from 0 to 1, with 1 indicating the greatest possible reliability. Although the reliability of both the WIHIC and the ATMI have established in prior studies, it can vary depending on the sample and was therefore checked again with my sample.

To check whether each of the learning environment scales and the two attitude scales measures a distinct construct, the discriminant validity was calculated for each scale for two units of analysis (individual and class mean). Scales that measure different characteristics should not have a strong correlation. The mean correlation of a scale with other scales was the index used to determine discriminant validity. A small mean correlation coefficient indicates a high probability that each of the scales measures a construct that is different from constructs measured by other scales.

A one-way ANOVA (analysis of variance) was used to determine the ability of the actual form of each learning scale to distinguish between classes. The eta^2 statistic obtained from ANOVA is a measure of the association of the between the independent variable and the dependent variable. It is the proportion of variance in the scale (effect size) which can be accounted for by class membership. The *F*-value is the statistic used to describe the statistical significance of the average amount of difference between group means relative to the amount of variance within each group (Urdan, 2010). For each scale of the actual form of the WIHIC, a one-way ANOVA was performed with class membership as the independent variable. The ability of an instrument to distinguish between classes is important because it indicates that it is sensitive to the differences in the learning environments of different classes.

3.5.3   *Differences Between High-school and College Students in Beginning Algebra Classes*

To answer my second research question concerning differences between high-school and college students' preferred learning environment, perceptions of actual environment and attitudes, a MANOVA was conducted. The dependent variables consisted of the three learning environment scales (Teacher Support, Involvement, and Task Orientation) from the WIHIC's actual form, the same three scales from the WIHIC's preferred form, and the two attitude scales from the ATMI. The independent variable was the age group.

Wilks' lambda is a test statistic used in multivariate analysis of variance (MANOVA) and it involves the proportion of variance in the dependent variables that is not accounted for by the independent variable. It is used in multivariate tests of differences between groups. In the multivariate setting, Wilks' lambda involves

the same role as the *F*-test in ANOVA. If the multivariate test using Wilk's lambda criterion reveals a statistically significant difference between groups for the set of dependent variables as a whole, then it is justifiable to interpret the univariate ANOVA results separately for each individual independent variable.

Effect size is a measure of the strength of the relationship between two variables. It is a way of determining the practical significance of a statistic by reducing the impact of the sample size (Urdan, 2010). Effect sizes were calculated to provide a measure of the magnitude of the differences between high-school and college students' scores separately for each scale of WIHIC and ATMI scale. Effect sizes were calculated in terms of the difference in means divided by the pooled standard deviation. Effect size can be classified as small (≤ 0.10), moderate (0.25), or large (≥ 0.40) (Cohen, 1988).

3.5.4   *Associations Between Attitudes and Learning Environments*

To answer the final research question concerning associations between students' perceptions of the classroom learning environment and their attitudes toward mathematics, simple correlation and multiple regression analyses were performed for two units of analysis (individual and class mean).

In order to determine relationships between the actual learning environment scales and the attitude scales, the three learning environment scales were used as independent variables in simple correlation and multiple regression analyses, while the two attitude scales served as the dependent variables. Simple correlation analysis provided information about the bivariate association between each attitude scale and each individual environment dimension. Multiple regression analysis provided a

more parsimonious picture of the joint influence of a set of correlated environment scales on attitudes. Through examining the regression coefficients, it was possible to identify which areas of the learning environment had a statistically significant relationship with attitudes when all other learning environment scales were mutually controlled.

The results of all of the statistical analyses are reported in Chapter 4: reliability and validity (Research Question 1) in Section 4.2; differences between age groups (Research Question 2) in Section 4.3; and associations between attitude and learning environment (Research Question 3) in Section 4.4.

3.6   Conclusion

Chapter 3 discussed the sample and methods of data collection and analysis used. The sample was comprised of 750 students in 38 classes from beginning algebra classes in Fresno County in California.   The group of 750 students were split between high-school students (383) and community-college students (367). The study concentrated on perceptual measures involving paper-and-pencil instruments.

The two instruments used to gather data from the participants were the What Is Happening In this Class? (WIHIC) and the Attitudes Toward Mathematics Inventory (ATMI).   Three scales (namely, Teacher Support, Involvement, and Task Orientation) were used to measure students' preferred and actual perceived learning environment.   The scales of Value of Mathematics and Self Confidence were included to measure the students' attitude toward mathematics.

In order to answer my first research question about the validity of questionnaire scales, factor, reliability and discriminant validity analyses were undertaken using WIHIC and the ATMI data from my study sample of high-school and community-college students in a beginning algebra course in Fresno County.

Differences between the two age groups (my second research question) were examined using MANOVA and effect sizes to answer my second research question. Whereas MANOVA was performed to check the statistical significance of differences between the two groups, effect sizes were calculated to indicate the magnitude of these differences between high-school students and the community-college students expressed in standard deviation units.

Associations between the learning environment and student attitudes were investigated using simple correlation and multiple regression analyses. Through regression analyses, it was possible to identify the areas of the learning environment that were significantly related to student attitudes when the other learning environment scales were mutually controlled.

The next chapter reports the results obtained from data analyses.

Chapter 4

DATA ANALYSIS AND RESULTS

4.1   Introduction and Overview

As discussed in Chapter 1, the main purpose of this study was to investigate differences between adolescents and adults in beginning algebra courses in terms of their perceptions of preferred and actual learning environment and their attitudes toward mathematics. In addition, I investigated associations between the learning environment and attitudes among high-school and community-college students in Fresno County.   Because valid and reliable tools were needed to assess the participating students' perceptions of their beginning algebra learning environment and their attitudes toward mathematics, another goal of the study was to validate modified versions of a learning environment questionnaire and an attitude questionnaire that could be used with confidence when gathering data to answer the research questions.

This chapter is devoted to describing the data analyses and reporting the findings based on the survey data. The data were collected from 750 students from 38 classes consisting of 367 high school students and 383 community college students in a beginning algebra class in Fresno County.   The instrument was made up of three scales from the actual and preferred forms of the What Is Happening In this Class? (WIHIC, Fraser, Fisher, & McRobbie, 1996) and two scales of the Attitudes Toward Mathematics Inventory (ATMI, Tapia & Marsh, 2000).   Teacher Support, Involvement and Task Orientation are the three scales chosen from the WIHIC. From the ATMI, the scales of Value of Mathematics and Self-Confidence were selected.

Analyses of data from the survey instruments helped to answer the following research questions:

1.   Are modified versions of the following questionnaires valid when used with beginning algebra students:

        (a) Preferred Form of the What Is Happening In this Class (WIHIC)?

        (b) Actual form of the What Is Happening In this Class (WIHIC)?

        (c) Attitudes Toward Mathematics Inventory (ATMI)?

2.   Are there differences between adolescents and adults in a beginning algebra course in terms of:

        (a) Preferred learning environment?

        (b) Perceived learning environment?

        (c) Attitudes toward mathematics?

3.   Are there associations between the learning environment of beginning algebra classes and students' attitudes toward mathematics?

The first objective of this study was to provide reliability and validity data for modified versions of the What Is Happening In this Class? (WIHIC) for assessing the preferred and actual learning environments and the Attitudes Toward Mathematics Inventory (ATMI) used to assess attitudes toward mathematics among high-school and community-college beginning algebra students in Fresno County. Measures of reliability and validity suggest the level of confidence that researchers can have in the results obtained using the instruments. The extent to which a survey instrument yields consistent data and measures distinct factors gives credibility to the results based on the data obtained using the instrument.

In order to answer Research Question 1, data collected from a sample of 750 students from 39 high school and community college classes were analyzed in terms of the factor structure, reliability, discriminant validity, and ability to distinguish between different classes. The results are reported in Section 4.2 below.

The second objective of this study was to explore whether differences exist between adolescents and adults in a beginning algebra course in terms of (a) preferred learning environment, (b) perceived or actual learning environment and (c) attitudes toward mathematics. Section 4.3 reports results for the differences between the two age groups. The third and final goal of the study was to ascertain whether associations exist between the learning environments of beginning algebra classes and students' and attitudes toward mathematics.   The results of analyses for associations between learning environment and attitude scales are reported in Section 4.4

In summary, the current chapter is arranged according to the following topics: Validity and reliability of WIHIC and ATMI (Section 4.2); comparison of compulsory adolescent classes and voluntary adult classes in terms of learning environment and attitudes (Section 4.3); associations between students' attitudes and learning environments (Section 4.4); and summary of the analyses and results (Section 4.5).

4.2   Reliability and Validity of the WIHIC and the ATMI

The validity and reliability of WIHIC and ATMI scales are reported using the following structure: Factor analysis of WIHIC (Section 4.2.1); factor analysis of ATMI (Section 4.2.2); internal consistency and discriminant validity of WIHIC and

ATMI (Section 4.2.3); and ability of actual form of WIHIC to differentiate between classes (Section 4.2.4).

To measure students' perceptions of their classroom learning environment, the preferred form and actual form of three scales from the WIHIC instrument were adapted for use in this study (Fraser, Fisher, & McRobbie, 1996). To measure students' attitudes toward mathematics, I used two relevant scales from Tapia and Marsh's ATMI (2004).

Factor analysis is one method that is commonly used to check the internal structure of an instrument. It is a data-reduction technique used for reducing a large number of items to a smaller set of factors. Through numerical calculations, factor analysis identifies the areas of an instrument that have common themes and are answered in a similar fashion by the participants in the study. These factors allow researchers to reduce the number of variables or items contained in an instrument to focus more closely on components of the area to be studied. If the factor analysis results for an instrument with one sample are consistent with results from previous analyses with other samples, that gives credibility to that instrument (Pallant, 2001).

Data collected from administering the questionnaires were analyzed using a separate principal axis factor analysis with varimax rotation and Kaiser normalization for the actual form of the WIHIC, the preferred form of the WIHIC, and the ATMI. This method has the ability to identify factors by maximizing the variance and then isolating the factors for easy identification.

Internal consistency (whether each item within a scale is measuring a common construct) was measured using Cronbach's alpha coefficient. Discriminant validity, or the extent that each scale is unique and independent, was measured using the mean correlation of a scale with the other scales in that instrument. In addition, for the actual form classroom learning environment questionnaire, the eta^2 statistic from an analysis of variance (ANOVA) was used as a measure of the ability of each scale to differentiate between the perceptions of students in different classes.

4.2.1   *Factor Analysis of WIHIC Data*

As discussed in Chapter 2, the WIHIC has a strong history of being a reliable and valid tool for assessing classroom environments worldwide, including Australia (Dorman, 2001), Asia (Chionh & Fraser, 2009; Khoo & Fraser, 2008; MacLeod & Fraser, 2010; Margianti, 2001), the United States of America (Martin-Dunlop & Fraser, 2008; Ogbuehi & Fraser, 2007; Wolf & Fraser, 2008), and cross-culturally in Taiwan and Australia (Aldridge & Fraser, 2000; Aldridge, Fraser, & Huang, 1999), Australia and Canada (Zandvliet & Fraser, 2005), and Australia, the UK and Canada (Dorman, 2003). In my study, factor and item analyses were conducted to determine which, if any, of the questionnaire items should be removed to improve the internal consistency reliability and factorial validity of WIHIC scales for my sample in Fresno County. Item analysis of the 24 WIHIC items showed that all items had sizable item-remainder correlations.

Table 4.1 shows the results of the separate factor analysis for the preferred form and for the actual form for the 24 items in three scales for the WIHIC when used with 750 students in 39 classes in Fresno County. A principal axis factor analysis with varimax rotation and Kaiser normalization was conducted. No item needed to be

removed from the study when I used the criteria that every item had to have a factor loading of at least 0.40 on its own scale and less than 0.40 on all other scales. For simplicity of interpretation, only factor loadings of 0.40 or above are recorded in Table 4.1.

Table 4.1. Factor Analysis Results for Preferred and Actual Forms of the What is Happening In this Class? (WIHIC)

| Item | Factor Loadings | | | | | |
| | Teacher Support | | Involvement | | Task Orientation | |
	Preferred	Actual	Preferred	Actual	Preferred	Actual
TS 1	0.65	0.69				
TS 2	0.69	0.73				
TS 3	0.70	0.77				
TS 4	0.51	0.56				
TS 5	0.68	0.73				
TS 6	0.70	0.76				
TS 7	0.66	0.67				
TS 8	0.48	0.51				
INV 9			0.75	0.73		
INV 10			0.75	0.82		
INV 11			0.60	0.62		
INV 12			0.76	0.76		
INV 13			0.58	0.62		
INV 14			0.70	0.67		
INV 15			0.57	0.56		
INV 16			0.59	0.62		
TO 17					0.64	0.72
TO 18					0.71	0.75
TO 19					0.69	0.74
TO 20					0.72	0.72
TO 21					0.74	0.77
TO 22					0.76	0.74
TO 23					0.76	0.74
TO 24					0.74	0.78
% Variance	37.60	34.72	13.30	17.02	8.05	9.15
Eigenvalue	9.02	8.33	3.19	4.08	1.93	2.19

N=750
Factor loadings less than 0.40 have been omitted from the table.
Principal axis factoring with varimax rotation and Kaiser normalization.

Factor analysis is a statistical procedure used to organize and group a set of observed variables. Varimax rotation produces the maximum distinctions between the factors. The factor analysis of the 24 items on each form of the WIHIC instrument demonstrated a strong factor structure consistent with previous research (Dorman,

2003; Fraser, 1998a; Ogbuehi & Fraser, 2007; B. A. Taylor, 2004). For both the actual and preferred forms of WIHIC, the *a priori* three-scale structure was replicated perfectly for my study in that all items have a factor loading of at least 0.40 on their own scale and less than 0.40 on all other scales, as shown in Table 4.1.

The bottom of Table 4.1 shows the eigenvalues and percentage of variance for each scale for each form of the instrument. Items are referred to by number, while the actual wording of the item can be found in Appendix C. The percentage of variance extracted from the preferred form of different WIHIC scales was 37.60%, 13.30% and 8.05% for Teacher Support, Involvement and Task Orientation, respectively, with a total of 58.95%. For the actual form, the percentage of variance for the same scales was 34.72%, 17.02% and 9.15%, respectively, with a total of 60.89%. Eigenvalues associated with each scale ranged from 1.93 to 9.02 for preferred form data and from 2.19 to 8.33 for actual form data.

These results are a strong signal that WIHIC's factor structure is clear and repeatable. The corroboration of the factor loadings, eigenvalues, and percentages of variance gives us confidence in both forms of the WIHIC for measuring components of the learning environment from the perspective of the student.

These results suggest that the three actual and preferred WIHIC scales appear to be valid when used in beginning algebra classrooms in Fresno County. The results of this study compare favorably with other research that has involved factor and reliability analyses of the WIHIC data in Australia, Canada (Dorman, 2003; Zandvliet & Fraser, 2005), Singapore (Chionh & Fraser, 2009; Khoo & Fraser,

2008), Brunei (Riah, Fraser, & Rickards, 1997), Korea (Kim, Fisher, & Fraser, 2000), and in the USA (Martin-Dunlop & Fraser, 2008; Wolf & Fraser, 2008).

4.2.2 *Factor Analysis of ATMI Data*

A principal axis factoring with varimax rotation and Kaiser normalization also was performed for the sample of 750 beginning algebra students to confirm the *a priori* structure of the ATMI comprising 25 items in the two scales of Value of Mathematics and Self-Confidence (see Appendix C). The factor loadings obtained are shown in Table 4.2. The analysis was performed to identify faulty items that could be removed in order to improve the internal consistency reliability and factorial validity of the two scales of the ATMI used in this study. As with the analysis of WIHIC data, the criteria for retention of each ATMI item was that its factor loading must be 0.40 on its own scale and less than 0.40 on the other scales (Field, 2005; Stevens, 1992; Thompson, 2004). Only factor loadings of at least 0.40 are reported in the table. Also, the bottom of Tables 4.1 and 4.2 show the eigenvalues and percentage of variance for each scale of the instrument. Items are referred to by number, while the actual wording of the item can be found in Appendix C.

The *a priori* three-scale structure was replicated perfectly in that all 25 items had a factor loading of at least 0.40 on their own scale and less than 0.40 on all other scales. The factor analysis of the 25 items of the modified ATMI instrument demonstrates a strong factor structure consistent with previous research (Moldavan, 2007; Tapia & Marsh, 2000a, 2000b, 2002, 2004).

The percentage of variance extracted was 37.2% for Value of Mathematics and 18.71% for Self-Confidence, with a total of 55.91%. The eigenvalues associated with the two factors were 9.30 and 4.67, respectively. The percentage of variance and the eigenvalue for each scale are shown at the bottom of Table 4.2. The results displayed in Table 4.2 support the structure of a two-scale, 25-item form of the ATMI.

Table 4.2. Factor Analysis Results for Attitudes Toward Mathematics Inventory (ATMI)

Item	Factor Loadings	
	Value of Mathematics	Self Confidence
VAM 25	0.70	
VAM 26	0.70	
VAM 27	0.72	
VAM 28	0.76	
VAM 29	0.77	
VAM 30	0.78	
VAM 31	0.67	
VAM 32	0.76	
VAM 33	0.72	
VAM 34	0.67	
SC 35		0.69
SC 36		0.77
SC 37		0.81
SC 38		0.80
SC 39		0.80
SC 40		0.74
SC 41		0.82
SC 42		0.42
SC 43		0.62
SC 44		0.61
SC 45		0.47
SC 46		0.67
SC 47		0.70
SC 48		0.65
SC 49		0.67
% Variance	37.20	18.71
Eigenvalue	9.30	4.67

N=750
Factor loadings less than 0.40 have been omitted from the table.
Principal axis factoring with varimax rotation and Kaiser normalization.

4.2.3 Internal Consistency Reliability and Discriminant Validity of WIHIC and ATMI

Internal consistency is commonly used to provide a measure of scale reliability and to provide information about the relationships among individual items in the scale. The data from the preferred and actual forms of the WIHIC and the ATMI were subjected to scale internal consistency analysis to investigate the extent to which items in the same scale measure a common construct. Reliability analysis was carried out using Cronbach's alpha coefficient for a sample of 750 students for two forms of the WIHIC questionnaire (preferred and actual) and the attitude scales (ATMI) using the individual and the class mean as the two units of analysis.

Table 4.3 reports the internal consistency reliability (Cronbach alpha coefficient) for the two forms of the modified WIHIC and the modified ATMI. The results show that the alpha coefficients for the three scales of the WIHIC and the two scales of the ATMI were high when two units of analysis (the student and the class mean) were used. When using the student as the unit of analysis, scale reliability values ranged from 0.89 to 0.91 for the WIHIC actual form and from 0.88 to 0.91 on the WIHIC preferred form. Reliability values ranged from 0.89 to 0.96 on the WIHIC actual form and from 0.92 to 0.97 on the WIHIC preferred form using the class mean as the unit of analysis. Alpha reliability values for the two ATMI scales were 0.92 and 0.93 using the student as the unit of analysis. Using the class mean as the unit of analysis, the alpha reliability values for the ATMI scales were 0.95 and 0.94. The alpha reliability coefficient for every scale in Table 4.3 is high (at least 0.88), therefore supporting the strong internal consistency of all scales.

Table 4.3. Internal Consistency Reliability (Cronbach Alpha Coefficient), Discriminant Validity (Mean Correlation with Other Scales) and Ability to Differentiate Between Classrooms (ANOVA Results) for the WIHIC

Scale	Unit of Analysis	Alpha Reliability	Discriminant Validity	ANOVA eta^2
Actual Environment				
Teacher Support	Student	0.90	0.28	0.21***
	Class	0.93	0.38	
Involvement	Student	0.89	0.25	0.14***
	Class	0.89	0.28	
Task Orientation	Student	0.91	0.18	0.22***
	Class	0.96	0.21	
Preferred Environment				
Teacher Support	Student	0.88	0.33	
	Class	0.96	0.49	
Involvement	Student	0.89	0.31	
	Class	0.92	0.46	
Task Orientation	Student	0.91	0.27	
	Class	0.97	0.46	
Attitudes				
Value of Mathematics	Student	0.92	0.15	
	Class	0.95	0.06	
Self Confidence	Student	0.93	0.15	
	Class	0.94	0.06	

*** $p<0.001$

 N=750

The eta^2 statistic (which is the ratio of 'between' to 'total sums of squares') represents the proportion of variance explained by class membership.

The mean correlation of a scale with the other scales was used as a convenient index of discriminant validity, or independence, of each WIHIC and ATMI scale. For the WIHIC actual form, the discriminant validity for different scales ranged from 0.18 to 0.28 at the student level and from 0.21 to 0.38 with the class mean as the unit of analysis. Discriminant validity for different WIHIC preferred scales ranged from 0.27 to 0.33 at the student level and from 0.46 to 0.49 with the class mean as the unit of analysis. The discriminant validity for both scales on the ATMI was 0.15 with the student as the unit of analysis and 0.06 at the class level. We can conclude that the raw scores on each instrument are relatively independent, but with some level of overlap, with the factor analysis attesting to independence for the factor scores. The

discriminant validity for this use of the WIHIC and the ATMI (Table 4.3) was higher than hoped for, but does not exceed acceptable limits (Campbell & Fiske, 1959).

My results are comparable to previous studies with the WIHIC and ATMI that showed good factorial validity and internal consistency reliability. Recent studies with the WIHIC among high-school mathematics students were undertaken by Kilgour (2006) and Zandvliet and Fraser (2005) in Australia, Chionh and Fraser (2009) in Singapore, and Taylor (2004) in the USA. University students were involved in studies using the WIHIC by Khoo and Fraser (2008), Martin-Dunlop and Fraser (2008) and Afari et al. (in press). The ATMI was used in the USA with high-school students in a study conducted by Tapia and Marsh (Tapia & Marsh, 2000b, 2002, 2004) and Schroedrer (2007) and with university students in studies conducted by Moldavan (2007) and Tapia and Marsh (Tapia & Marsh, 2000b, 2002).

4.2.4 Ability of Actual Form of WIHIC to Differentiate Between Classes

A desirable characteristic of the actual form of any classroom environment scale is the ability to differentiate between classrooms. Ideally, students within the same classroom should hold relatively similar perceptions, but average class perceptions should vary from classroom to classroom. An ANOVA was performed with each of the three actual learning environment scales from the WIHIC as the dependent variable and with class membership as the independent variable. The eta^2 statistic is the ratio of 'between' to 'total' sum of squares and provides an estimate of the strength of the association between class membership and each scale. The presence of a significant between-class difference from ANOVA provides information about a

scale's ability to differentiate significantly between the perceptions of students in different classes.

The ANOVA results (Table 4.3) for the sample of 750 students in 39 classes demonstrates that there were significant differences ($p < 0.01$) between classrooms for the actual form of each WIHIC scale. Values for the eta^2 statistic ranged between 0.14 and 0.22 for different WIHIC scales. Overall, it can be concluded that each WIHIC scale was able to differentiate between classes.

4.3 Comparison Between Compulsory Adolescent and Voluntary Adult Beginning Algebra Students in Terms of Preferred and Actual Learning Environment Perceptions and Attitudes Toward Mathematics

This section reports differences between beginning algebra high-school students and community-college students in terms of their perceptions of actual and preferred learning environment and attitudes toward mathematics. The sample consisted of 383 high-school students and 367 community-college students. The same questionnaires were administered to the two groups. The first administration involved 24 items from three scales of the preferred WIHIC (Teacher Support, Involvement and Task Orientation) and 25 items from the scales of Value of Mathematics and Self-Confidence from the ATMI. The second administration involved 24 items from the same three scales of the actual form of the WIHIC and no items from the ATMI.

MANOVA was used to investigate differences between high-school and college students (the independent variable) in terms of eight dependent variables consisting of three scales of the actual form of the WIHIC, three scales of the preferred form of the WIHIC, and the two scales of the ATMI. Because the multivariate test yielded

significant results overall using Wilks' lambda criterion, the univariate ANOVA for each individual scale was interpreted and recorded (last column of Table 4.3).

Table 4.4 reports the two descriptive statistics: the average item mean and the average item standard deviation for each group. The average item mean provides a basis for comparing average scores from scales which could have different numbers of items.

Effect sizes were calculated to provide a measure of the magnitude of the differences between high-school and college students' scores separately for each scale of WIHIC and ATMI. The effect size describes the magnitude of a difference (Pallant, 2001). Effect sizes were calculated in terms of the difference in means divided by the pooled standard deviation. Effect size can be classified as small (≤ 0.10), moderate (0.25), or large (≥ 0.40) (Cohen, 1988).

Table 4.4 also shows the average item mean and average item standard deviation separately for high-school and college students, as well as the difference between high-school and college students (effect size), for each scale of the actual and preferred forms of the WIHIC and the ATMI. For the preferred form of WIHIC, differences between groups were statistically significant and associated with effect sizes of 0.68 (Teacher Support), 0.36 (Involvement), and 0.78 (Task Orientation) standard deviations, which are all large according to Cohen. For the WIHIC actual environment scales, between-group differences were statistically significant for Teacher Support (effect size of 0.24) and Task Orientation (effect size of 0.70) standard deviations. However, differences between high-school students and community-college students were statistically nonsignificant for the actual form of

the WIHIC scale of Involvement (with a small effect size of 0.11 standard deviations), suggesting that the two groups were similar in their perceptions. For the ATMI, differences between groups were statistically significant for Value of Mathematics and associated with an effect size of 0.50 standard deviations. Differences between high-school students and community-college students were statistically nonsignificant for the ATMI scale of Self Confidence (with a small effect size of 0.18 standard deviations).

The results displayed in Table 4.4 show that the differences between the high-school and community-college groups were statistically significant for: the actual form of the two WIHIC scales of Teacher Support and Task Orientation; the preferred form of all three WIHIC scales; and one of the two attitude scales (Value of Mathematics).

Table 4.4   Average Item Mean, Average Item Standard Deviation and Difference Between College and High School Students' Perceptions for Actual and Preferred WIHIC Scales and ATMI Scales

	Average Item Mean		Average Item SD		Difference	
Scale	College	School	College	School	Effect size	*F*
Actual Environment						
Teacher Support	3.41	3.19	0.95	0.86	0.24	3.31**
Involvement	2.58	2.68	0.93	0.91	-0.11	-1.49
Task Orientation	4.53	4.07	0.53	0.76	0.70	9.45**
Preferred Environment						
Teacher Support	3.66	3.11	0.74	0.88	0.68	9.15**
Involvement	3.06	2.75	0.83	0.87	0.36	5.07**
Task Orientation	4.58	4.07	0.51	0.77	0.78	10.55**
Attitudes						
Value of Mathematics	4.03	3.66	0.71	0.78	0.50	6.73**
Self Confidence	3.28	3.44	0.87	0.88	-0.18	-2.44

College (*n*=367) School (*n*=383)
**$p<0.01$

The statistically significant between-group differences were all in the same direction and were all positive, with college students' scores being higher in those six cases. Determining if an effect size is meaningful is a matter of perspective. Although it could be debated just how meaningful the effect sizes are, by Cohen's (1988) standards, the effect sizes associated with statistically significant differences in Table 4.4 are moderate to large effect sizes (one-quarter to three-quarters of a standard deviation) and are quite meaningful. The results in Table 4.4 suggests that the community-college students experienced greater support, perceived a stronger task orientation in their beginning algebra classrooms, and had more positive attitudes toward the value of mathematics than their high-school counterparts.

4.4   Associations Between Learning Environments and Attitudes

This section reports associations between students' attitudes toward mathematics and their perceptions of the actual learning environment. The dependent variables were Value of Mathematics and Self Confidence scales from the ATMI. For this study involving 750 students in 39 classes, associations between students' attitudes and the learning environment were investigated using simple correlation and multiple regression analyses using two units of analysis (the individual and the class mean).

Simple correlation analysis provided information about the bivariate association between each attitude scale and each individual environment dimension. Multiple regression analysis provided a more parsimonious picture of the joint influence of a set of correlated environment scales on attitudes. The regression coefficients from the multiple regression analysis provided information about the magnitude of the relationship between an attitude scale and a particular environment scale when the other two environment scales were mutually controlled.

Table 4.5   Simple Correlation and Multiple Regression Analyses for Associations between Learning Environment and Attitude Scales for Two Units of Analysis

Scale	Unit of Analysis	Value of Mathematics		Self Confidence	
		r	β	r	β
Teacher Support	Student	0.23**	0.08	0.11**	-0.03
	Class	0.47**	0.30	0.17	-0.23
Involvement	Student	0.21**	0.08	0.20**	0.17**
	Class	0.17	-0.13	0.37*	0.51*
Task Orientation	Student	0.41**	0.35**	0.19**	0.16**
	Class	0.68**	0.57**	0.07	0.09
Multiple Correlation (R)	Student		0.41**		0.24**
	Class		0.71**		0.40
R^2	Student		0.17		0.06
	Class		0.50		0.16

*$p<0.05$, **$p<0.01$
$N= 750$ in 38 classes

The results of simple correlation (r) and multiple regression (β) analyses of attitude-environment associations are reported in Table 4.5 for two units of analysis. Table 4.5 shows that the simple correlation was statistically significant between each WIHIC scale (Teacher Support, Involvement and Task Orientation) and both ATMI scales (Value of Mathematics and Self Confidence) with the student as the unit of analysis. With the class mean as the unit of analysis, the simple correlation was statistically significant between the ATMI scale of Value of Mathematics and the WIHIC scales of Teacher Support and Task Orientation and between Self Confidence and Involvement.

The multiple correlation (R) between Value of Mathematics and the set of three WIHIC scales was 0.41 with the individual as the unit of analysis and 0.71 with the class mean as the unit of analysis, and was statistically significant in both cases. The multiple correlation for Self Confidence was 0.24 with the individual as the unit of

analysis and 0.40 with the class mean as the unit of analysis, but was statistically significant only at the student level.

In order to determine which specific learning environment scales of the WIHIC accounted for most of the variance in attitude scales when the other environment scales are mutually controlled, standardized regression weights (β) were examined. As evidenced by the results in Table 4.5, when using the Value of Mathematics as the dependent variable, the WIHIC scale of Task Orientation was a significant independent predictor at both the individual and class level of analysis. When using Self Confidence as the dependent variable, the WIHIC scales of Involvement and Task Orientation were significant and independent predictors when the student was used as the level of analysis, and the WIHIC scale of Involvement was a significant independent predictor with the class as the unit of analysis. The direction of every significant correlation and significant regression coefficient in Table 4.5 was positive, suggesting that a greater emphasis on the three learning environment scales of Teacher Support, Involvement and Task Orientation was related to higher Value of Mathematics and Self Confidence scores.

The magnitudes, statistical significance and direction of the associations in Table 4.5 clearly indicate an association between learning environments and students' attitudes toward mathematics for this group of beginning algebra students in Fresno County. Generally, more positive student attitudes were associated with greater teacher support, students being more involved in the events of the class, and students giving more attention to the tasks assigned. As a whole, students seemed to show more self confidence when they were involved in the routines and events of the class. The results found in my study for attitude-environment associations replicate

considerable prior research (Chionh & Fraser, 2009; Fraser Aldridge & Adolphe, 2010; Wong & Fraser, 1996).

4.5   Summary of Analyses and Results

This chapter reported the findings of a study in Fresno County involving 750 high-school and community-college students' perceptions of their actual and preferred learning environments and their attitudes toward mathematics. Three scales from the actual and preferred forms of the WIHIC (namely, Teacher Support, Involvement, and Task Orientation) and two scales from the ATMI (namely, Value of Mathematics and Self Confidence) were administered to a sample of 383 high-school students and 367 community-college students.

In order to answer Research Question 1, data collected from the sample of 750 beginning algebra students in Fresno County were statistically analyzed to determine the validity and reliability of the WIHIC and ATMI questionnaires, in terms of their factor structure, internal consistency reliability, and the ability of the actual form of the WIHIC to differentiate between classrooms. The main findings are summarized below.

Finding 1: Factor analyses revealed that the actual form of the WIHIC, the preferred form of the WIHIC and the ATMI each displayed sound factorial validity, suggesting that they measure independent components of the learning environment or student attitudes. The *a priori* three-scale structure for the WIHIC and the *a priori* two-scale structure for the ATMI were replicated perfectly in that all items had a factor loading of at least 0.40 on their own scale and less than 0.40 on all other scales. The total proportion of variance accounted for was almost 60% for the WIHIC preferred form,

slightly more than 60% for the WIHIC actual form, and nearly 56% for the two ATMI scales.

Finding 2: The Cronbach alpha reliability coefficient for each scale of both forms of the WIHIC was high, exceeding 0.85 for both the individual and the class as the mean as units of analysis. The alpha coefficient for each scale of the ATMI also was high and it exceeded 0.92 when using either the class or the individual as the unit of analysis.

Finding 3: Discriminant validity for each scale of the WIHIC (using the mean correlation of a scale with the other scales) was satisfactory for both units of analysis for both forms.

Finding 4: ANOVA revealed that each scale of the actual form of the WIHIC was able to differentiate significantly between the perceptions of students in different classrooms.

In order to answer the second research question concerning the magnitude of differences between high-school and college students' preferred learning environment, perceptions of their actual environment and attitudes, effect sizes were used. Also, MANOVA was used to determine the statistical significance of differences. The eight dependent variables consisted of three scales of the actual form of the WIHIC, three scales of the preferred form of the WIHIC, and the two scales of the ATMI. Key findings are listed below.

Finding 5: Relative to high-school students, college students had statistically significantly:

- higher actual Teacher Support and Task Orientation scores,
- higher preferred Teacher Support, Involvement and Task Orientation scores,
- higher Value of Mathematics scores.

Research Question 3, involving associations between the actual learning environment and student attitudes toward mathematics, was answered by performing simple correlation and multiple regression analyses for two units of analysis (namely, the individual and the class mean). The main findings are summarized below.

Finding 6: A positive and statistically significant correlation existed between Value of Mathematics and the WIHIC scales of Teacher Support, Involvement and Task Orientation with the student as the unit of analysis and with the scales of Teacher Support and Task Orientation with the class as the unit of analysis. A positive and statistically significant correlation existed between Self Confidence and the WIHIC scales of Teacher Support, Involvement and Task Orientation with the student as the unit of analysis and between Self Confidence and Involvement with the class as the unit of analysis.

Finding 7: The multiple correlation between the three WIHIC scales and each of the two ATMI scales was statistically significant for both attitude scales for the individual as the unit of analysis, but only for Value of Mathematics for the class as the unit of analysis. Task Orientation was a significant independent predictor of Value of Mathematics for both units of analysis, Involvement was a significant independent predictor of Self Confidence for both units of analysis, and Task

Orientation was a significant independent predictor of Self Confidence with the student as the unit of analysis.

Findings 6 and 7 are consistent with previous research that found positive and statistically significant associations between learning environment and student attitudes scales (Aldridge & Fraser, 2000; Biggs, 2008; Chionh & Fraser, 2009; Fraser, 2007, in press; Ogbuehi & Fraser, 2007).

The significance of these findings is discussed in the next chapter, together with some possible biases or limitations associated with the collection, analyses and interpretation of the data. Also, the next chapter provides a summary of my thesis and discusses the major findings of my study, its limitations and biases, its significance and implications, and recommendations for further research.

Chapter 5

DISCUSSION AND CONCLUSION

5.1   Introduction

Learning environments research has a well-established history of roughly 40 years and is experiencing a strong growth rate. However, no studies have investigated the differences between adolescents and adults in a beginning algebra class in terms of preferred learning environment, actual learning environment, and attitudes toward mathematics.

This chapter provides a summary of my thesis in Section 5.2. Section 5.3 is devoted to the major findings of my study, while Section 5.4 discusses the limitations and biases of the study. Significance and implications of the study are discussed in Section 5.5 and possibilities for further research are presented in Section 5.6. The chapter ends with some concluding thoughts and summary of the study in Section 5.7.

5.2   Summary of Thesis

My study represents a unique investigation of the learning environments of beginning algebra students in both high schools and community colleges. Three questions shaped the study:

1.   Are modified versions of the following questionnaires valid when used with beginning algebra students:

   (a) Preferred Form of the What Is Happening In this Class (WIHIC)?

   (b) Actual form of the What Is Happening In this Class (WIHIC)?

(c) Attitudes Toward Mathematics Inventory (ATMI)?

2.   Are there differences between adolescents and adults in a beginning algebra course in terms of:

(a) Preferred learning environment?

(b) Perceived learning environment?

(c) Attitudes toward mathematics?

3.   Are there associations between the learning environment of beginning algebra classes and students' attitudes toward mathematics?

Chapter 1 began by providing an overview of the charge given to beginning algebra students in high schools and in community colleges. The California Department of Education has defined the expectations for successful completion of a beginning algebra course and for state-wide standardized examinations to assess beginning algebra achievement at the end of 8th grade. This has led to students enrolled in beginning algebra courses in high school or college being below grade level. Although the curriculum is similar at the two levels, the students are not. Therefore, it became a point of curiosity for me to find out if the high school and college students perceive their respective learning environments differently and how the attitudes toward mathematics differ between the two levels of students. I investigated differences between adolescents in a compulsory beginning algebra course in high school and adults voluntarily taking a course at the same level at the community-college level.

Chapter 2 provided a review of the related literature and described each of the instruments used in gathering data for the study. Section 2.2 described the early work and history of learning environment research, beginning in the 1960s with the research of Walberg and Moos (Moos, 1974a; Walberg & Anderson, 1968) and leading up to the many recent applications of learning environment research (Fraser, 2007).

Section 2.3 provided details about development, validity and reliability of eight of the learning environment instruments that have historical and practical significance. Two of those described are early instruments such as the Learning Environment Inventory (LEI, Walberg & Anderson, 1968) and the Classroom Environment Scale (CES, Moos & Trickett, 1974). Additional instruments were developed for more specialized environments such as the Individualized Classroom Environment Questionnaire (ICEQ, Rentoul & Fraser, 1979), the College and University Classroom Environment Questionnaire (CUCEI, Fraser & Treagust, 1986), the Constructivist Learning Environment Survey (CLES, P.C. Taylor, Fraser, & Fisher, 1997) and the Science Laboratory Environment Inventory (SLEI, Fraser, Giddings, & McRobbie, 1992). The My Class Inventory is generally used with children in elementary settings and the Questionnaire on Teacher Interaction investigates the interpersonal relationships between students and teachers (QTI, Wubbels, 1993; Wubbels & Brekelmans, 1998).

Special attention was paid to the development and application of the What Is Happening In this Class? (WIHIC) questionnaire which was chosen for collecting learning environment data in this study (Section 2.4). The full WIHIC assesses the scales of Teacher Support, Student Cohesiveness, Involvement, Investigation, Task

Orientation, Cooperation and Equity. For this study, only the scales of Teacher Support, Involvement and Task Orientation were included in the survey instrument. These three scales, combined with two scales from an attitudes toward mathematics questionnaire, were identified by the researcher as most salient.

Section 2.4 discussed the history of studying students' attitudes toward mathematics and the development and validation of several surveys for assessing students' attitudes toward mathematics. Because the Attitudes Toward Mathematics Inventory (ATMI) was chosen for the study, much of the discussion related to the development, validation and application of the ATMI. Of the four scales assessed by the ATMI (Self-Confidence, Value of Mathematics, Enjoyment and Motivation), only the first two were included in this study because of their appropriateness to both high school and college students and to minimize the time required to administer the survey.

Along with the review of literature relating to the history of learning environment research and various instruments, a review of past research related to learning environments was included. Of particular interest was past research involving the WIHIC and the ATMI. No previous research has combined these two instruments, but plenty of earlier studies report the reliability and validity of each of the instruments. The WIHIC has been used with university students in Singapore (Khoo & Fraser, 2008), Indonesia (Margianti, Fraser, & Aldridge, 2001), Dubai (MacLeod & Fraser, 2010) and California (Martin-Dunlop & Fraser, 2008). Similar studies have been conducted with high school students in Canada (Raaflaub & Fraser, 2002), Brunei (Riah & Fraser, 1998), Australia (Dorman, 2008), and California (B. A. Taylor, 2004), and cross-nationally in Australia and Canada (Zandvliet & Fraser, 2005).

Chapter 3 was devoted to describing the research methodology followed to investigate the three research questions. Section 3.2 detailed the quantitative research methods and Section 3.3 described the data sources in terms of the role of the participants, the sample used and the population from which it was drawn. The data were collected from 383 high-school students and 367 community-college students enrolled in a typical beginning algebra course.

In Section 3.4, more background and details were provided about the instruments used in the study. Three scales (Teacher Support, Investigation, and Task Orientation) from the WIHIC personal-preferred form and two scales (Value of Mathematics and Self Confidence) from the ATMI comprised the first phase of the data collection at the beginning of the school year. The same three scales of the WIHIC personal-actual form were given in a survey a few weeks later. The three scales of the WIHIC contained 8 items each and 25 items were used from the two scales of ATMI (making a total of 49 questions).

To answer Research Question 1, concerning the validity of scales, data from the three instruments were first analyzed for factor structure, reliability, and discriminant validity. Factor analysis was carried out using the principal axis factoring with varimax rotation and Kaiser normalization. Scale internal consistency reliability was determined by computing Cronbach alpha coefficients, while discriminant validity was quantified by using the mean correlation of a scale with other scales. For the actual form of the WIHIC, the eta^2 statistic from ANOVA was used to determine whether the actual form of the instrument could differentiate between classes.

Differences between high-school and college students' preferred learning environment, perceptions of actual environment and attitudes were investigated by conducting a MANOVA in order to answer Research Question 2. The dependent variables used were the three scales from the WIHIC actual form, the same three scales from the WIHIC preferred form, and the two attitude scales. School level was the independent variable. Because the multivariate test yielded significant results overall using Wilks' lamda criterion, the univariate ANOVA for each individual scale was interpreted. Effect sizes were calculated in terms of the difference in means divided by the pooled standard deviation to determine the magnitude of the differences between high-school and college students' scores separately for each scale.

Research Question 3 concerned the associations between beginning algebra students' perceptions of their learning environment and attitudes toward mathematics. Simple correlation was performed to provide information about the bivariate associations between students' perceptions of the classroom environment and attitudes. Using the learning environment scales as the independent variables, relationships between this set of scales and each attitude scale were investigated. These associations were investigated for both the student and the class mean as the units of analysis.

Multiple regression analysis provided a more parsimonious picture of the joint influence of a set of correlated environment scales on attitudes. Through examining the regression coefficients, it was possible to identify which areas of the learning environment had a statistically significant relationship with attitudes when all other learning environment scales were mutually controlled.

Chapter 4 reported the data analyses and results for the three research questions in this study. The major findings of the study are summarized in the following section.

5.3   Major Findings of the Study

The major findings of this study are divided below into three areas, with each relating to one of my research objectives. Each subsection that follows summarizes the results of the data analyses performed to answer each of the research questions.

To answer the first research question about the validity of the questionnaires, Section 5.3.1 summarizes the findings related to factor analysis, scale internal consistency reliability, and scale discriminant validity for the learning environment scales and the attitude scales. Section 5.3.2 summarizes findings for the second research question, concerning a comparison of high-school and community-college beginning algebra students in terms of preferred and actual learning environment perceptions and attitudes toward mathematics. The final section, Section 5.3.3, summarizes the findings for simple correlation and multiple regression analyses for associations between classroom learning environment and attitudes toward mathematics (the third research question).

5.3.1   Validity and Reliability of Learning Environment and Attitude Scales

Factor analysis of data from the WIHIC for my sample of 750 students revealed that the *a priori* structure was replicated with every item in the actual form and the preferred form. Every item had a factor loading greater than 0.40 on its own scale, but less than 0.40 with all other scales. Varimax rotation produces the maximum distinctions between the factors. The factor analysis of the 24 items on each form of the WIHIC instrument revealed a strong factor structure consistent with previous

research (Dorman, 2003; Ogbuehi & Fraser, 2007). The total percentage of variance accounted for by the three scales was nearly 60% for the preferred form and just over 60% for the actual form. Eigenvalues for all scales were greater than 1.5.

Principal axis factoring with varimax rotation with Kaiser normalization was performed for a sample of 750 beginning algebra students to confirm the *a priori* structure of the ATMI comprising 25 items in two scales. The *a priori* two-scale structure was replicated perfectly in that all 25 items have a factor loading of at least 0.40 on their own scale and less than 0.40 on the other scale. The total percentage of variance extracted for the two scales from the ATMI was roughly 56%. The eigenvalues associated with the two factors were both greater than 4.

The Cronbach alpha coefficients for the WIHIC scales ranged from 0.89 to 0.91 for the actual form and from 0.88 to 0.91 for the WIHIC preferred form when using the student as the unit of analysis. Reliability values ranged from 0.89 to 0.96 for the WIHIC actual form and from 0.92 to 0.97 for the preferred form when using the class mean as the unit of analysis. Alpha reliability values for the two ATMI scales were 0.92 and 0.93 using the student as the unit of analysis, and 0.95 and 0.94 using the class mean as the unit of analysis. The reliability coefficient for every WIHIC and ATMI scale was at least 0.88, therefore demonstrating strong internal consistency for all scales.

The mean correlation of a scale with the other two scales was used to determine that the discriminant validity ranged from 0.18 to 0.28 for the WIHIC actual form at the student level and from 0.21 to 0.38 with the class mean as the unit of analysis. Discriminant validity (scale intercorrelation) for different WIHIC preferred scales

ranged from 0.27 to 0.33 at the student level and from 0.46 to 0.49 with the class mean as the unit of analysis. The discriminant validity (scale intercorrelation) for the two scales of the ATMI was 0.15 with the student as the unit of analysis and 0.06 at the class level. This confirms a reasonable level of independence among scales between raw scores on WIHIC and ATMI scales, with the factor analyses attesting to the independence of factor scores.

The ANOVA results demonstrate that there were significant differences between the perceptions of students in different classrooms for the actual form of each WIHIC scale. Values for the eta^2 statistic (which represents the proportion of variance accounted for by class membership) ranged between 0.14 and 0.22 for different WIHIC scales. Overall, it can be concluded that each WIHIC scale was able to differentiate between classes.

These results suggest that the three actual and preferred WIHIC scales and the two scales of the ATMI appear to be valid when used in beginning algebra classrooms in Fresno County. The results of this study compare favorably with other research that has involved factor and reliability analyses of WIHIC data in Australia and Canada (Dorman, 2003; Zandvliet & Fraser, 2005), Singapore (Chionh & Fraser, 2009; Khoo & Fraser, 2008), Brunei (Riah, Fraser, & Rickards, 1997), Korea (Kim, Fisher & Fraser, 2000), and the USA (Martin-Dunlop & Fraser, 2008; Wolf & Fraser, 2008). Also my results for the validity of the ATMI replicates previous findings in the USA with high-school students (Schroeder, 2007; Tapia & Marsh, 2000, 2004); and university students (Moldavan, 2007; Tapia & Marsh, 2000, 2002).

5.3.2 *Comparison of High-school and Community-college Beginning Algebra Students in Terms of Preferred and Actual Learning Environment Perceptions and Attitudes Toward Mathematics*

After the instruments had been shown to be valid and reliable for the beginning algebra classes studied in Fresno County, differences between high-school students and college students were investigated for each of the scales measuring learning environment and attitudes toward mathematics using MANOVA. The eight dependent variables consisted of the three scales of the actual form of the WIHIC, the three scales of the preferred form of the WIHIC, and the two scales of the ATMI. Because the multivariate test yielded significant results overall using Wilks' lambda criterion, the univariate ANOVA for each individual scale was interpreted.

The results showed that the differences between the high-school and community-college groups were statistically significant for: the actual form of the two WIHIC scales of Teacher Support and Task Orientation; the preferred form of all three WIHIC scales; and one of the two attitude scales (Value of Mathematics).

For the preferred form of WIHIC, differences between groups were statistically significant and associated with effect sizes of 0.68 standard deviations (Teacher Support), 0.36 standard deviations (Involvement), and 0.78 standard deviations (Task Orientation) standard deviations, which are all large according to Cohen (1988). For the WIHIC actual environment scales, between-group differences were statistically significant for Teacher Support (effect size of 0.24) and Task Orientation (effect size of 0.70) standard deviations. However, differences between high-school students and community-college students were statistically nonsignificant for the actual form of the WIHIC scale of Involvement (with a small effect size of 0.11 standard deviations), suggesting that the two groups were similar in their perceptions. For the

ATMI, differences between groups were statistically significant and associated with effect sizes of 0.50 standard deviations for Value of Mathematics. Differences between high-school students and community-college students were statistically non-significant for the ATMI scale of Self Confidence (with a small effect size of 0.18 standard deviations).

The directions of the statistically significant between-group differences were all positive, with college students' scores being higher in those six cases. The results suggest that community-college students experienced greater teacher support and task orientation in their beginning algebra classrooms and had more positive attitudes toward the value of mathematics than their high-school counterparts.

5.3.3   Associations Between Learning Environment and Attitudes

When associations were explored between the three actual learning environment factors and each of the attitude scales using simple correlation and multiple regression analyses, a positive and statistically significant correlation emerged between each WIHIC scale (Teacher Support, Involvement and Task Orientation) and both ATMI scales (Value of Mathematics and Self Confidence) with the student as the unit of analysis. With the class mean as the unit of analysis, the simple correlation was statistically significant between the ATMI scale of Value of Mathematics and the WIHIC scales of Teacher Support and Task Orientation and between Self Confidence and Involvement.

The multiple correlation between Value of Mathematics and the set of three WIHIC scales was 0.41 with the individual as the unit of analysis and was 0.71 with the class mean as the unit of analysis, and was statistically significant in both cases. The

multiple correlation for Self Confidence was 0.24 with the individual as the unit of analysis and 0.40 with the class mean as the unit of analysis, but was statistically significant only at the student level.

In order to determine which specific learning environment scales of the WIHIC accounted for most of the variance in attitude scales when the other environment scales were mutually controlled, standardized regression weights were examined. With the Value of Mathematics as the dependent variable, the WIHIC scale of Task Orientation was a significant independent predictor at both the individual and class levels of analysis. When using Self Confidence as the dependent variable, the WIHIC scales of Involvement and Task Orientation were significant and independent predictors when the student was used as the level of analysis, and the WIHIC scale of Involvement was a significant independent predictor with the class as the unit of analysis. The direction of every significant correlation and significant regression coefficient was positive, suggesting that a greater emphasis on the three learning environment scales was related to more positive attitudes.

The magnitudes, statistical significance and direction of associations suggest that there was a relationship between learning environments and students' attitudes toward mathematics for this group of beginning algebra students in Fresno County. More positive student attitudes were associated with greater teacher support, students being more involved in the events of the class, and students giving more attention to the tasks assigned. As a whole, students seemed to show more self confidence when they were involved in the routines and events of the class. These findings are consistent with previous research that reported positive and statistically significant

associations between learning environment and attitude scales (Aldridge & Fraser, 2000; Chionh & Fraser, 2009; Fraser, 1998a; Ogbuehi & Fraser, 2007).

5.4   Limitations and Biases of the Study

The possibility for error, bias and lack of validity are present in any research (Anderson, 1998). The process of designing and conducting the research, as well as collecting and analyzing data, provide these opportunities for bias. Careful planning, detailed record keeping and faithful attention to detail in this study were undertaken in an effort to minimize such shortcomings.

Sample size is one such source of potential invalidity. Ideally, data would come from the entire population of high-school and community-college beginning algebra students. However, in Fresno County, roughly only 23% of the beginning algebra students in high schools participated and only 16% of beginning algebra students in a community college setting participated. The actual percentage of community-college students is slightly higher if online courses are omitted from the population. Nevertheless, the sample size used in this study of 383 high-school students and 367 community-college students was modest but still sufficient to allow use of statistical analysis such as factor analysis, multiple regression analysis, and ANOVA.

In addition to sample size, sample representativeness also is important. Participants in this study were chosen based on which school districts granted approval, followed by which principals granted consent and which teachers were willing to give up precious classroom time in order to allow students to participate. One large district within Fresno County chose not to participate in the research because district personnel and students were currently involved in research projects for their own

purposes. Although demographic data were not collected from the student participants, the participating classes were all heterogeneously grouped with regard to socioeconomics, ethnicity and gender. I carefully selected a sample that was reasonably typical based on my experience. However, still there is the need for caution in generalizing my findings to broader groups as I cannot be sure about exactly how typical the sample was.

Another potential limitation was the degree of honesty of the participating students' responses. I believe that I reduced this threat through my detailed procedure for administering the questionnaires. Students were informed of the purpose of my study, as well as the voluntary nature of the process and the precautions that were implemented to protect survey responses. Surveys were labeled with first names in order to permit matching of Part I and Part II for data entry, but no other personal data were collected. Classroom teachers never handled the surveys and the completed surveys were stored in a locked file drawer in my office. Any questionnaire responses that were incomplete or appeared recklessly answered were not included in the data base.

The elimination of incomplete or recklessly-answered questionnaires was also a limitation in that it reduced the effective number of participants by nearly 50%. Disregarding incomplete questionnaires has possible shortcomings (Little & Rubin, 1987). If the eliminated questionnaires form a representative and relatively small portion of the entire dataset, then deletion indeed might be a reasonable approach. However, deletion leads to valid inferences in general only when missing data are missing completely at random. If the discarded questionnaires differ systematically from the rest, estimates can be biased. In multivariate studies, deletion can result in a

sizable portion of the data being eliminated and an unacceptable loss of power occurs.

It might have been wiser to retain the questionnaire responses with missing data for three or fewer items and use a statistical process to compensate for missing data. Imputation, the practice of 'filling in' missing data with plausible values, is one approach to analyzing incomplete data that appears to solve the missing-data problem at the beginning of the analysis. However, a naive or unprincipled imputation method can create more problems than it solves according to Little and Rubin (1987).

Although past studies have reported statistically significant associations between learning environment and achievement (Chionh & Fraser, 2009; Ma, 1997; Ma & Kishor, 1997; Wolf & Fraser, 2008), my research did not include any measures of student achievement. It is, therefore, impossible to conclude from this study whether or not there was any relationship between the learning environment and achievement for these students.

Because learning environment research is enhanced by using mixed methods, combining quantitative and qualitative data is recommended by many in the field (Aldridge & Fraser, 2000; Fraser & Tobin, 1991; Tobin & Fraser, 1998). Supplementing quantitative data with qualitative data by using classroom observations and/or interviews allows for a deeper understanding of the learning environment. Although it was originally the intention to support the quantitative data with a limited number of semi-structured interviews, this proved unrealistic

because of class schedules, the time required to enter the raw data, and the need for me to travel overseas to visit Curtin University.

5.5   Significance and Implications of this Study

At the beginning of the research process, before results could be interpreted, before data were collected, before a methodology was decided upon, and even before research questions could be crafted, my experiences as a teacher led me to explore the learning environment and attitudes of beginning algebra students in high schools and community colleges. I have witnessed the similarities in the course content of beginning algebra at the two levels. I have experienced teaching the content over 183 50-minute periods in 36 weeks, over 62 100-minute periods in 18 weeks, and over 81 50-minute periods in 17 weeks. I have taught the same content to small classes of around 20 students and to large classes with nearly 80 students. I have taught using 'traditional' methods and 'reform' methods. However, none of these variations seemed as radical as the move from teaching at the high-school level to teaching at the college level. Therefore I wanted to conduct research that would have an impact on my professional life and the academic life of my students. I wanted to understand some of the differences between the two groups and the connections between the learning environment and students' attitudes. It was my goal to conduct research with sound methods and techniques that would not only reinforce past findings, but also shed new light on the real world of teaching beginning algebra.

The findings of my study supported my experiences as a teacher of both high-school and college beginning algebra. I found that college students preferred a greater

amount of teacher support, involvement and task orientation than their high-school counterparts. This is plausible because college students have voluntarily chosen to enroll in a beginning algebra course. College students also perceived greater actual teacher support and task orientation in their learning environments than high-school participants. College students generally have access to their teachers outside class hours as teachers are required to hold office hours in addition to the class meeting times. Because meeting with a teacher outside class hours requires a sense of intrinsic and internal motivation, this also could explain the greater task orientation perceived by college students.

College students also reported that they placed greater value on the study of mathematics, perhaps because they valued what a two-year college degree can offer them, or because they were completing a two-year degree as a prerequisite for transfer to a four-year university qualification. It is also possible that, at this stage in their lives, they had selected a career path and valued an education that moved them toward this end.

The results of my study could suggest that more effort should be made in high-school beginning algebra classes to demonstrate teacher support. Some schools in the area where I live do pay teachers for spending time before and after school to meet with students. Sometimes, however, this interferes with the times when students are provided with transportation to school. Many schools experiment with task orientation strategies to increase the amount of energy that students put into their assigned tasks. Several textbook publishers have designed web-based curricula with imbedded calendars in an attempt to increase student and parent awareness of required tasks. The lower value that high-school students place on mathematics

could also explain the lower scores for task orientation. If a student does not perceive value in the study of mathematics, he or she might not feel compelled to stay on task or return assignments in a timely fashion. High-school beginning algebra students valued mathematics less than their college counterparts.

Nevertheless, teachers of college beginning algebra students must be prepared to offer strong teacher support, keep their students involved and applaud their efforts to stay on task. High-school beginning algebra teachers need to support their students not only in the study of algebra, but also to promote the merits of staying involved and on task.

Future research could focus on differences between actual and preferred learning environment scores for each age group. How close are teachers to providing the level of support that students in each group prefer? Are students as involved as they would like to be? Is task orientation a high priority for students and are teachers providing as much or more structure than students prefer?

The findings from my study have the potential to assist current and future educators and researchers in gaining more insight into the mathematics classroom environments of high schools and community colleges. Based on results from this study, it is evident that elements of the learning environment can influence students' attitudes toward mathematics. Based on research conducted in other settings, together with research that focuses on other aspects of the mathematics classroom, teachers need to carefully decide how they can shape the learning environment to best suit their students.

Future researchers are likely to be interested in my finding that the WIHIC and the ATMI were valid and reliable when used with high-school and community-college students undertaking beginning algebra classes in Fresno County. This study could guide future research into learning environments and/or students' attitudes toward mathematics in high schools or in community colleges in California and elsewhere.

Beyond what I have already gained from this study and am currently incorporating into my professional life, there are benefits for other teachers of mathematics. Many part-time college instructors are full-time high school teachers who move between the two programs. Understanding the learning environment and attitudes of the two groups also is likely to guide teachers in creating a learning environment that is positive rather than remaining indifferent to it.

My study adds to the richness of learning environment research with a primary focus on the mathematics classroom (e.g. Chionh & Fraser, 2009; Dorman, 2001; Kilgour, 2006; Majeed, Fraser, & Aldridge, 2002; e.g. Mink & Fraser, 2005; Moldavan, 2007; Ogbuehi & Fraser, 2007; Spinner & Fraser, 2005). Relatively few past learning environment studies have focused specifically on mathematics classes, and none of these have focused on two different age groups taking the same mathematics course.

5.6 Recommendations for Future Research

Research begets more research. As in all learning settings, the answers at which we arrive usually generate new questions. My study was influenced by those who have gone before me, and presumably others will be influenced and motivated by my study to continue the tradition.

If I were to continue from where this study left off, I would replicate my research with a bigger sample or perhaps with similar samples in different geographical locations. Replication would lead to greater confidence in my findings and broader applicability. It would be appropriate to extend the research to include schools from other countries, which would allow international comparison and replication.

Another extension of this study would involve combing quantitative and qualitative methods. Qualitative data collected through interviews or focus groups can support the quantitative data and provide richer insight into the data. Interviews, observations and focus groups have proven extremely useful in learning environment research (Aldridge, Fraser, & Huang, 1999; Mink & Fraser, 2005; Spinner & Fraser, 2005; Tobin & Fraser, 1998). Qualitative data can complement quantitative findings in providing new insights and explanations.

Given the opportunity to spend more time in classrooms, I would recommend conducting additional research using more scales from the WIHIC with a similar population. While I limited my study to the scales of Teacher Support, Involvement and Task Orientation, I believe that it would be of interest to also compare between-groups results for the WIHIC scales of Student Cohesiveness and Equity. It would be of additional interest to investigate any changes in the way in which males and females perceive the learning environment after they transition from high school to college?

There are other lines of research that could prove useful and beneficial to the mathematics education community. Learning environment has been shown repeatedly to be related to student achievement (Chionh & Fraser, 2009; Wolf &

Fraser, 2008).   Further research is warranted into the relationship between the learning environment and achievement at the high-school level and community-college levels.   Because there is currently no standardized achievement test for beginning algebra students in college, and certainly there is nothing standardized between the high school and the college, an achievement test would need to be created and validated for the study. Such a test could then be given as a pretest and a posttest to monitor achievement over time.

5.7   Summary

Learning environment research has influenced the modern classroom. Since the early pioneers introduced the concept in the late 1960s, the field of learning environment research has grown from an evaluation of Harvard Project Physics (Walberg & Anderson, 1968) to being an international and a multi-disciplinary field, with learning environment questionnaires being used as a source of dependent and independent variables in a variety of applications in many countries (Fraser, 2007). Likewise, the study of attitudes toward mathematics has a rich history and a plethora of applications. Neale (1969) began to study attitudes toward mathematics in the late 1960s and positive relationships between attitude toward mathematics and mathematics achievement were noted as early as the 1980s (Minato, 1983; Minato & Yanase, 1984).

It is my hope that the research reported here will contribute to the ongoing tradition of studying associations between learning environment and attitudes toward mathematics. Through a better understanding of these two fields, the potential exists to improve the classroom experience for students and offer them a greater chance at success and confidence.

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Appendix A

Beginning Algebra Standards

High School Algebra I Standards

(Curriculum Development and Supplemental Materials Commission State of California, 2005)

1.0   Students identify and use the arithmetic properties of subsets of integers and rational, irrational, and real numbers, including closure properties for the four basic arithmetic operations where applicable:

2.0   Students understand and use such operations as taking the opposite, finding the reciprocal, taking a root, and raising to a fractional power. They understand and use the rules of exponents.

3.0   Students solve equations and inequalities involving absolute values.

4.0   Students simplify expressions before solving linear equations and inequalities in one variable, such as $3(2x-5) + 4(x-2) = 12$.

5.0   Students solve multistep problems, including word problems, involving linear equations and linear inequalities in one variable and provide justification for each step.

6.0   Students graph a linear equation and compute the x- and y-intercepts (e.g., graph $2x + 6y = 4$). They are also able to sketch the region defined by linear inequality (e.g., they sketch the region defined by $2x + 6y < 4$).

7.0   Students verify that a point lies on a line, given an equation of the line. Students are able to derive linear equations by using the point-slope formula.

8.0   Students understand the concepts of parallel lines and perpendicular lines and how those slopes are related. Students are able to find the equation of a line perpendicular to a given line that passes through a given point.

9.0   Students solve a system of two linear equations in two variables algebraically and are able to interpret the answer graphically. Students are

able to solve a system of two linear inequalities in two variables and to sketch the solution sets.

10.0 Students add, subtract, multiply, and divide monomials and polynomials. Students solve multistep problems, including word problems, by using these techniques.

11.0 Students apply basic factoring techniques to second- and simple third-degree polynomials. These techniques include finding a common factor for all terms in a polynomial, recognizing the difference of two squares, and recognizing perfect squares of binomials.

12.0 Students simplify fractions with polynomials in the numerator and denominator by factoring both and reducing them to the lowest terms.

13.0 Students add, subtract, multiply, and divide rational expressions and functions. Students solve both computationally and conceptually challenging problems by using these techniques.

14.0 Students solve a quadratic equation by factoring or completing the square.

15.0 Students apply algebraic techniques to solve rate problems, work problems, and percent mixture problems.

16.0 Students understand the concepts of a relation and a function, determine whether a given relation defines a function, and give pertinent information about given relations and functions.

17.0 Students determine the domain of independent variables and the range of dependent variables defined by a graph, a set of ordered pairs, or a symbolic expression.

18.0 Students determine whether a relation defined by a graph, a set of ordered pairs, or a symbolic expression is a function and justify the conclusion.

19.0   Students know the quadratic formula and are familiar with its proof by completing the square.

20.0   Students use the quadratic formula to find the roots of a second-degree polynomial and to solve quadratic equations.

21.0   Students graph quadratic functions and know that their roots are the x-intercepts.

22.0   Students use the quadratic formula or factoring techniques or both to determine whether the graph of a quadratic function will intersect the x-axis in zero, one, or two points.

23.0   Students apply quadratic equations to physical problems, such as the motion of an object under the force of gravity.

24.0   Students use and know simple aspects of a logical argument:

25.0   Students use properties of the number system to judge the validity of results, to justify each step of a procedure, and to prove or disprove statements.

College Beginning Algebra Standards
(Curriculum Renewal Across the First Two Years, 2007)

1. Problem Solving

The student will:

- solve problems presented in the context of real world situations with emphasis on model creation and interpretation;
- develop a personal framework of problem solving techniques (e.g. read the problem at least twice; define variables; sketch and label a diagram; list what is given; restate the question asked; identify variables and parameters; use analytical, numerical and graphical solution methods as appropriate; determine plausibility of and interpret solution);
- create, interpret, and revise models and solutions of problems.

2. Functions and Algebra

The student will:

- understand the concepts of function and rate of change;
- master algebraic techniques and manipulations necessary for problem-solving and modeling in this course;
- use multiple perspectives (symbolic, numeric, graphic, and verbal) to explore elementary functions, including linear, exponential, power, polynomial, logarithmic, and periodic, as appropriate;
- recognize and use standard transformations such as translations and dilations with graphs of elementary functions.

3. Data Analysis

The student will:

- collect (in scientific discovery or activities, or from the Internet, textbooks, or periodicals), plot, and display data in various forms;
- apply algebraic transformations to linearize data for analysis;
- fit an appropriate curve to a scatter plot and use the resulting function for prediction and analysis;
- determine the appropriateness of a model via scientific reasoning.

4. Systems of Equations

The student will:

- use systems of equations to model real world situations;
- solve systems of linear and non-linear equations using a variety of methods.

Appendix B

Information Sheets and Consent Forms

Science and Mathematics Education Centre

Beginning Algebra Learning Environments

My name is Tiffany Friesen and I am a mathematics teacher at Fresno City College. I am currently conducting research for my Ph.D. in Mathematics Education and Learning Environments at Curtin University of Technology.

Purpose of my Research

I am investigating the differences that may exist between the beginning algebra classroom setting that adolescent and adult students wish they were in and the beginning algebra classroom setting that they currently experience. I believe that adolescents and adults in a beginning algebra course wish for and perceive different environments. I am also investigating how adolescents and adults differ in their attitudes toward mathematics.

The Student's Role

I will be asking students to complete a two part survey. The first part of the survey will ask them to think about the classroom and the teacher. It will ask you what kinds of activities are comfortable for him or her and how they like to be treated. The second part of the survey will ask students about some of their thoughts about math.

Consent to Participate

Your child's involvement in the research is completely voluntary. If at any point you wish him or her to stop participating all you need to do is inform your teacher and the research assistant in your class. If you do not turn in this form I will assume you have not agreed to participate and have not given me permission to use your student's responses in my research.

Confidentiality

The responses are completely confidential. I will keep all personal information separate from your responses and I will be the only person who has access to this information. I will keep the responses from your survey in a locked cabinet for five years and then I will destroy it.

Further Information

If you would like further information about the research, please feel free to contact me at my office: 442-4600 x 8164 or by email: tiffany.friesen@fresnocitycollege.edu. If you prefer you may contact my supervisor Dr. Barry Fraser at B.Fraser@curtin.edu.au.

I have read the information above. I know that I am allowed to ask questions of Tiffany Friesen or her advisor via email. I understand that all of the personal information and responses will be kept confidential and that the information gathered from this research may be published but that no names or any other personal information that reveals anyone's identity will be used, and I agree to let my child participate in this research.

Student Name _____Name of Parent/Guardian _____

Signature _____ Date _____

Investigator <u>Tiffany Friesen</u>   Signature _____

PARTICIPANT INFORMATION SHEET

My name is Tiffany Friesen and I am a mathematics teacher at Fresno City College. I am currently conducting research for my Ph.D. in Mathematics Education and Learning Environments at Curtin University of Technology.

Purpose of my Research

I am investigating the differences that may exist between the beginning algebra classroom setting that adolescent and adult students wish they were in and the beginning algebra classroom setting that they currently experience. I believe that adolescents and adults in a beginning algebra course wish for and perceive different environments. I am also investigating how adolescents and adults differ in their attitudes toward mathematics.

Your Role

I will be asking you to complete a two part survey. The first part of the survey will ask you to think about your classroom and your teacher. It will ask you what kinds of activities you are comfortable doing and how you like to be treated. The second part of the survey will ask you about some of your thoughts about math. In three weeks I will ask you to complete another survey almost like the first. The only difference is that you will be asked to answer questions about the class you are in.

Consent to Participate

Your involvement in the research is completely voluntary. If at any point you wish to stop participating all you need to do is inform your teacher and the research assistant in your class. Your grade will not be affected in any way if you choose not to participate. Once you have turned in the completed consent forms I will assume you have agreed to participate and have given me permission to use your responses in my research.

Confidentiality

Your responses are completely confidential. If you choose to participate your name will not appear on your survey. I will keep all personal information separate from your responses and I will be the only person who has access to this information. I will keep the responses from your survey in a locked cabinet for five years and then I will destroy it.

Further Information

If you would like further information about the research, please feel free to contact me at my office: 442-4600 x 8164 or by email: tiffany.friesen@fresnocitycollege.edu. If you prefer you may contact my supervisor Dr. Barry Fraser at B.Fraser@curtin.edu.au.

Thank you for your participation in this research. I really appreciate your time and help.

Curtin
University of Technology

PARTICIPANT CONSENT FORM

_____

• I understand the purpose and procedures of the study.

• I have been provided with the participation information sheet.

• I understand that the procedure itself may not benefit me.

• I understand that my involvement is voluntary and I can withdraw at any time without problem.

• I understand that no personal identifying information like my name will be used in any published materials.

• I understand that all information will be securely stored for at least 5 years before a decision is made as to whether it should be destroyed.

• I have been given the opportunity to ask questions about this research.

• I agree to participate in the study outlined to me.

_____

Name: _____

Signature: _____

Date: _____

Appendix C

Questionnaire Parts I and II

Part I: Preferred Learning Environment and Attitudes Toward Mathematics

Part II: Actual Learning Environment

Items 1–24 in Part I in this appendix are based on the preferred form of the What Is Happening In this Class? (WIHIC) questionnaire developed by Aldridge, Fraser and Huang (1999). Items 25–49 in Part I are based on the Attitudes Toward Mathematics Inventory (ATMI) developed by Tapia and Marsh (1996). Items 1–24 in Part II in this appendix are based on the actual form of the What Is Happening In this Class? (WIHIC) questionnaire developed by Aldridge, Fraser and Huang (1999). The WIHIC is discussed in Sections 2.4 and 3.4.1 and the ATMI is discussed in section 2.5 and 3.4.2 of the thesis. These questionnaires were used in my study with the permission of their authors.

Part I

NAME_____

What is Happening in this Class?
(Preferred Form)
Attitudes Toward Mathematics Inventory

Directions for Students

This questionnaire contains statements about practices that could take place in this class. You will be asked how often you would like each practice to take place.

There are no 'right' or 'wrong' answers. Your opinion is what is wanted. Think about how well each statement describes what this class is like for you.

TS	Almost Never	Seldom	Some-times	Often	Almost Always
1. The teacher would take a personal interest in me.	1	2	3	4	5
2.. The teacher would go out of his/her way to help me.	1	2	3	4	5
3. The teacher would consider my feelings.	1	2	3	4	5
4. The teacher would help me when I have trouble with the work.	1	2	3	4	5
5. The teacher would talk with me.	1	2	3	4	5
6. The teacher would be interested in my problems.	1	2	3	4	5
7. The teacher would move about the class to talk with me.	1	2	3	4	5
8. The teacher's questions would help me to understand.	1	2	3	4	5
IV	Almost Never	Seldom	Some-times	Often	Almost Always
9. I would discuss ideas in class.	1	2	3	4	5
10. I would give my opinions during class discussions.	1	2	3	4	5
11. The teacher would ask me questions.	1	2	3	4	5
12. My ideas and suggestions would be used during classroom discussions.	1	2	3	4	5
13. I would ask the teacher questions.	1	2	3	4	5
14. I would explain my ideas to other students.	1	2	3	4	5
15. Students would discuss with me how to go about solving problems.	1	2	3	4	5
16. I would be asked to explain how I solve problems.	1	2	3	4	5

TO		Almost Never	Seldom	Some-times	Often	Almost Always
17.	Getting a certain amount of work done would be important to me.	1	2	3	4	5
18.	I would do as much as I set out to do.	1	2	3	4	5
19.	I would know the goals for this class.	1	2	3	4	5
20.	I would be ready to start this class on time.	1	2	3	4	5
21.	I would know what I am trying to accomplish in this class.	1	2	3	4	5
22.	I would pay attention during this class.	1	2	3	4	5
23.	I would try to understand the work in this class.	1	2	3	4	5
24.	I would know how much work I have to do.	1	2	3	4	5

VM		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
25.	Mathematics is a very worthwhile and necessary subject.	1	2	3	4	5
26.	I want to develop my mathematical skills.	1	2	3	4	5
27.	Mathematics helps develop the mind and teaches a person to think.	1	2	3	4	5
28.	Mathematics is important in everyday life.	1	2	3	4	5
29.	Mathematics is one of the most important subjects for a person to study.	1	2	3	4	5
30.	Math courses would be very helpful no matter what I decide to study.	1	2	3	4	5
31.	I can think of many ways that I use math outside of school.	1	2	3	4	5
32.	I think studying advanced mathematics is useful.	1	2	3	4	5
33.	I believe studying math helps me with problem solving in other areas.	1	2	3	4	5
34.	A strong math background could help me in my professional life.	1	2	3	4	5

SC		Strongly Disagree	Disagree	Neutral	Agree	Strongly Agree
35.	Mathematics is one of my most dreadful subjects.	1	2	3	4	5
36.	My mind goes blank and I am unable to think clearly when working with mathematics.	1	2	3	4	5
37.	Studying mathematics makes me feel nervous.	1	2	3	4	5
38.	Mathematics makes me feel uncomfortable.	1	2	3	4	5
39.	I am always under a terrible strain in a math class.	1	2	3	4	5
40.	When I hear the word mathematics, I have a feeling of dislike.	1	2	3	4	5
41.	It makes me nervous to even think about having to do a mathematics problem.	1	2	3	4	5
42.	Mathematics does not scare me at all.	1	2	3	4	5
43.	I have a lot of self-confidence when it comes to mathematics.	1	2	3	4	5
44.	I am able to solve mathematics problems without too much difficulty.	1	2	3	4	5
45.	I expect to do fairly well in any math class I take.	1	2	3	4	5
46.	I am always confused in my mathematics class.	1	2	3	4	5
47.	I feel a sense of insecurity when attempting mathematics.	1	2	3	4	5
48.	I learn mathematics easily.	1	2	3	4	5
49.	I believe I am good at solving math problems.	1	2	3	4	5

Part II   NAME _____

What is Happening in This Class? (WIHIC)
(Actual Form)

Directions for Students

This questionnaire contains statements about practices that DO take place in this class. You will be asked how often each practice takes place.

TS		Almost Never	Seldom	Some-times	Often	Almost Always
1.	The teacher takes a personal interest in me.	1	2	3	4	5
2.	The teacher goes out of his/her way to help me.	1	2	3	4	5
3.	The teacher considers my feelings.	1	2	3	4	5
4.	The teacher helps me when I have trouble with the work.	1	2	3	4	5
5.	The teacher talks with me.	1	2	3	4	5
6.	The teacher is interested in my problems.	1	2	3	4	5
7.	The teacher moves about the class to talk with me.	1	2	3	4	5
8.	The teacher's questions help me to understand.	1	2	3	4	5
IV		Almost Never	Seldom	Some-times	Often	Almost Always
9.	I discuss ideas in class.	1	2	3	4	5
10.	I give my opinions during class discussions.	1	2	3	4	5
11.	The teacher asks me questions.	1	2	3	4	5
12.	My ideas and suggestions are used during classroom discussions.	1	2	3	4	5
13.	I ask the teacher questions.	1	2	3	4	5
14.	I explain my ideas to other students.	1	2	3	4	5
15.	Students discuss with me how to go about solving problems.	1	2	3	4	5
16.	I am asked to explain how I solve problems.	1	2	3	4	5
TO		Almost Never	Seldom	Some-times	Often	Almost Always
17.	Getting a certain amount of work done is important to me.	1	2	3	4	5
18.	I do as much as I set out to do.	1	2	3	4	5
19.	I know the goals for this class.	1	2	3	4	5
20.	I am ready to start this class on time.	1	2	3	4	5
21.	I know what I am trying to accomplish in this class.	1	2	3	4	5
22.	I pay attention during this class.	1	2	3	4	5
23.	I try to understand the work in this class.	1	2	3	4	5
24.	I know how much work I have to do.	1	2	3	4	5