Science and Mathematics Education Centre

A Cross-National Study of Students' Perceptions of Mathematics Classroom Environment, Attitudes Towards Mathematics and Academic Self-Efficacy Among Middle School Students in Hong Kong and the USA

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Declaration

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

Signature:

Date: December 2013

Abstract

The major purpose of this cross-national study was to compare mathematics classes in Hong Kong and the USA in terms of classroom learning environment, attitudes toward mathematics, and academic efficacy. Data were collected from 1,309 seventh and eighth mathematics students in 35 classes in the USA and 23 classes in Hong Kong using 56 items from three previously-validated and reliable instruments. Students' perceptions of the learning environment were measured using four scales from the What Is Happening In this Class? (WIHIC) questionnaire (Teacher Support, Involvement, Cooperation, and Equity). Students' attitudes towards mathematics were assessed using Attitudes Towards Mathematical Inquiry and Enjoyment of Mathematics from the Test of Mathematics-Related Attitudes (TOMRA). Academic Efficacy, from Aldridge and Fraser's (2008) adaptation of Morgan-Jinks Student Efficacy Scale (MJSES), was included to measure students' self-concept as it relates to their mathematics ability. The questionnaire was translated into Chinese to accommodate the language needs of students in Hong Kong. Another purpose of this study was to investigate associations between students' perceptions of mathematics classroom learning environment and the student outcomes of attitudes towards mathematics and academic efficacy.

Principal axis factoring with varimax rotation and Kaiser normalization revealed that the majority of items belonged to their *a priori* scale and no other scale (with 52 out of the 56 items having a factor loading above 0.40 on their own scale only) and eigenvalues were above unity. The scales of the WIHIC, TOMRA and MJSES were all found to exhibit strong internal consistency reliability and a reasonable level of independence among raw scale scores, with the factor analysis attesting to the independence of factor scores. The percentage of variance for the USA ranged from 4.81% to 33.59% for WIHIC scales, with a total of 56.06%. For Hong Kong, the percentage of variance for WIHIC scales ranged from 4.87% to 40.25%, with a total of 60.52%. The percentage of variance for TOMRA and MJSES scales for the USA ranged from 10.71% to 38.47%, with a total of 60.35%. For Hong Kong, the percentage of variance ranged from 6.08% to 46.49%, with a total of 66.27%.

Differences between students in the USA and Hong Kong in terms of their perceptions of the learning environment, attitudes towards mathematics, and academic efficacy were investigated using both inferential statistics and effect sizes. A comparison of the two countries revealed interesting anomalies in that USA students consistently perceived their classroom environments more favorably than did students in Hong Kong on all scales, but Hong Kong students expressed more enjoyment of their mathematics classes than did students in the USA. Using MANOVAs, a statistically significant differences between students in the USA and students in Hong Kong were identified for all learning environment, attitudes towards mathematics and academic efficacy scales, except the Involvement scale. The effect size for between-country differences for each learning environment, attitude and academic efficacy scale was over one third of a standard deviation, ranging from –0.38 standard deviations (Enjoyment) to 1.13 standard deviations (Equity), indicating a medium to large difference between countries.

Simple correlation and multiple regression analyses were performed to identify possible associations between students' perceptions of mathematics classroom learning environment and the student outcomes of attitudes towards mathematics and academic efficacy. Statistically significant and positive associations association emerged between learning environment and students' attitudes towards mathematics/academic self-efficacy.

This study's distinctive contribution is that it is the first learning environment study in Hong Kong, as well as the first cross-national study of learning environments involving the USA and Hong Kong. It is also one of the few cross-national studies involving validation of a questionnaire assessing learning environment, attitudes to mathematics inquiry and academic efficacy, comparing countries in terms of classroom learning environments, and investigating associations between classroom learning environment, students' attitudes and academic efficacy. This cross-cultural comparative study has the potential to provide a better understanding about educational systems as seen by the students within the culture, generating new insights for teachers and educators, broadening their perspective on teaching and learning and, hopefully, initiating collaboration across countries in an attempt to advance the efforts and accomplishments of educators worldwide.

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Chapter 1

INTRODUCTION AND OVERVIEW

1.1 Introduction

Internationally, USA students consistently lag behind their international counterparts, such as Korea, Chinese Taipei, Korea, Singapore, Hong Kong, and Japan, in mathematics and science achievement (Mullis, Martin, & Foy, 2008). The Trends in International Mathematics and Science Study (TIMSS) (2012) indicated that achievement in mathematics was relatively higher in many Asian countries, where large class sizes and teacher-centered learning environments prevail. The TIMSS 2011 also revealed that Hong Kong, the Asian country that was chosen in the present study, had higher average mathematics achievement than all 56 countries at the fourth grade level and also was the fourth top-performing country among 56 countries at the eighth grade level.

In the light of stagnant mathematics performance, waves of reforms have become a predominant issue facing public schools in the United States since the late 1980s. Although research in mathematics education in high-performing countries has been conducted for over decade (National Governors Association Center for Best Practices & Council of Chief State School Officers, 2010), the main focus was only on achievement and curriculum design. There are relatively few cross-national studies that have been conducted into mathematics classroom learning environment and affective learning outcomes, such attitudes, enjoyment, anxiety and self-efficacy.

This chapter provides an introduction and overview for the thesis under four sections. Section 1.2 – Background and Context of the Study – describes the educational challenges (Section 1.2.1), the field of learning environments (Section 1.2.2), and the locations where research was conducted (Section 1.2.3). Section 1.3 – Purpose and Research Questions for the Study – states the purpose and the three research questions for the present study. The significance of the study is outlined in Section 1.4, and an overview of the thesis is provided in Section 1.5.

1.2 Background and Context of the Study

This section provides background information relevant to the present study, including an introduction to current educational challenges (Section 1.2.1), a brief description of the field of learning environments (Section 1.2.2), and the locations where research was conducted (Section 1.2.3).

1.2.1 Educational Challenges

The challenges facing education today are more varied than in the past. They encompasses the rapidly-increasing diversity of the population, the growing internationalization of commerce and culture, the explosive development of information technologies, and other major technical and social transformations. There is no simple, universal prescription for success (National Academy of Sciences, 1997), but reform in mathematics education, coupled with recognizing the need for versatility in the face of cultural change, are imperative. Successful educational reform is dependent on professional understanding, consent, and advocacy. Professional practice and belief systems must be aligned with our new generation. As Stigler and Heibert (1999) have pointed out, reforms without cultural change tend to be superficial and ineffective. Cultural change is necessary, but this comes gradually, over time, as beliefs and attitudes change. Cultural change has to come from the bottom up, not from the top down. It has to come from students themselves and from the classrooms where the business of learning takes place.

Therefore, students' reactions to and perceptions of their educational experience are important. Students are in a good position to make judgments about classrooms because they have experienced many different learning environments and have had enough time in the class to form accurate opinions (Fraser, 2012). However, despite the obvious importance of classroom learning environment, educators and researchers have relied heavily and sometimes exclusively on the assessment of academic achievement and other learning outcomes. Although no one would dispute the worth of achievement, the influence of classroom learning environment should not be ignored. My study drew on the field of learning environments, with students' perceptions of their classroom learning environments, attitudes towards the subject, and academic efficacy forming the foundation of this study.

1.2.2 Field of Learning Environments

Education consists not just of curriculum content and outcomes, but also involves cultivating moral, emotional, physical, psychological and spiritual dimensions of the developing child. Education typically takes place in classrooms. Besides the physical space and organization of a classroom, another valuable goal of education is to have a positive learning environment, which involves the intangible aspects of a classroom, such as climate, culture, ambience, and social or emotional atmosphere that give students a particular feel of their classroom. "It is the quality of life lived in classrooms that determines many of the things that we hope for from education — concern for community, concern for others, commitment to the task in hand" (Fraser, 2001, p. 2). In fact, a considerable number of studies of learning environments have been undertaken and provide compelling evidence that the classroom learning environment has a strong influence on student outcomes, including achievement to which so much interest is directed (Fraser, 2001, 2012). Although classroom learning environment is a subtle concept, remarkable progress has been made during the past 40 years in its conceptualisation, assessment and investigation with diversified and international populations. A considerable amount of work has been undertaken in many countries on developing methods for investigating how teachers and students perceive the environments in which they work and learn. More details about the field of learning environments, such as its historical background and the development of learning environment instruments is presented in Chapter 2.

1.2.3 Locations where Research Was Conducted

The present study was conducted in the two distinct areas of Clovis, California and Hong Kong. This section provides background information relevant to these two areas, including an overview of City of Clovis, California (Section 1.2.3.1), an overview of Clovis Unified School District (Section 1.2.3.2), and Hong Kong and its education system (Section 1.2.3.3).

1.2.3.1 Overview of City of Clovis, California

The present study was conducted in Clovis which is a suburban city in Fresno County, California, United States, with a population of 99,983 encompassing over 23 square miles in area. The city of Clovis is located midway between Los Angeles and San Francisco, northeast of Fresno, in the agriculturally rich San Joaquin Valley. Lying at the foot of the Sierra Nevada Mountain Range, which includes Yosemite, Kings Canyon, and Sequoia National Parks, Clovis has been known as 'Gateway to the Sierras' since its incorporation in 1912. Figure 1.1 shows historic center of Clovis, namely, Old Town Clovis. According to 2010 United States Census, Clovis had a population of 95,631, which included White Non-Hispanic (70.9%), Hispanic or Latino (25.6%), Asian (10.7%), African-American (2.7%), other ethnicities (3.8%) (U. S. Census Bureau, 2010).

Clovis' rich history started with its inception as a small Western town and the pioneer family of Stephen H. Cole who homesteaded 320 acres of government land. His son, Clovis M. Cole, recognized that the vast grazing land would adapt to dry grain farming. Eventually, the young Cole began farming wheat on 50,000 acres from Centerville to Madera County and was touted by the press as the 'Wheat King of the United States'. Another earlier settler, Marcus Pollasky, proposed and coordinated the construction of a railroad through the grain, cattle, and mining country and into the timber-rich forests of the nearby Sierra. The City eventually grew up around the San Joaquin Division of the Southern Pacific Railroad, which played an important role in the founding and growth of Clovis. In addition to the arrival of the 'Iron Horse', completing the 42 mile-long Shaver log flume, developing the 40-acre Clovis mill and finishing plant, expanding grain production, and raising livestock all combined to ensure the founding of Clovis in 1891.

Figure 1.1 Old Town Clovis

Over the course of the next 100 years, Clovis continued to grow. Many credit this success to the visionary Clovis Unified School District, while others point to forward-thinking local civic leaders. Nowadays, Clovis's economic base consists of retail sales and services and light manufacturing. Availability of housing, high-quality hospital care, excellent schools with modern facilities, responsive safety services, a mild climate, access to varied recreational opportunities, and strong community identity all contribute to Clovis' reputation as a fine place to live. The median income for a household in the city was $65,300, and the median income for a family was $76,331. The per capita income for the city was $27,749. About 7.6% of families and 10.4% of the population were below the poverty line, including 12.1% of those under age 18 years and 9.4% of those age 65 years or over (U. S. Census Bureau, 2010).

1.2.3.2 Overview of Clovis Unified School District

Founded in 1959, Clovis Unified School District, the school district in which this study was conducted, is currently one of largest districts in California covering about 198 square miles, including the cities of Clovis and Fresno, the community of Friant, and some of Fresno County, California.

As of August 2013, the school district is divided into five areas with a total enrollment of 39,435 students attending 49 schools (32 elementary schools, five intermediate schools, five high schools, one adult school and six alternative education campuses). The ethnic make-up of the school district is: 45.3% White Non-Hispanic; 32.6% Hispanic or Latin; 12.8% Asian; 3.3% African American; 3.2% Multiple or No response; 2.8% Other ethnicities.

Clovis Unified schools have been named 31 times by the National Blue Ribbon Schools Program and honored 100 times as California Distinguished Schools. The District's Title I schools have also achieved distinction through the California Academic Achievement Award designation on 25 different occasions. Clovis Unified is the only school district in the nation to have all five of its intermediate schools designated as Taking Center Stage ─ Schools to Watch. Figure 1.2 shows the campus of one of the Clovis high schools, namely, Clovis East High School.

Figure 1.2 Clovis East High School

1.2.3.3 Overview of Hong Kong and its Education System

The present study was also conducted in another city where world-class business, recreational, educational, and cultural buildings and structures converge in a diverse and welcoming environment for visitors around the world. Hong Kong is an cosmopolitan city located at the mouth of the Pearl River Delta on the southeast coast of China. It is one of the most densely populated cities in the world, with a population of over seven million people in 426 square miles of hilly terrain. Its territory consists of Hong Kong Island, the Kowloon Peninsula, and the New Territories. The lack of space caused demand for denser constructions, which developed the city to a centre for modern architecture and the world's most vertical city. Figure 1.3 and 1.4 shows spectacular skylines of Hong Kong with Victoria Harbour situated between Hong Kong Island and the Kowloon Peninsula and the night view of Victoria Harbor. As one of the world's leading international financial centers, Hong Kong has one of the highest per capita incomes in the world. The dense space also led to a highly developed transportation network with the public transport travelling rate exceeding 90%, the highest in the world. Hong Kong has numerous high international rankings in various aspects. For instance, its economic freedom, financial and economic competitiveness, quality of life, corruption perception, and Human Development Index are all ranked highly. According to estimates from both United Nations and World Health Organization, Hong Kong had the longest life expectancy of any region in the world in 2012. Hong Kong also has the highest average IQ score of 81 countries around the world.

Hong Kong mainly consists of ethnic Chinese, making up more than 93.6% of the population, and Filipino and Indonesian foreign domestic helpers are the ethnic minorities who account for 4% of the entire population. Cantonese and English are both official languages of Hong Kong.

Because Hong Kong was a colony of the British Empire for 156 years, the education system of Hong Kong is largely modelled on that of the United Kingdom, particularly the English system. After the transfer of sovereignty from United Kingdom to China occurred in 1997, the government of Hong Kong maintained a policy of 'mother tongue instruction' in which the medium of instruction is Cantonese, with written Chinese and English. In secondary schools, 'biliterate and trilingual' proficiency is emphasized, and Mandarin-language education has been increasing. This means that both Chinese and English are acknowledged as official languages, with Cantonese being acknowledged as the *de facto* official spoken variety of Chinese in Hong Kong, while also accepting Mandarin.

Figure 1.3 Skylines of Hong Kong with Victoria Harbour Situated between Hong Kong Island and the Kowloon Peninsula

Figure 1.4 Victoria Harbour Night View

Hong Kong's education system features a non-compulsory three-year kindergarten, followed by a compulsory six-year primary education, a compulsory three-year junior secondary education, a non-compulsory two-year senior secondary education that leads to the Hong Kong Certificate of Education Examinations, and a two-year matriculation course leading to the Hong Kong Advanced Level Examinations. To make it easier and more likely that the majority of students receive 12 years of education, more in line with the education system in China and the USA, the New Senior Secondary academic structure and curriculum was implemented in September 2009 to provide all students with three years of compulsory junior and three years of compulsory senior secondary education. Under the new curriculum, there is only one public examination, namely, the Hong Kong Diploma of Secondary Education. Figure 1.5 shows the exterior of a typical school in Hong Kong and Figure 1.6 shows a snapshot of Hong Kong classroom. In Hong Kong, the classroom is characterised by its large size (overall average class size of 35) and low teacher-student ratio, as well as being dominated by the teacher (TIMSS, 2012). The need to prepare for important examinations fosters an environment of extreme pressure to succeed and promotes the use of direct-instruction teaching practices and rote learning. Teachers demonstrate mathematics problems and use worksheets to reinforce mathematics concepts. Students are able to recognize and recall information by memorizing facts and using drill-and-practice techniques to enhance procedural mathematics understanding. Hong Kong students also spend a considerable amount of time on mathematics tutoring and 'cram schools' to prepare for examinations (Mullis, Martin, & Foy, 2008).

Figure 1.5 Exterior View of School in Hong Kong

Figure 1.6 A Snapshot of Hong Kong Classroom

1.3 Purpose and Research Questions for the Study

The purpose of the present cross-national study was to compare mathematics classes in Hong Kong and the USA in terms of classroom learning environment, attitudes toward mathematics, and academic efficacy. Because results from the TIMSS indicate that student achievement in mathematics is higher in Hong Kong, where class sizes are larger and classroom learning environments are teacher-centered compared with the USA, I was interested in finding out how students in Hong Kong perceive their mathematics classroom learning environments relative to students in the USA. In addition to analysing and comparing students' perceptions of the learning environment, I also investigated and compared the two countries in terms of students' attitudes towards mathematics and their academic efficacy. To accomplish this, I validated a modified questionnaire for use in mathematics classes in the USA and Hong Kong and then compared countries in terms of students' perceptions of the learning environment, their attitudes toward mathematics, and academic efficacy.

Additionally, I explored associations between students' perceptions of mathematics classroom learning environment and the student outcomes of attitudes towards mathematics and academic efficacy. In past studies, learning environments have been linked to improved students' attitudes toward mathematics and self-efficacy beliefs regarding academic competence (Chionh & Fraser, 2009; Goh & Fraser, 1998; Lorsbach & Jinks, 1999).

The present study of mathematics classes in Hong Kong and the USA focused on classroom learning environments, attitudes toward mathematics, and academic efficacy and was guided by three research questions:

1. Is it possible to develop valid and reliable measures of mathematics students' perceptions of classroom learning environments, attitudes toward mathematics, and academic efficacy in the USA and Hong Kong?

2. Are there differences between students in the USA and Hong Kong in terms of perceptions of the learning environment, attitudes towards mathematics, and academic efficacy?

3. Are there associations between students’ perceptions of their mathematics classroom learning environment and two types of student outcomes (attitudes and academic efficacy related to mathematics)?

1.4 Significance of the Study

The most educationally significant aspect of the present study is its cross-national character. It is one of the few cross-national studies that have involved either the validation of a questionnaire assessing learning environment, attitudes to mathematics and academic efficacy, or the investigation of associations between classroom learning environment and student attitudinal outcomes.

In addition, the present two-country study in the USA and Hong Kong is one of the first cross-national studies of learning environments involving the USA and any Asian country. Although research has been conducted in the learning environments field for over 40 years (Fraser, 2012), only relatively few past studies in mathematics have explored associations between classroom learning environment and student attitudes and academic efficacy.

Another significant contribution made by the present study was through translating and validating a widely-applicable questionnaire, the What Is Happening In this Class? (WIHIC), to assess students' perceptions of the learning environment for future use by researchers and teachers in Hong Kong.

Lastly, findings from this study could have practical implications for educators in both countries. This cross-national study is likely to provide new insights for teachers and educators, broaden their pedagogical perspectives and strengthen their sensitivity to distinctive features, not only of classroom environments and educational system in other countries, but also of the classroom environments and educational system of our own countries. Such cross-national studies provide greater variation in variables of interest, such as teaching practices and students' attitudes, and hence have the potential to provide a better understanding of the relative influence of a number of important variables in the teaching and learning processes.

This is likely to promote collaboration across countries in advancing the efforts and accomplishments of educators worldwide (Ferguson & Meyer, 1998).

1.5 Overview of the Thesis

This thesis is comprised of five chapters. Chapter 1, entitled Introduction and Overview, outlines the background, purposes and rationale for the present study. Furthermore, the research questions and the significance of the study are delineated, as well as an overview of the thesis being provided.

Chapter 2, entitled Review of the Literature, comprehensively reviews literature on learning environment, attitudes toward mathematics, and academic efficacy. There are five major sections in Chapter 2. The first section defines the term 'learning environment' and provides an overview of the history of the field of classroom learning environments. The second section is devoted to 12 important learning environment instruments that have been designed and validated over the past 40 years, and reviews noteworthy studies associated with each instrument. Because the What Is Happening In this Class? (WIHIC) questionnaire was the primary research instrument used in the present study, past research utilizing the WIHIC is provided in considerable detail in this section as well. The third section discusses the use of learning environment scales in the evaluation of educational innovations.

The present study also examined associations between students' perceptions of mathematics classroom learning environments and two types of student outcomes, namely, attitudes to mathematics and academic efficacy related to mathematical tasks. In order to investigate this question, two scales (with eight items each) from the Test of Mathematics-Related Attitudes (TOMRA) and an academic efficacy scale were used. The next section of Chapter 2 reviews past studies involving associations between the learning environment and students' cognitive and affective learning outcomes. The last major section reviews the development and validation of TOMRA, which is a modified version of the Test of Science-Related Attitudes (TOSRA) created by Fraser (1978, 1981) to measure seven science-related attitudes among secondary school students. Also, this section defines the term 'academic efficacy' and reviews past research involving associations between the learning environment and academic efficacy.

Chapter 3, entitled Research Methodology, contains four major sections. The first section discusses the instruments chosen, along with their modification, the second section describes the sample for this study, and the third section explains the procedures of data collection. A fourth major section presents the methods of the data analysis. Chapter 3 concludes by discussing some limitations associated with the methods used in this study.

Chapter 4, entitled Analyses and Results, describes the data analyses and reports the findings from statistical tests relevant to: the validity and reliability of the learning environment, attitudes towards mathematics and academic efficacy scales; differences between USA and Hong Kong in learning environments, attitudes towards mathematics and academic efficacy; and associations between the learning environment and attitudes towards mathematics and academic efficacy.

Chapter 5, entitled Discussion and Conclusion, provides a summary of the thesis. A discussion of the major findings, distinctive contributions, significance and implications of this study are presented, as well as some of its constraints and limitations. Recommendations for future study and an overall chapter summary/concluding remarks are provided at the end of this chapter.

Chapter 2

REVIEW OF THE LITERATURE

2.1 Introduction

The purpose of the present cross-national study was to compare mathematics classes in Hong Kong and the USA in terms of classroom learning environment, attitudes toward mathematics, and academic efficacy. This chapter reviews literature related to all of these three areas under seven sections. Section 2.2 – Historical Background of Classroom Learning Environments – defines the term 'learning environment' and provides an overview of the history and development of research on classroom learning environments. Section 2.3 – Development of Learning Environment Instruments – describes 12 noteworthy questionnaires that have been designed and validated over the past 40 years. Because the What Is Happening In this Class? (WIHIC) questionnaire was the primary research instrument in the present study, considerable detail on past research utilizing the WIHIC is provided in this section as well. Section 2.4 – Use of Learning Environment Scales in Evaluation of Educational Innovations – describes past studies using learning environment instruments to evaluate educational innovations.

The present study also examined whether associations exist between students' perceptions of mathematics classroom learning environment and two types of student outcomes, namely, attitudes to mathematics and academic efficacy related to mathematical tasks. In order to investigate this question, two scales (eight items each) from the Test of Mathematics-Related Attitudes (TOMRA) and an academic efficacy scale were used. Section 2.5 – Associations between Learning Environments and Student Outcomes – reviews past studies involving associations between the learning environment and students' cognitive and affective learning outcomes. Section 2.6 – Attitudes towards Mathematics and Academic Efficacy – reviews literature on attitudes and the development and validation of TOMRA, which is a modified version of the Test of Science-Related Attitudes (TOSRA) created by Fraser (1978, 1981) to measure seven science-related attitudes among secondary school students. Also, this section defines the term ‘academic efficacy’ and reviews past research involving associations between the learning environment and academic efficacy. Finally, Section 2.7 provides a summary of this chapter.

Through a review of the literature, a clearer understanding of the areas involved in this research, as well as potential areas for further research, can be obtained. This review also provides a better understanding of the associations between students’ perceptions of mathematics classroom learning environment and two types of student outcomes: attitudes towards mathematics and academic efficacy.

2.2 Historical Background of Classroom Learning Environments

According to Fraser (1998a), "learning environment refers to the social, psychological and pedagogical contexts in which learning occurs" (p. 3). Besides of the physical space and organization of a classroom, the learning environment describes the intangible aspects of a classroom, such as climate, culture, ambience, and social or emotional atmosphere, that give students a particular feel of their classroom. The learning environment also encompasses out-of-school settings, such as the home, museums, field trips, and television. As technologies advance, new information technology (IT) learning environments or e-learning environments, including multimedia, internet and World Wide Web instructional settings, have evolved and contributed considerably to educational progress (Anonymous, 2007). Meanwhile, a considerable number of studies of learning environments have been undertaken and provide compelling evidence that the classroom learning environment has a strong influence on student outcomes including achievement (Fraser, 2001, 2012).

The history of learning environments research has its roots in the social sciences. Lewin and Murray were the pioneer psychologists who investigated the effect of psychosocial environments. Lewin (1936) emphasized that “both the environment and its interaction with personal characteristics of the individual are potent determinants of human behavior" (p. 103). He represented his ideas through his well-known formula, $B=f(P, E)$, in which Behavior (B) is a function of both the Person (P) and the Environment (E). He also distinguished between *alpha press*, which involves the environmental forces that are assessed by a detached observer, and *beta press,* which involves the environmental forces that are perceived by an outside observer (Fraser, Fisher, & McRobbie, 1996). Murray (1938) applied Lewin's ideas of alpha and beta press to his 'needs-press model' in which *press* (environmental forces) interacts with the characteristics of personality (needs).

Stern, Stein, and Bloom (1956) expanded Murray's notion of *beta press* into *private beta press*, the perceptions of a specific individual in an environment, and *consensual beta press,* perceptions of the collective group as a whole. These classifications of perceptions led to analysis of data from a variety of viewpoints and levels of statistical analysis, including the whole class or the individual student.

Building upon the ideas of Lewin and Murray, research on learning environments in education began with the work of Herbert Walberg and Rudolf Moos on perceptions of classroom environment in the late 1960s and early 1970s in the United States (Fraser, 2007). The first learning environment questionnaire for use in educational settings, called the Learning Environment Inventory (LEI), was developed by Walberg and Anderson (1968) to assess students' perceptions of their learning environment during an evaluation of Harvard Project Physics. At about the same time, working with Trickett at Stanford University, Moos began studying social climate scales in a variety of human environments, including psychiatric hospitals (Houts & Moos, 1969), correctional institutes (Moos & Houts, 1968), university residences (Gerst & Moos, 1972) and work sites (Moos, 1974).

Moos developed a scheme to classify any human environment into three dimensions. *Relationship dimensions* are those relating to the nature and intensity of personal relationships. *Personal development dimensions* refer to the path through which knowledge development progresses. *System maintenance and system change dimensions* refer the orderliness, clarity, control and responsiveness to change in the environment (Moos & Trickett, 1974). This work ultimately led to the development of the Classroom Environment Scale (CES, Moos, 1979; Moos & Trickett, 1974, 1987), which further allowed researchers to study the specific learning environment related to schools. Moos and Trickett exerted a profound influence on the development of major learning environment instruments.

Following the early pioneering research of Walberg and Moos in the USA, the focus of learning environments research shifted to the South Pacific. In Australia, under the lead of Fraser, learning environments research became firmly established in the early 1980 and continued to develop to the present day. Fraser and his colleagues initiated programmatic research with the My Class Inventory (MCI; Fisher & Fraser, 1981) and the Individualised Classroom Environment Questionnaire (ICEQ; Fraser, 1990; Fraser & Butts, 1982), which was the first learning environment instrument to focus on student-centered classrooms and to assess those dimensions that are salient in open or individualised classroom settings. Subsequently, Fraser (2012) was involved in developing other specific-purpose classroom environment instruments in Australia and cross-validating and applying them for a variety of research purposes internationally. These widely-used questionnaires include the Science Laboratory Environment Inventory (SLEI), Constructivist Learning Environment Survey (CLES) and What Is Happening In this Class? (WIHIC), which are discussed in detail later in this chapter.

In the Netherlands, Wubbels and his colleagues began other programmatic research focusing on the interactions between teachers and students in the classroom and often involving use of the Questionnaire on Teacher Interaction (QTI; Wubbels, 1993). Subsequently, research on teacher–student interpersonal behavior spread to many countries and the QTI was cross-validated at different grade levels in the USA (Wubbels & Levy, 1993), Australia (Fisher, Henderson, & Fraser, 1995), Korea (Kim, Fisher, & Fraser, 2000; Lee, Fraser, & Fisher, 2003), Singapore (Goh & Fraser, 1996; Quek, Wong, & Fraser, 2005), Brunei Darussalam (Khine & Fisher, 2002; Scott & Fisher, 2004), and Indonesia (Fraser, Aldridge, & Soerjaningsih, 2010).

Fraser (1998c, 2002) notes that the field of learning environment has undergone remarkable growth in the conceptualisation, assessment and investigation of diversified and internationalized populations during the past 40 years. Since the establishment of the American Educational Research Association (AERA) Special Interest Group (SIG) on the Study of Learning Environments in 1984, the high level of recognition of the field of learning environments is evident in major publications: one of 10 sections in Kluwer's *International Handbook of Science Education* (Fraser

& Tobin, 1998); one of 19 chapters in Gabel's *Handbook of Research on Science Teaching and Learning* (Fraser, 1994); a section in Anderson's *International Encyclopedia of Teaching and Teacher Education*; the birth of *Learning Environments Research: An International Journal* (Fraser, 1998b), a book series entitled Advances in Learning Environments Research (Aldridge & Fraser, 2008); and numerous literature reviews focusing on learning environments including chapters in the *Handbook of Research on Science Education* (Fraser, 2007) and, most recently, the *Second International Handbook of Science Education* (Fraser, 2012).

2.3 Development of Learning Environment Instruments

This section describes significant learning environment instruments and provides information about their development. Table 2.1 summarizes various learning environment instruments and shows the name of each scale in each instrument, the level (primary, secondary, higher education) for which each instrument is suited, the year developed and the author(s), the number of items contained in each scale, and the classification of each scale according to Moos' (1974) scheme for classifying human environments. Section 2.3.1 focuses on a review of literature about the Learning Environment Inventory (LEI), and this is followed by Section 2.3.2 and Section 2.3.3, which provides a description of the background and development of the Classroom Environment Scale (CES) and My Class Inventory (MCI), respectively. After reviewing three these early and historically-important classroom learning environment instruments that are 'teacher-centered', a review of literature is provided for more recent instruments that are designed with 'student-centered' classrooms in mind namely, the Individualised Classroom Environment Questionnaire (ICEQ) (Section 2.3.4), the College and University Classroom Environment Inventory (CUCEI) (Section 2.3.5), the Questionnaire on Teacher Interaction (QTI) (Section 2.3.6), and the Constructivist Learning Environment Survey (CLES) (Section 2.3.7). Section 2.3.8 is a review of literature about the Science Laboratory Environment Inventory (SLEI). Section 2.3.9 describes learning environment questionnaires that pertain to technology-based classrooms. The most widely-used classroom learning environment instrument, the What Is Happening In this Class? (WIHIC), is reviewed in Section 2.3.10 in greater detail than the previously-mentioned nine instruments because it was chosen for use in the present study.

2.3.1 Learning Environment Inventory (LEI)

As mentioned in Section 2.2, the Learning Environment Inventory (LEI), one of the first learning environment questionnaires developed, was used by Walberg and Anderson in the late 1960s in association with the assessment and research related to Harvard Project Physic program (Walberg & Anderson, 1968). The final version of the LEI consists of 105 items in the 15 scales of Cohesiveness, Friction, Favoritism, Cliqueness, Satisfaction, Apathy, Speed, Difficulty, Competitiveness, Diversity, Formality, Material Environment, Goal Direction, and Disorganization (seven items per scale). The responses, in terms of degree of agreement or disagreement with each statement on a four-point Likert scale, are Strongly Disagree, Disagree, Agree, and Strongly Agree. The scoring direction is reversed for some items (Fraser, Anderson, & Walberg, 1982). A sample item from the Speed scale is: "The pace of the class is rushed."

The LEI was subsequently used in many studies in which classroom learning environment dimensions served as dependent variables or independent variables, such as the gender of the science teacher (Lawrenz & Welch, 1983), teacher personality (Walberg, 1968), class size (Anderson & Walberg, 1972), and new curricular initiatives (Fraser, 1979). The LEI was also used in studies of associations between classroom learning environment and student outcomes, such as academic achievement (Cort, 1979; O'Reilly, 1975), attitudes (Cort 1979; Haladyna, & Shaughnessy, 1981), and understanding of the nature of science, and science process skills (Fraser, 1979). Moreover, the LEI has been translated into various languages (Hindi, Thai and Indonesia) and cross-validated at different grade levels and subject areas in the USA and Canada (Anderson & Walberg, 1972; Walberg & Anderson, 1968), Israel (Hofstein, Gluzman, Ben-Zvi, & Samuel, 1979), India (Walberg, Singh, & Rasher, 1977), and Brazil (Holsinger, 1973).

Table 2.1 Overview of Scales Contained in 12 Classroom Environment Instruments

Instrument	Level	Year Developed & Author(s)	Items per Scale	Scales Classified According to Moos' Scheme: Relationship Dimensions	Personal Development Dimensions	System Maintenance and Change Dimensions
Learning Environment Inventory (LEI)	Secondary	1968 Walberg & Anderson	7	Cohesiveness Friction Favoritism Cliqueness Satisfaction Apathy	Speed Difficulty Competitiveness	Diversity Formality Material Environment Goal Direction Disorganisations Democracy
Classroom Environment Scale (CES)	Secondary	1974 Moos & Trickett	10	Involvement Affiliation Teacher Support	Task Orientation Competition	Order and Organisation Rule Clarity Teacher Control Innovation
Individualised Classroom Environment Questionnaire (ICEQ)	Secondary	1979 Rentoul & Fraser	10	Personalisation Participation	Independence Investigation	Differentiation
My Class Inventory (MCI)	Elementary	1982 Fraser, Anderson & Walberg	6–9	Cohesiveness Friction Satisfaction	Difficulty Competitiveness	
College and University Classroom Environment Inventory (CUCEI)	Higher Education	1986 Fraser & Treagust	10	Personalisation Involvement Student Cohesiveness Satisfaction	Task Orientation	Innovation Individualisation
Questionnaire on Teacher Interaction (QTI)	Secondary/ Primary	1990 Creton, Hermans, & Wubbels	8–10	Leadership Helpful/Friendly Understanding Student Responsibility and Freedom Uncertain Dissatisfied Admonishing Strict		
Science Laboratory Environment Inventory (SLEI)	Upper Secondary/ Higher Education	1995 Fraser, Giddings & McRobbie	7	Student Cohesiveness	Open-Endedness Integration	Rule Clarity Material Environment
Constructivist Learning Environment Survey (CLES)	Secondary	1997 Taylor, Fraser & Fisher	7	Personal Relevance Uncertainty	Critical Voice Shared Control	Student Negotiation
What Is Happening In this Class? (WIHIC)	Secondary	1996 Fraser, Fisher & McRobbie	8	Student Cohesiveness Teacher Support Involvement	Investigation Task Orientation Cooperation	Equity
Computer Laboratory Environment Inventory (CLEI)	Secondary	1997 Newby & Fisher	5	Student Cohesiveness	Open-Endedness Integration	Rule Clarity Material Environment
Web-Based Learning Environment Instrument (WEBLEI)	Higher Education	2003 Chang & Fisher	4	Access Response	Interaction	Results
Technology-Rich Outcomes-Focused Learning Environment Inventory (TROFLEI)	Secondary	2008 Aldridge & Fraser	10	Student Cohesiveness Teacher Support Involvement Young Adult Ethos	Task Orientation Investigation Cooperation Differentiation	Equity Computer Usage

Adapted from Fraser (1998b, 2012)

2.3.2 Classroom Environment Scale (CES)

The Classroom Environment Scale (CES, Moos, 1974; Moos & Trickett, 1974, 1987) evolved from an extensive research program involving assessing psychosocial environments in a wide variety of settings, as mentioned in Section 2.2. Based on Moos' scheme for classifying psychosocial environments into three dimensions (relationship, personal development, and system maintenance and system change), Trickett and Moos developed the original version of the CES which consisted of 242 items representing 13 conceptual dimensions and trialled it in 26 high school classrooms. Then, the number of items was reduced to 208 and administered in 38 high school classrooms. The final version of the CES consists of nine scales (Involvement, Affiliation, Teacher Support, Task Orientation, Competition, Order and Organization, Rule Clarity, Teacher Control, and Innovation) with 10 items of True–False response format in each scale. A sample item from the Innovation scale is: "New ideas are always being tried out here." The CES was used as a source of predictor and criterion variables in studies comparing students' actual versus preferred perceptions, and students' actual versus teachers' actual perceptions (Fisher & Fraser, 1983a). The CES was also used to investigate associations between classroom learning environment and student outcomes, such as student satisfaction and moods (Trickett & Moos, 1974), student absences and grades (Moos & Moos, 1978), academic achievement, attitudes (Fraser & Fisher, 1982b) and inquiry skills (Fisher & Fraser, 1983a; Fraser & Fisher, 1982b).

2.3.3 My Class Inventory (MCI)

The My Class Inventory (MCI) was developed as a simplified form of the LEI for use with students aged 8–12 years or students experiencing reading difficulties (Fraser, Anderson, & Walberg, 1982). The MCI contains only five of the LEI's original 15 scales: Cohesiveness, Friction, Difficulty, Satisfaction, and Competitiveness. The LEI's four-point Likert response format was reduced to a two-point (Yes or No) response format (Fraser, Anderson, & Walberg, 1982) in the MCI. Fisher and Fraser (1981) validated and modified the MCI with 2,305 seventh-grade students in 100 classrooms in 30 schools throughout Tasmania, Australia. The reduced 38-item version of the MCI (six for Cohesiveness, eight for Friction, eight for Difficulty, nine for Satisfaction, and seven for Competitiveness) was used to explore associations between students' perceptions of the learning environment and their outcomes of inquiry skills, understanding of the nature of science, and attitudes (Fraser & Fisher, 1982a, 1982b, 1982c). A sample item from the Satisfaction scale is: "Children seem to like the class." The results revealed that the modified MCI scales displayed satisfactory internal consistency, discriminant validity, and predictive validity.

The MCI was validated at different grade levels in numerous countries. In Sydney, Australia, Fraser and O'Brien (1985) used the actual and preferred forms of the MCI with a sample of 758 third-grade students. They validated both actual and preferred forms of the MCI for measuring classroom psychosocial environment in elementary schools. This article also reported use of the MCI in three promising lines of research, namely, associations between classroom environment and student achievement, differences between students and teachers in their perceptions of actual and preferred classroom environments, and practical attempts to improve classroom environments.

In Singapore, Goh, Young, and Fraser (1995) modified the MCI's original Yes−No response format to a three-point response format (Seldom, Sometimes and Most of the Time) and included a Task Orientation scale in their research. Goh et al. found the modified MCI to be valid and useful in research applications with 1,512 fifth-grade mathematics students in 39 classes.

In Brunei Darussalam, Majeed, Fraser, and Aldridge (2002) used a modified MCI to assess classroom learning environment in mathematics classes and to investigate associations between classroom learning environment and student satisfaction with a sample of 1,565 lower-secondary students. The study is noteworthy because the factorial validity of the MCI had not previously been established in earlier research in other countries. The study revealed a satisfactory factor structure for a refined three-scale version of the MCI assessing Cohesiveness, Difficulty, and Competitiveness (the Satisfaction scale was used as an attitudinal outcome variable). The study also revealed that students generally perceived a positive learning environment in mathematics classes, that boys and girls held different perceptions of the same classroom learning environment (with boys perceiving their classroom learning environments more favorably than girls), and that statistically significant associations existed between student satisfaction and the classroom learning environment both at the student and class levels of analysis for most MCI scales.

In Texas, Scott Houston, Fraser and Ledbetter (2008) used the MCI and qualitative methods to evaluate the effectiveness of science instruction using a textbook, science kits, or a combination of both with a sample of 588 third to fifth-grade students. The study attested the factorial validity and reliability of the MCI and suggested that using science kits was associated with a more positive learning environment in terms of student Satisfaction and Cohesiveness (Scott Houston, Fraser, & Ledbetter, 2008).

Working with a sample of 120 fifth-grade students in Florida, Mink and Fraser (2005) used the MCI to evaluate the impact of a teacher inservice program entitled Project SMILE (Science and Mathematics Integrated with Literary Experiences). The MCI exhibited satisfactory internal consistency reliability and discriminant validity, and the implementation of SMILE had a positive impact on the learning environment and attitudes, especially in terms of student Satisfaction and Cohesiveness.

2.3.4 Individualised Classroom Environment Questionnaire (ICEQ)

The Individualised Classroom Environment Questionnaire (ICEQ) was the first instrument that was 'student-centered' and that assessed those dimensions which distinguish individualised and inquiry-based classrooms from conventional ones (Fraser, 1990). The ICEQ was developed and validated by Rentoul and Fraser (1979) through an extensive literature analysis and interviewing of teachers and 225 secondary students in 15 classes in Sydney, Australia. The final version of the ICEQ consists of 50 items, with an equal number of items measuring each of the following five scales: Personalisation, Participation, Independence, Investigation and Differentiation. Each item is responded to on a five-point frequency scale consisting of Almost Never, Seldom, Sometimes, Often, and Very Often. The scoring direction is reversed for many of the items. A sample item from the Personalisation scale is "The teacher considers students' feeling."

The ICEQ was used in some studies in which the classroom learning environment served as the criterion variable and independent variables included use of an innovation in individualised education (including open and inquiry-based classrooms) (Fraser, 1979), the introduction of a new Dutch physics curriculum (Wierstra, 1984), the comparison of students' actual versus preferred perceptions, or of students' actual versus teachers' actual perceptions (Fisher & Fraser, 1983b; Fraser, 1982), and beginning teachers' attitudes towards individualised teaching approaches (Rentoul & Fraser, 1981).

The ICEQ was also validated at different grade levels in various countries. In the Netherlands, Wierstra (1984) used the ICEQ to investigate associations between classroom learning environment and cognitive achievement and attitudinal outcomes with 398 high school students in 9 physics classes. In Sydney, Australia, Fraser and Butts (1982) validated the ICEQ with 712 students in 30 junior high school classes. In Tasmania, Australia, Fraser, Nash and Fisher (1983) combined the ICEQ and CES to study associations between classroom learning environment and student anxiety with 116 eighth and ninth grade students in 116 science classes. In Indonesia, an instrument consisting of nine seven-item scales based upon the CEQ and CES was translated into Indonesian language by Fraser, Pearse and Azmi (1982) in a study of the predictability of students' outcomes (satisfaction and anxiety) from their perceptions of classroom learning environment with 373 eighth and ninth grade students in 18 social science classes. In Brunei Darussalam, Asghar and Fraser (1995) found that classroom learning environment dimensions were predictors of students' attitudinal outcomes in lower secondary schools.

2.3.5 College and University Classroom Environment Inventory (CUCEI)

The College and University Classroom Environment Inventory (CUCEI) was developed by Fraser and Treagust (1986) for the use in seminars in higher education settings with a sample of 372 students and 20 instructors. The final version of the CUCEI consists of 49 items to assess students' or instructors' perceptions of the following seven psychosocial dimensions (scales) of actual or preferred classroom environment: Personalisation, Involvement, Student Cohesiveness, Satisfaction, Task Orientation, Innovation, and Individualisation (seven items per scale). The responses, in terms of degree of agreement or disagreement with each statement on a four-point Likert scale, are Strongly Disagree, Disagree, Agree, and Strongly Agree. The scoring direction is reversed for approximately half of its items. A sample item from the Task Orientation scale is: "Activities in this class are clearly and carefully planned."

The CUCEI was used in an evaluation of alternative high schools (called 'senior colleges') in Australia by Fraser, Williamson and Tobin (1987) among 536 students in 45 classes. The study revealed that students in alternative high schools perceived greater involvement, satisfaction, innovation, and individualisation than the control groups.

In Wellington, New Zealand, Logan, Crump and Rennie (2006) used the modified CUCEI in two independent studies of computing classrooms involving 265 students in secondary schools and 239 students at university level. They found that statistical performance was not completely satisfactory for either sample.

2.3.6 Questionnaire on Teacher Interaction (QTI)

As mentioned above, in the Netherlands, Wubbels and his colleagues began programmatic research focusing on the nature and quality of interpersonal relationships between teachers and students (Créton, Hermans, & Wubbels, 1990; Wubbels & Brekelmans, 2005; Wubbels, Brekelmans, & Hooymayers, 1991; Wubbels & Levy, 1993). Based on the theoretical model of interpersonal behavior involving an *influence* dimension (Dominance, D – Submission, S) and a *proximity* dimension (Cooperation, C – Opposition, O), the Questionnaire on Teacher Interaction (QTI) was developed and first used at the senior high level in the Netherlands (Wubbels, 1993). It has been used at various grade levels in the USA (Wubbels & Levy, 1993). The QTI assesses student perceptions of eight teacher behavior aspects, which are Leadership, Helping/Friendly, Understanding, Student Responsibility/Freedom, Uncertain, Dissatisfied, Admonishing, and Strict behavior.

The frequency responses for each item range from Never to Always on a five-point Likert scale. A sample item from the Student Responsibility/Freedom scale is: "She/he gives us a lot of free time."

The QTI has been translated into numerous different languages (e.g. Dutch, English, French, German, Hebrew, Russian, Slovenian, Swedish, Norwegian, Finnish, Spanish, Turkish, Mandarin Chinese, Singapore Chinese and Indonesian) (Wubbels & Brekelmans, 2012) and cross-validated at various grade levels in the USA (Wubbels & Levy, 1993) and Australia (Fisher, Henderson, & Fraser, 1995). A more economical 48-item version has been developed and validated in Singapore with a sample of 1,512 fifth grade students in 39 mathematics class in 13 schools (Goh & Fraser, 1996; Goh, Young, & Fraser, 1995). Also, Fisher and Cresswell (1998) modified the QTI to form the Principal Interaction Questionnaire (PIQ) which assesses teachers' or principals' perceptions of the same eight dimensions of a principal's interaction with teachers. The study revealed that there were a number of significant differences between perceptions of the actual and ideal interpersonal behavior of principals. For example, although teachers perceived their principals as exhibiting a relatively high degree of cooperative behavior, they would have preferred the principals to be even more cooperative (Fisher & Cresswell, 1998).

To investigate different aspects of science classroom environments in Korea, a translated version of the QTI, as well as the Science Laboratory Environment (SLEI) and Constructivist Learning Environment Survey (CLES), were validated and used with 439 students in senior high schools (Lee, Fraser, & Fisher, 2003). In another study, Kim, Fisher and Fraser (2000) validated the QTI with 543 eighth-grade science students. In Brunei Darussalam, Khine and Fisher (2002) validated and used the QTI with 1,188 science students, and Scott and Fisher (2004) validated a version of the QTI in Standard Malay with 3,104 upper primary students in 136 elementary-school classrooms. Scott and Fisher showed that achievement had a positive relationship with cooperative behaviors and a negative relationship with submissive behaviors. In another study in Singapore, Quek, Wong, and Fraser (2005) validated the QTI with 497 gifted and non-gifted secondary-school chemistry students and reported some stream (gifted versus non-gifted) and gender differences in QTI scores. In Indonesia, Fraser, Aldridge, and Soerjaningsih (2010) translated the QTI into the Indonesian language and cross-validated it with a sample of 422 university students in 12 research methods classes. In Turkey, Telli, den Brok and Cakiroglu (2010) used a Turkish translation of the QTI and four scales from the TOSRA with a large sample of 7,484 grade 9−11 science students from 278 classes in 55 public school in 13 major Turkish cities. The use of multilevel analysis of variance indicated that the influence dimension of the QTI was related to student enjoyment, while proximity was associated with attitudes towards inquiry and enjoyment.

2.3.7 Science Laboratory Environment Inventory (SLEI)

The Science Laboratory Environment Inventory (SLEI) was developed to evaluate the distinct learning environment of science laboratory classes in high school or higher education (Fraser, Giddings, & McRobbie, 1995; Fraser & McRobbie, 1995; Fraser, McRobbie, & Giddings, 1993). The SLEI contains 35 items in five scales, namely, Student Cohesiveness, Open-Endedness, Integration, Rule Clarity, and Material Environment (seven items per scale). The frequency responses for each statement on a five-point scale are Almost Never, Seldom, Sometimes, Often, and Very Often. A sample item from the Integration scale is: "I use the theory from my regular science class sessions during laboratory activities." Fraser, Giddings and McRobbie (1995) field tested and validated the SLEI simultaneously with a sample of 5,447 students in 269 classes in six different countries, namely, the USA, Canada, England, Israel, Australia, and Nigeria. Subsequently, it was cross-validated with 1,594 Australian students in 92 classes (Fraser & McRobbie, 1995) and 489 senior high-school biology students in Australia (Fisher, Henderson, & Fraser, 1997).

In Korea, Fraser and Lee (2009) translated the SLEI into the Korean language for use in a study of differences between the classroom environments for three streams (science-independent, science-oriented and humanities) with 439 high-school science students. The study attested to the sound factorial validity and internal consistency reliability of the SLEI, as well as its ability to differentiate between the perceptions of students in different classrooms. In general, students in the science-independent stream perceived their science laboratory classroom environment more favorably than did students in either the humanities or science-oriented stream.

In Singapore, Wong and Fraser (1995) cross-validated the English version of the SLEI in the study of 1,592 tenth-grade chemistry students in 56 classes in 28 schools. In a study of 497 gifted and non-gifted secondary-school chemistry students in Singapore, Quek, Wong, and Fraser (2005) validated the QTI and reported some stream (gifted versus non-gifted) and gender differences in QTI scores.

In Miami, USA, Lightburn and Fraser (2007) used the SLEI in a study to evaluate the efficacy of using anthropometric activities among a sample 761 high-school biology students. Data analyses supported the SLEI's factorial validity, internal consistency reliability and ability to differentiate between classrooms, as well as supporting the positive influence of using anthropometric activities in terms of both classroom learning environment and student attitudes.

2.3.8 Constructivist Learning Environment (CLES)

The Constructivist Learning Environment Survey (CLES) was developed by Taylor, Fraser, and Fisher (1997) to evaluate the extent to which a classroom environment is consistent with a constructivist epistemology. Constructivists view learning as a process in which the learner actively constructs or builds new ideas or concepts based upon current and past knowledge. In other words, new knowledge is constructed in the context of the learner's prior knowledge, experiences, and beliefs. “Children must be active participants in the development of their own understanding" (Van De Walle, 2001, p. 26) Constructing knowledge, therefore, is a highly active endeavour on the part of the learner (Cobb & von Glasersfeld as cited in Van De Walle, 2001) and involves internalized concepts, rules, and general principles that subsequently can be applied in a practical real-world context. The CLES helps teachers to reflect on their epistemological assumptions and refine their teaching practice (P. C. Taylor, Fraser, & Fisher, 1997). The original version of the CLES consists of 36 items in the five scales of Personal Relevance, Uncertainty, Critical Voice, Shared Control, and Student Negotiation. The responses, in terms of the frequency of each statement on a five-point scale, are Almost Never, Seldom, Sometimes, Often, and Almost Always. A sample item from the Shared Control scale is: "I help the teacher to decide what activities I do." Taylor and his colleagues (1997) used the refined 30-item version of the CLES in two major studies, namely, an evaluation of urban systemic reform project in Dallas (with a large sample of approximately 1,600 Grade 9 to 12 science students) and an Australian option of the Third International Mathematics and Science Study (with a sample of 494 eighth and ninth-grade science students). Both studies exhibited sound factorial validity and internal consistency reliability for the CLES.

The validity and usefulness of the CLES has been established at different grade levels in numerous studies over the past two decades. Johnson and McClure (2004) investigated the use of the CLES for providing insights into the classroom learning environment of beginning teachers as part of a longitudinal study conducted in Minnesota. A shorter 20-item version of the CLES was administered to 290 upper-elementary, middle, and high-school science teachers and preservice teachers and their students. The results indicated satisfactory factorial validity and internal consistency reliability for the CLES.

Working with a diverse sample of 1,079 students in 59 science classes taught by 12 teachers in North Texas, Nix, Fraser and Ledbetter (2005) developed a new form of the 30-item CLES, namely, the CLES–Comparative Student version, to access the impact of an innovative teacher development program (based on the Integrated Science Learning Environment, ISLE, model) in classrooms. This led to the validation of this version of the CLES in terms of factorial validity, internal consistency reliability and discriminant validity. Data analyses also revealed that students whose science teacher had attended the ISLE program perceived a more positive classroom learning environment, especially in terms of Personal Relevance and Uncertainty of Science, than other students whose science teacher had attended alternative field trip programs (non-ISLE). In a follow-up study, Nix and Fraser (2010) used Johnson and McClure's 20-item version of the CLES to evaluate the implementation of the ISLE model over three semesters involving 17 teacher and 845 students. The study revealed that using the ISLE model in teacher education programs cultivated a more positive learning environment in teachers' middle-school science classroom.

In Miami, USA, Perio and Fraser (2009) translated the modified CLES into Spanish and administered the English and Spanish version to 739 grade K–3 science students. Data analyses supported the factor structure and internal consistency reliability of the CLES and revealed strong and positive associations between the nature of the classroom learning environment and students' attitudes during a short three-month period of classroom intervention.

In a cross-national study, Aldridge, Fraser, Taylor and Chen (2000) cross-validated the CLES with a sample of 1,081 eighth- to ninth-grade science students in 50 classes in Australia, while the new Chinese version was administered to 1,879 seventh- to ninth-grade science student in 50 classes in Taiwan. Data analyses supported each scale’s internal consistency reliability, factor structure and ability to differentiate between classrooms, and revealed interesting differences between average scale scores in Taiwan and Australia. Australian students perceived more constructivist learning environments than Taiwanese students, especially in terms of Critical Voice and Student Negotiation.

In research in Korea, Kim, Fisher and Fraser (1999) translated the CLES into the Korean language and cross-validated it with a sample of 1,083 tenth grade science students in 24 classes. The original five-factor structure was replicated for the Korean version of both an actual and a preferred form of the CLES. Similarly, Lee and Fraser (2002) replicated the five-factor structure of the Korean-language version of the CLES among 440 grade 10 and 11 science students in 13 classes.

The CLES also has been validated for the use in South Africa with a sample of 1,868 grade 4–6 learners in 43 mathematics classes (Aldridge, Fraser, & Sebela, 2004). The primary focus of this study was to assist South African teachers to become more reflective practitioners in their daily classroom teaching. Data analyses supported the CLES's factorial validity, internal consistency reliability and ability to differentiate between the perceptions of students in different classrooms. Through the use of the CLES in this teacher action research, learners' perceptions of the constructivist emphasis in their classroom learning environments improved during the 12-week intervention.

2.3.9 Technology-based Classroom Learning Environment Questionnaires

The rapid and revolutionary changes in technology, as well as the emergence of the Internet, the World Wide Web, and new digital media, have generated many forecasts of their potential to transform education (Dutton, 2005). This potential has evolved from the Internet's roots in ever-changing computers and developments in electronic devices during the latter half of the 20th century, but technology also represents a new phenomenon linked to classroom learning environments. To measure the perceptions of these new types of classroom learning environments, several instruments have been developed.

Based on the SLEI, the Computer Laboratory Environment Inventory (CLEI) was developed by Newby and Fisher (1997) to assess students' perceptions of various aspects of their computer laboratory environment in Australia. The CLEI has five scales, namely, Student Cohesiveness, Open-Endedness, Integration, Technology Adequacy, and Laboratory Availability. Each scale consists of seven items which are responded to on a five-point frequency scale (Almost Never, Seldom, Sometimes, Often, and Very Often). Some questions are reverse scored. A sample item from the Technology Adequacy scale is: "The computers are suitable for running the software I am required to use." The CLEI was validated in a cross-national studies with a sample of 104 students from Business School of Curtin University of Technology in Western Australia and 109 students from the College of Business and Economics at California State University, Fullerton (Newby, 2002).

The Distance and Open Learning Environment Scale (DOLES) was developed by Jegede, Fraser and Fisher (1995) for use among university students studying by distance education. The DOLES has the five core scales of Student Cohesiveness, Teacher Support, Personal Involvement and Flexibility, Task Orientation and Material Environment, and Home Environment, as well as the two optional scales of Study Centre Environment and Information Technology Resources. Jegede and colleagues provided support for the DOLES' internal consistency reliability and factor structure for a sample of 660 university students.

The Technology-Rich Outcomes-Focused Learning Environment Inventory (TROFLEI) was developed by Aldridge and Fraser (2008) to assess students' perceptions of their classroom learning environments in outcomes-focused learning settings in an innovative new post-secondary school in Perth, Western Australia. The TROFLEI incorporates all of the WIHIC's seven scales (Student Cohesiveness, Teacher Support, Involvement, Task Orientation, Investigation, Cooperation and Equity), but also includes three other important scales that were salient in the context of this new school. To capture the individualised nature of the outcome-based program, the Differentiation scale was adapted from the ICEQ to assess the extent to which the teacher provides opportunities for students to choose the topic on which to work and to proceed at their own pace. Because technology-rich learning environments require students to use computers in a range of different ways, the Computer Usage scale was developed to provide information about the extent to which students use computers as a tool to communicate with other students and to access information. The Young Adult Ethos scales was also included to assess the extent to which teachers give students responsibility for their own learning and treat them as young adults.

The TROFLEI contains 80 items with eight items in each of 10 scales that are responded to using on a five-point frequency scale (Almost Never, Seldom, Sometimes, Often, and Very Often). A sample item from the Computer Usage scale is: "I use the computer to obtain information from the Internet." In order to provide more economical way to administer the questionnaire, the TROFLEI pioneered a side-by-side layout of the responses for rating actual and preferred forms of a questionnaire simultaneously.

The TROFLEI was extensively field tested in Western Australia and Tasmania with a sample of 2,317 students from 166 grade 11 and 12 classes (Aldridge & Fraser, 2008). The study reported strong factorial validity and internal consistency reliability for both the actual and preferred forms of the TROFLEI. Also, the actual form of each scale was capable of differentiating between the perceptions of students in different classrooms. In the same study, Aldridge and Fraser (2008) used the TROFLEI to investigate some determinants of classroom environment, revealing interesting differences in classroom environment perceptions between males and females and between students enrolled in university-entrance examinations and in wholly school-assessed subjects.

Aldridge, Dorman and Fraser (2004) used multitrait–multimethod modelling with a subsample of 1,249 students, of whom 772 were from Western Australia and 477 were from Tasmania (compared with 2,317 students in their entire sample). When the 10 TROFLEI scales were used as traits and the actual and preferred forms of the instrument as methods, the results supported the TROFLEI's construct validity and sound psychometric properties, as well as indicating that the actual and preferred forms share a common structure.

With a sample of 4,146 grade 8–13 students from Western Australia and Tasmania, Dorman, Aldridge and Fraser (2006) used cluster analysis with the TROFLEI to identify five relatively homogeneous groups of classroom environments. Using the same sample, Dorman and Fraser (2009) used structural equation modelling to investigate associations between students' affective outcomes and their classroom environment perceptions.

To establish the cross-cultural validity and reliability of the TROFLEI, Welch, Cakir, Peterson and Ray (2012) explored the relationship between the learning environment and students' achievement with approximately 980 students attending grades 9–12 in Turkey and 130 students attending grades 9–12 in the USA. The TROFLEI was translated into Turkish, and this was followed by an independent back translation of the Turkish version into English again by bilingual colleagues who were not involved in the original translation. Scale reliability analyses and confirmatory factor analysis (CFA) for both actual and preferred responses to the TROFLEI were performed separately for the Turkish and the USA participants to confirm the structure of the TROFLEI across these two distinct samples.

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

The validated and robust instrument, What Is Happening In this Class? (WIHIC), was chosen for this study. The WIHIC questionnaire is the most-frequently used classroom instrument around the world today (Fraser, 2012) and contributes to parsimony in the field because it combines modified versions of salient scales from a wide range of existing questionnaires with additional scales that accommodate contemporary educational concerns, such as equity and constructivism. In this subsection, the development of the WIHIC (Section 2.3.10.1) and studies involving the use of the WIHIC at the elementary-school level (Section 2.3.10.2), middle-school level (Section 2.3.10.3), secondary-school level (Section 2.3.10.4), and university level (Section 2.3.10.5) are reviewed. Cross-national studies utilizing the WIHIC are reviewed in Section 2.3.10.6.

2.3.10.1 Development of the WIHIC

The original version of the WIHIC, developed by Fraser, Fisher, and McRobbie (1996), consisted of 90 items in nine scales. It was refined to 54 items in seven scales using a sample of 255 junior high school science and mathematics students from Australia (Fraser, Fisher, & McRobbie, 1996). After statistical analysis and interviews with students, the WIHIC was expanded to 80 items in the eight scales of Student Cohesiveness, Teacher Support, Autonomy/Independence, Involvement, Investigation, Task Orientation, Cooperation and Equity (Aldridge & Fraser, 2000; Fraser, Fisher, & McRobbie, 1996). The second version of the WIHIC was field-tested with 1,081 Australian students and 1,879 Taiwanese students (using a translated version) in 50 junior high school science classes (Aldridge, Fraser, & Huang, 1999). The final version of the WIHIC omitted the Autonomy/Independence scale and includes 56 items in seven scales. Table 2.2 lists the seven scales of the final version of the WIHIC and provides a description and a sample item of each scale. The response alternatives for the WIHIC, in terms of the frequency of each statement on a five-point scale, are Almost Never, Seldom, Sometimes, Often, and Almost Always.

After the follow-up interview with 45 students in the same study, the WIHIC was modified into a Class form (which assesses a student's perceptions of the class as whole) and a Personal form (which assesses a student's personal perceptions of his or her role in a classroom) because many students report somewhat different perceptions for the class as a whole and for their personal role within the classroom.

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

Scale Name	Description	Sample Item
Student Cohesiveness	Extent to which students know, help, and support each other.	I work well with other class members.
Teacher Support	Extent to which the teacher helps, befriends, trusts, and shows interest in students.	The teacher goes out of her/his way to help me.
Involvement	Extent to which students have attentive interest, participate in discussions, perform additional work, and enjoy the class.	I discuss ideas in class.
Investigation	Emphasis on the skills and processes of inquiry and their use in problem solving and investigation.	I carry out investigations to answer the teacher's questions.
Task Orientation	Extent to which it is important to complete activities planned and to stay on the subject matter.	I pay attention during this class.
Cooperation	Extent to which students cooperate, rather than compete, with each other on learning tasks.	I work with other students in this class.
Equity	Extent to which students are treated equally by the teacher.	I am treated the same as other students in this class.

Based on Aldridge, Fraser & Huang (1999)
All items are scored 1, 2, 3, 4, and 5, respectively, for the responses Almost Never, Seldom, Sometimes, Often, and Almost Always.

The WIHIC has been used at all educational levels and in a variety of classrooms: the elementary level (Allen & Fraser, 2007), high schools (Dorman, 2003), teacher education programs (Martin-Dunlop & Fraser, 2008), middle-school geography and/or mathematics classes (Chionh & Fraser, 2009; Ogbuehi & Fraser, 2007), the tertiary level (Khoo & Fraser, 2008), science classes (Aldridge & Fraser, 2000; Riah & Fraser, 1998; Wolf & Fraser, 2008) and technology-rich classes (Fraser & Raaflaub, 2013; Khoo & Fraser, 2008; Zandvliet & Fraser, 2004). In addition, the WIHIC has been cross-validated and translated into five languages: Chinese (Aldridge, Fraser, & Huang, 1999), Spanish (Allen & Fraser, 2007), Indonesian (Fraser, Aldridge, & Adolphe, 2010), Korean (Kim, Fisher, & Fraser, 2000), and Arabic (Afari, Aldridge, Fraser, & Khine, 2013; MacLeod & Fraser, 2010).

Table 2.3 summarizes 22 studies with their unique contributions in terms of using the WIHIC in various countries and in various languages. The first three studies in Table 2.3 are examples of research conducted at the elementary-school level which are reviewed in Section 2.3.10.2. The next 12 studies in Table 2.3 involved the use of the WIHIC at the middle-school and secondary-school levels and are reviewed in Section 2.3.10.3 and Section 2.3.10.4, respectively. The next three studies involved the use of the WIHIC at the university level and are reviewed in Section 2.3.10.5. The last four entries in Table 2.3 are cross-national studies using the WIHIC and these are reviewed in Section 2.3.10.6.

2.3.10.2 Elementary-School Studies with WIHIC

The first three studies in Table 2.3 are the examples of the use of the WIHIC at the elementary-school level. In South Florida, Allen and Fraser (2007) used a modified version of the WIHIC in both English and Spanish language with a sample of 520 students in grades 4 and 5 and their 120 parents to investigate students' and parents' perceptions of science classroom learning environments. Data analyses supported the WIHIC's factorial validity, internal consistency reliability and ability to differentiate between the perceptions of students in different classrooms. Both students and parents preferred a more positive classroom environment than the one perceived to be actually present, but effect sizes for actual-preferred difference were larger for parents than for students. Associations were found between some learning dimensions (especially task orientation) and student outcomes (especially attitudes).

Table 2.3 Studies That Have Involved the Use of the WIHIC

Reference(s)	Country(ies)	Language(s)	Sample(s)	Factorial Validity & Reliability	Associations with Environment for:	Unique Contributions
Elementary-School Level						
Allen & Fraser (2007)	Florida, USA	English Spanish	120 parents and 520 grade 4 and 5 students	✓	Attitudes Achievement	Involved both parents and students Actual–preferred differences were larger for parents than students.
Pickett & Fraser (2009)	Florida, USA	English	573 grade 3–5 students	✓	Attitudes Achievement	Mentoring program for beginning teachers was evaluated in terms of changes in learning environment in teachers' school classrooms.
Robinson & Fraser (2013)	Florida, USA	English Spanish	78 parents and 172 kindergarten science students	✓	Attitudes Achievement	Kindergarten level Involved parents Spanish translation Relative to students, parents perceived a more favorable environment but preferred a less favorable environment.
Middle-School Level						
Kim, Fisher & Fraser (2000)	Korea	Korean	543 grade 8 science students in 12 schools	✓	Attitudes	Korean translation Sex differences in WIHIC scores
den Brok et al. (2006)	California, USA	English	665 middle-school science students in 11 schools	✓	NA	Girls perceived the environment more favorably.
Ogbuehi & Fraser (2007)	California, USA	English	661 middle-school mathematics students	✓	Two attitudes scales	Used 3 WIHIC & 3 CLES scales Innovative teaching strategies promoted task orientation.
Wolf & Fraser (2008)	New York, USA	English	1,434 middle-school science students in 71 classes	✓	Attitudes Achievement	Inquiry-based laboratory activities promoted cohesiveness & were differentially effective for males and females.

Table 2.3 (continued)

Reference(s)	Country(ies)	Language(s)	Sample(s)	Factorial Validity & Reliability	Associations with Environment for:	Unique Contributions
Aldridge, Fraser & Ntuli (2009)	South Africa	Isizulu	1,077 grade 4–7 students	✓	NA	Preservice teachers undertaking a distance-education program used environment assessments to improve teaching practices.
Helding & Fraser (2013)	Florida, USA	English Spanish	924 students in 38 grade 8 & 10 science classes	✓	Attitudes Achievement	Spanish translation Students of NBC teachers had more favorable classroom environment perceptions.
Secondary-School Level						
Khine and Fisher (2001)	Brunei Darussalam	English	1,188 Form 5 science students	✓	Attitudes Enjoyment	Differences in classroom environment according to teacher's cultural background
Taylor & Fraser (2013)	California, USA	English	745 grade 9 to 12 mathematics students	✓	Attitudes Enjoyment Anxiety	Combined quantitative and qualitative methods Differences were found between genders.
Wahyudi & Treagust (2004)	Indonesian	Indonesian	1,400 lower-secondary science students in 16 schools	✓	NA	Indonesian translation Urban students perceived greater cooperation & less teacher support than suburban students.
Koul & Fisher (2005)	India	English	1,021 science students in 31 classes	✓	NA	Differences in classroom environment according to cultural background
Dorman (2008)	Australia	English	978 secondary school students	✓	NA	Multitrait–multimethod modelling validated actual and preferred forms.
Chionh & Fraser (2009)	Singapore	English	2,310 grade 10 geography & mathematics students	✓	Attitudes Achievement Self-esteem	Differences between geography & mathematics classroom environments were smaller than between actual & preferred environments.

Table 2.3 (continued)

Reference(s)	Country(ies)	Language(s)	Sample(s)	Factorial Validity & Reliability	Associations with Environment for:	Unique Contributions
University Level						
Martin-Dunlop & Fraser (2008)	California, USA	English	525 female university science students in 27 classes	✓	Attitudes	Very large increases in learning environment scores for an innovative course
MacLeod & Fraser (2010)	UAE	Arabic	763 college students in 82 classes	✓	NA	Arabic translation Students preferred a more positive actual environment.
Afari et al. (2013)	UAE	Arabic	352 college students in 33 classes	✓	Enjoyment Academic efficacy	Arabic translation Use of games promoted a positive classroom environment.
Cross-National studies						
Aldridge, Fraser & Huang (1999); Aldridge & Fraser (2000)	Australia Taiwan	English Mandarin	1,081 (Australia) & 1,879 (Taiwan) junior high science students in 50 classes	✓	Enjoyment	Mandarin translation Combined quantitative and qualitative methods
Dorman (2003)	Australia UK Canada	English	3,980 high school students	✓	NA	Confirmatory factor analysis substantiated invariant structure across countries, grade levels & genders.
Fraser, Aldridge & Adolphe (2010)	Australia Indonesia	English Bahasa	567 students (Australia) and 594 students (Indonesia) in 18 secondary science classes	✓	Several attitude scales	Differences were found between countries and genders.
Zandvliet & Fraser (2004, 2005)	Australia Canada	English	1,404 students in 81 networked classes	✓	Satisfaction	Involved both physical (ergonomic) and psychosocial environments

Based on Fraser (2012)

To evaluate a two-year science mentoring program for beginning elementary school teachers, Pickett and Fraser (2009) validated the WIHIC with 573 third to fifth grade students in a large, culturally- and ethnically-diverse urban school district in the Miami area of Florida, USA. The study demonstrated that the WIHIC is a useful instrument for providing teachers with students' feedback as a guide for improving specific aspects of their classroom environments. It also showed that the professional development (a mentoring program) had a positive impact on the mentored teachers' behaviors and student outcomes (achievement and attitudes).

In another study in Florida, USA, Robinson and Fraser (2013) used a modified version of the WIHIC in both the English and Spanish languages with a sample of 172 kindergarten students from six classes and 78 parents of the same students from the same six classes to investigate both students' and their parents' perceptions of both preferred and actual learning environments. The results confirmed that the modified version of the WIHIC questionnaire in both English and Spanish languages displayed satisfactory factorial validity and internal consistency reliability. Parents perceived a more favorable actual classroom environment than did kindergarten students, but students preferred a much more favorable classroom learning environment than did their parents. The researchers also reported statistically significant associations between kindergarten students' perceptions of the classroom environment and the outcomes of achievement and attitudes to science.

2.3.10.3 Middle-School Studies with WIHIC

The next six studies in Table 2.3 involved the use of the WIHIC at the middle-school level. In research in Korea, Kim, Fisher and Fraser (2000) translated the WIHIC into the Korean language and cross-validated it with a sample of 543 eighth-grade science students in 12 classes. The findings showed that there were positive relationships of classroom environment and interpersonal teacher behavior with students’ attitudinal outcomes. Relative to girls, boys perceived their learning environments and their teachers’ interpersonal behavior more favorably and reported more favorable attitudes toward their science classes.

In California, den Brok, Fisher, Rickards and Bull (2006) utilized the WIHIC to examine the influence of gender, socioeconomic status, ethnicity and class size on students' perceptions of their classroom learning environment. Data collected from 665 middle-school science students in 11 schools were analyzed. The WIHIC scales exhibited strong factorial validity and internal consistency reliability, but its ability to distinguish between multicultural classes, teachers, or schools was found to be limited for a number of scales, such as Student Cohesiveness, Task Orientation, and Involvement. The study also revealed that girls generally perceived their learning environment more positively than did boys.

The validity of the WIHIC was confirmed in a study evaluating an innovative teaching strategy for enhancing the classroom environment, students' attitudes and conceptual development in California (Ogbuehi & Fraser, 2007). Data were collected from 661 inner-city middle-school mathematics students from 22 classes using three instruments (CLES, WIHIC and TOSRA). Data analyses supported the factor structure, internal consistency reliability, discriminant validity and the ability to distinguish between different classes for these questionnaires. Results also indicated that the innovative teaching strategies promoted task orientation and achievement.

In New York, Wolf and Fraser (2008) used the WIHIC with a sample of 1,434 middle-school physical science students 71 classes to compare inquiry and non-inquiry laboratory teaching in terms of students' perceptions of the classroom learning environment, attitudes towards science, and achievement. The WIHIC scales exhibited strong factorial validity and internal consistency reliability and they were able to differentiate between the perceptions of students in different classrooms. The study also revealed that inquiry-based activities were differentially effective for male and female students. Whereas males benefited more from inquiry methods, females seemed to be benefit more from non-inquiry approaches in terms of attitudes to science and classroom task orientation, cooperation and equity.

Using a primary-school version of the WIHIC with a sample of 1,077 grade 4–7 learners, Aldridge, Fraser and Ntuli (2009) conducted the first learning environment study at the primary school level in South Africa aimed at guiding improvements in the teaching practices of in-service teachers undertaking a distance-education program. This study cross-validated a modified version of the WIHIC in the IsiZulu language and supported the success of teachers' use of the WIHIC questionnaire in guiding improvements in their teaching practice.

In Florida, USA, Helding & Fraser (2013) used a modified version of the WIHIC in both the English and Spanish languages with a sample of 924 students in grades 8 and 10 in 28 science classes in investigating the effectiveness of National Board Certified (NBC) teachers in terms of students' perceptions of classroom learning environment. This study supported the WIHIC's validity and reliability for the use with middle-school students in Florida and revealed that students of NBC teachers had more favorable classroom environment perceptions.

2.3.10.4 Secondary-School Studies with WIHIC

The validity and usefulness of the WIHIC has been established at the secondary-school level in various countries. In Brunei Darussalam, Khine and Fisher (2001) used the WIHIC with a sample of 1,188 Form 5 students from 54 science classes to study classroom environment and teachers' cultural background. The study showed that teachers from different cultural backgrounds established different types of learning environments. The results also indicated that the WIHIC is a useful instrument with which to measure the effect of differences in cultural background and as a basis for the identification and development of desirable teacher behaviors that are more likely to lead to a more effective learning environment.

In Taylor and Fraser's (2013) study involving 745 students in 34 mathematics classes from grade 9 to 12 in four high schools located in Southern California, the What Is Happening In this Class? (WIHIC), Test of Mathematics-Related Attitudes (TOMRA), and Revised Mathematics Anxiety Ratings Scale (RMARS) (Plake & Parker, 1982) were used to investigate gender differences in students' perceptions of learning environments, attitudes towards mathematics, and mathematics anxiety. Factor analyses revealed that the instruments used in this study were factorially valid and reliable. Female students perceived more Equity, Student Cohesiveness, Task Orientation and Cooperation than did male students.

Wahyudi and Treagust (2004) cross-validated an Indonesian-language version of a modified form of the WIHIC questionnaire in a study of 1,188 secondary students in 72 science classes and their science teachers in 16 lower secondary schools in urban, suburban and rural areas of Kalimantan Selatan, Indonesia. The study confirmed that the Indonesian version of the modified WIHIC was valid and reliable for the Indonesian educational context. There were significant differences between students' perceptions of the actual and preferred learning environment. Students preferred a more favorable classroom learning environment than the one which they actually experienced. The study also revealed that students in urban schools perceived greater cooperation and less teacher support than did students in suburban schools.

In India, to investigate associations between students' cultural background and their perceptions of their teacher's interpersonal behavior and classroom learning environment, the WIHIC was administered to 1,021 grade 9−10 students from 31 science classes in seven different private co-educational schools (Koul & Fisher, 2005). Statistical analyses supported the WIHIC's factorial validity, internal consistency reliability and ability to differentiate between the perceptions of students in different classrooms. Kashmiri students perceived their classrooms and teacher interaction more positively than students from other cultural groups.

In Australia, Dorman (2008) employed confirmatory factor analysis with multitrait–multimethod modelling to investigate the construct validity of the WIHIC questionnaire. A sample of 978 students from 63 randomly-drawn classes in Queensland secondary schools responded to actual and preferred forms of the WIHIC. Separate confirmatory factor analyses for the actual and preferred forms of the WIHIC supported the seven-scale *a priori* structure of the instrument. The use of multitrait–multimethod modelling with the seven scales as traits and the two forms of the instrument as methods supported the construct validity of the WIHIC. This study provided "strong evidence of the sound psychometric properties of the WIHIC" (p. 179).

In Singapore, a comprehensive study involved the use of the WIHIC among 2,310 grade 10 students in 75 geography and mathematics classes in 38 schools examined associations between actual classroom environment and several student outcomes:

examination results, self-esteem and three attitudes scales from the widely-used Test of Science-Related Attitudes (TOSRA) (Chionh & Fraser, 2009). Data analyses supported the WIHIC's factorial validity, internal consistency reliability and ability to differentiate classrooms. The study revealed that better examination scores were achieved for students who perceived the environment as more cohesive, whereas self-esteem and attitudes were more favorable in classrooms perceived as having more teacher support, task orientation and equity. Differences between geography and mathematics classroom environments were small relative to the large differences between students' actual and preferred classroom environments.

2.3.10.5 University Studies with WIHIC

The sixteenth to eighteenth studies in Table 2.3 involved the use of the WIHIC in universities. Martin-Dunlop and Fraser (2008) used four scales from the WIHIC (Student Cohesiveness, Instructor Support, Investigation, and Cooperation), two scales from the SLEI (Open-Endedness and Material Environment) and an attitude scale from TOSRA (Enjoyment of Science Lessons) to assess the effectiveness of an innovative science course for prospective elementary teachers and to investigate learning environment–attitude associations in a large urban university. Data were collected from a sample consisting of 27 classes with 525 female students prior to the course and at the end of the course. The findings for the internal consistency reliability, discriminant validity, and ability to differentiate between classrooms replicated considerable previous research, and attested to the robustness of the instruments. The researchers also reported large and statistically significant improvements on all seven scales assessing the laboratory learning environment and attitudes towards science.

In Dubai, UAE, a modified version of the WIHIC was translated into Arabic by MacLeod & Fraser (2010) in a study with a sample of 763 college students in 82 classes. The WIHIC exhibited sound factorial validity and internal consistency reliability for both its actual and preferred forms, and the actual form differentiated between the perceptions of students in different classrooms. Students preferred a more positive classroom learning environment than the one which they actually experienced on all scales.

In another study involving the use of an Arabic translation of the WIHIC in Abu Dhabi, UAE, Afari, Aldridge, Fraser and Khine (2013) sampled 352 students in 33 tertiary-level mathematics classes. In addition to validating the WIHIC, two modified attitude scales (Enjoyment of Mathematics Lessons and Academic Efficacy) from the TOSRA and Jinks and Morgan's (1999) Student Efficacy Scale were used to investigate the effectiveness of using games in mathematics classes. Statistically significant improvements were found between students' pretest and posttest scores for the WIHIC scales of Teacher Support, Involvement, Personal Relevance and both attitude scales, suggesting that the use of games promoted a positive classroom environment.

2.3.10.6 Cross-National Studies

The last four entries in Table 2.3 involved the use of the WIHIC in cross-national studies, which can provide new insights for educational research, broaden the perspective for researchers and strengthen their sensitivity to distinctive features of their own educational system. "The taken-for-granted familiar educational practices, beliefs and attitudes in one country can be exposed, made 'strange' and questioned when research involves two countries" (Fraser, 2002, p. 16). Carrying out cross-national studies can provide greater variation in variables of interest, such as teaching methods and students' attitudes, and hence a better understanding of the relative influence of a number of significant variables in the teaching and learning processes.

In a cross-national study involving six Australian and seven Taiwanese researchers working together on a study of learning environments, the WIHIC was used with 1,879 Taiwanese students and 1,081 Australian students in 50 junior high school science classes in each country (Aldridge, Fraser, & Huang, 1999). The WIHIC was translated into Chinese, followed by an independent back translation of the Chinese version into English again by team members who were not involved in the original translation. For each country, Aldridge and Fraser (2000) reported strong factorial validity and internal consistency reliability and that each WIHIC scale was capable of differentiating significantly between the perceptions of students in different classrooms.

Using a cross-national sample of 3,980 grades 8, 10 and 12 mathematics students from England, Canada and Australia, Dorman (2003) conducted a comprehensive study to validate the WIHIC and to examine its factor structure across country, grade level and student gender. Confirmatory factor analysis supported the seven-scale *a priori* structure of the instrument, with fit statistics indicating a good fit of the model to the data. The use of multi-sample analyses within structural equation modelling substantiated invariant factor structures across country, grade levels and student genders. Results from this study supported "the wide international applicability of the WIHIC as a valid measure of classroom psychosocial environment" (p. 231).

In another cross-national study, Fraser, Aldridge and Adolphe (2010) used the WIHIC in both English and the Bahasa Indonesian language with a sample of 594 Indonesian students and 567 Australian students in a total of 36 classes in order to: cross-validate the modified WIHIC; investigate differences between countries and genders in perceptions of environment; and investigate associations between students' attitudes to science and their perceptions of classroom environment. Statistical analyses confirmed the validity and reliability of the WIHIC for both the Indonesian and Australian samples. The study revealed some differences between countries and between genders in students' perceptions of their classroom environments, as well as positive associations between the classroom environment and student attitudes to science in both countries.

In addition to using the WIHIC to evaluate psychosocial classroom environments, Zandvliet and Fraser (2004, 2005) used the Computerised Classroom Ergonomic Inventory (CCEI) to evaluate the physical (ergonomic) learning environment in classrooms using information technology. Zandvliet and Fraser sampled 1404 senior high school students in 81 computer networked classes in Australia and Canada. A modified version of the WIHIC exhibited good factorial validity and internal consistency reliability. When student satisfaction was used as a dependent variable, direct and statistically significant associations with satisfaction were found for psychosocial environment variables, but not for physical environment variables, such as the workspace and visual environments. Moreover, this study suggested a model of educational productivity for learning environments in technology-rich classrooms based on statistically significant associations emerging between physical and psychosocial learning environment variables in classrooms using new information technologies.

2.4 Use of Learning Environment Scales in Evaluation of Educational Innovations

Another important application of learning environment questionnaires is as a source of process criteria in curriculum or program evaluation. Numerous researchers have incorporated WIHIC scales into specific-purpose questionnaires tailored to the particular contexts and purposes of their studies. Studies involving the use of the WIHIC in evaluating technology in the classroom (Section 2.4.1), innovative educational curricula (Section 2.4.2), and innovative approaches for teacher education (Section 2.4.3) are reviewed below.

2.4.1 Evaluation of Technology in the Classroom

Working with 671 high-school geography students in 24 classes in Singapore, Teh and Fraser (1994) developed and validated the four-scale instrument Geography Classroom Environment Inventory (GCEI) to assess the effectiveness of using micro-PROLOG-based computer-assisted learning in terms of student achievement, attitudes and classroom environment. Compared with a control group, a group of students using computer-assisted learning had much higher scores for achievement, attitudes and classroom environment. In Australia, 120 grade 11 students and seven teachers of applied computing classes responded to a five-scale classroom environment inventory (assessing Investigation, Open-Endedness, Organisation, Material Environment and Satisfaction), based on the LEI, ICEQ and SLEI, as part of an evaluation of inquiry-based computer-assisted learning (Maor & Fraser, 1996). In general, students perceived Investigation and Open-endedness more positively after using a computerized database. Although teachers' and students' perceptions showed a similar trend, teachers' perceptions generally were more positive than those of the students.

In Indonesia, the validity and reliability of an Indonesian translation of the WIHIC and the QTI were confirmed in a study with 422 college students from 12 research methods classes (Soerjaningsih, Fraser, & Aldridge, 2001). These researchers reported statistically significant associations between the learning environment and the student outcomes of course achievement, interest in computers, and attitude towards the internet.

Across four schools in Ontario, Canada, Fraser and Raaflaub (2013) surveyed 1,173 grade 7 to 12 students to investigate their perceptions of the learning environment in mathematics and science classrooms when laptop computers were used. In addition to validating actual and preferred versions of the WIHIC along with one additional learning environment scale regarding computer usage and two attitudes scales, data analyses revealed that both male and female students perceived the actual learning environment similarly, but that females preferred less computer usage than boys.

In another study in Indonesia (Margianti, Fraser, & Aldridge, 2002), a Bahasa version of the WIHIC and the Enjoyment of Science Lessons scale modified from the TOSRA were used in university computer-based mathematics classes to investigate the relationship between students' perceptions of their learning environment and cognitive and affective outcomes. The sample consisted of 2,498 students from 24 statistics and 25 linear algebra classes. Margianti and colleages reported strong factorial validity and reliability for the parallel versions of the WIHIC in English and Indonesian, but the ability to differentiate between classroom was lower than previous similar studies (Fraser, Aldridge, & Adolphe, 2010; Soerjaningsih, Fraser, & Aldridge, 2001; Wahyudi & Treagust, 2004). Margianti (2002) suggested this was because of the nature of university classrooms in Indonesia, which are typically more uniform than high school classrooms. Additional analyses comparing actual and preferred learning environments, contrasting male and female perceptions, and investigating associations between students' perceptions of their learning environment and cognitive and affective outcomes generally replicated previous studies.

In Miami, MacDowell-Goggin and Fraser (2004) investigated the effects of technology on students' perceptions of their science learning environment with 860 primary students. They found strong associations between most of the WIHIC scales and students' experiencing pleasure in science. In a cross-national study, the WIHIC and the Computerised Classroom Ergonomic Inventory (CCEI) were used by Zandvliet and Fraser (2004, 2005) among 1,404 senior high school students from 81 classes in Australia and Canada for evaluating both psychosocial and physical learning environments in classrooms using information technology.

In Singapore, a sample of 250 adults in 23 computer classes in five computer education centres was used to validate a modified version of the WIHIC (Khoo & Fraser, 2008). Factor analysis supported a five-factor structure (Trainer Support, Involvement, Autonomy/Independence, Task Orientation, and Equity) and internal consistency indices were satisfactory for the WIHIC. In general, students perceived their learning environments favorably in terms of the levels of Trainer Support, Task Orientation, and Equity. However, the analyses indicated that males perceived more Trainer Support and Involvement, while females perceived lower levels of Equity. Additionally, student satisfaction varied between students of different sexes and ages. Students reported greater satisfaction in classes perceived to have more Trainer Support, Involvement, and Task Orientation.

2.4.2 Evaluation of Innovative Educational Curricula

In a one-year study in Florida of 120 fifth grade students whose teachers participated in a teacher inservice program, entitled Project SMILE (Science and Mathematics Integrated with Literary Experiences), the MCI exhibited satisfactory internal consistency reliability and discriminant validity. The implementation of SMILE had a positive impact on the learning environment and attitudes, especially in terms of student satisfaction and classroom cohesiveness (Mink & Fraser, 2005).

To assess the effectiveness of an innovative mathematics program, the Class Banking System (CBS), which enables teachers to use constructivist ideas and approaches, the Individualised Classroom Environment Questionnaire (ICEQ), Constructivist Learning Environment Survey (CLES), Test of Mathematics-Related Attitudes (TOMRA), and concept map tests were administered to two groups of fifth grade students (N=53 and N=66) as pretests and posttests over an academic year in Miami-Dade County (Spinner & Fraser, 2005). Spinner and Fraser reported satisfactory internal consistency and discriminant validity for each ICEQ, CLES, and TOMRA scale. To enrich the data collected from those questionnaires, three case studies (one for the experimental group and two for the control group) were undertaken based on observations of and interviews with selected students. CBS students experienced more favorable changes in terms of mathematics concept development, attitudes to mathematics, and perceived classroom environment on several dimensions of the CLES (e.g., Personal Relevance, Shared Control) and the ICEQ (e.g., Participation and Differentiation).

In the Limpopo Province of South Africa, working with a sample of 2,638 eighth-grade science students from 50 classes in 50 schools, Aldridge, Laugksch, Seopa and Fraser (2006) developed and validated the Outcomes-Based Learning Environment Questionnaire (OBLEQ), which contains four scales from the WIHIC, one scale each from the ICEQ and CLES, and a new scale (called Responsibility for Own Learning). This questionnaire was translated into the Sepedi language and used to monitor the implementation of outcomes-based classroom environments. In addition to validating a widely-applicable questionnaire suited for outcomes-based education, the researchers used case studies to support and check the accuracy of profiles of OBLEQ scores for specific classes.

To evaluate the use of anthropometric activities among a sample of 761 high-school biology students in 25 classes in term of learning environment and student outcomes (achievement and attitudes), Lightburn and Fraser (2007) validated the Science Laboratory Environment Inventory (SLEI). Data analyses supported the SLEI's factorial validity, internal consistency reliability and ability to differentiate between classrooms. The efficacy of using anthropometric activities was supported by pretest–posttest differences in achievement, as well as by a comparison with a control group's attitudes and perceptions of classroom learning environment. Overall, results provided a degree of support for the positive influence of using anthropometric activities in terms of students' attitudes and the classroom learning environment.

In Western Australia and Tasmania with a sample of 2,317 students from 166 grade 11 and 12 classes, Aldridge and Fraser (2008) used the actual and preferred forms of the TROFLEI to assess students' perceptions of their classroom learning environments in outcomes-focused education. The results indicated that there were statistically significant improvements in students' perceptions of classroom environment over the years from 2001 to 2004 for all TROFLEI scales with the exception of the Equity scale, as well as for Academic Efficacy from the attitude instrument.

To investigate the effectiveness of an Algebra 1 intervention program, Success Lab, Landon and Fraser (2011, April) employed learning environment scales from the WIHIC, attitude scales from the Attitudes Toward Mathematics Inventory (ATMI), and an academic-efficacy scale based on the Patterns of Adaptive Learning Scales (PALS) with a sample of 313 ninth grade students from 20 Algebra 1 classes in three central California high schools. Data analyses confirmed the internal consistency reliability and discriminant validity. The study suggested that students participating in the intervention class, Success Lab, had more positive learning environment perceptions, attitudes towards mathematics and academic efficacy than the non-intervention group.

2.4.3 Evaluation of Innovative Approaches for Teacher Education

The effectiveness of an innovative science course for prospective elementary teachers in terms of laboratory learning environments and attitudes towards science was examined for 525 female students in 27 classes at a large American urban university (Martin-Dunlop & Fraser, 2008). A questionnaire was comprised of four scales from the WIHIC (Student Cohesiveness, Instructor Support, Investigation, and Cooperation), two scales from the SLEI (Open-Endedness and Material Environment) and an attitude scale from TOSRA (Enjoyment of Science Lessons). Data analyses supported the questionnaire's internal consistency reliability, discriminant validity, and ability to differentiate between classrooms. The researchers also reported large and statistically significant improvements on all seven scales assessing the laboratory learning environment and attitudes towards science (ranging from 1.51 standard deviations for Student Cohesiveness to 6.47 standard deviations for Open-Endedness).

The effectiveness of an innovative teacher professional development program, called Alliance+ project, that integrates technology into mathematics and science lessons, was evaluated in terms of students' perceptions of the classroom learning environment and their attitudes towards science/mathematics (Biggs, 2009). The sample consisted of 759 sixth- to eighth-grade mathematics and science students of seven mathematics/science teachers (four Alliance+ participants and three non-participants) in one middle school in Miami-Dade County, Florida. Students responded to learning environment scales and an attitude scale based on the Constructivist Learning Environment Survey (CLES), the What Is Happening In this Class? (WIHIC) questionnaire and the Test of Science-Related Attitudes (TOSRA). Students' perceptions of three classroom learning environment scales (Teacher Support, Cooperation, and Critical Voice) were more positive for Alliance+ teachers than for a comparison group. The Alliance+ project was found to be effective in improving of students' attitudes to mathematics, but not science.

Pickett and Fraser (2009) evaluated a two-year science mentoring program for beginning elementary school teachers in terms of their students' perceptions of classroom learning environment, achievement and attitudes. The modified version of the WIHIC was administrated to 573 third to fifth grade students in a large, culturally-diverse and ethnically-diverse urban school district in the Miami area of Florida, USA. The study illustrated that the modified version of the WIHIC is a useful instrument to provide teachers with students' feedback in order to to improve specific aspects of their classroom environments. Higher achievement scores were found in classes with more investigation and equity. The results also showed that the two-year science mentoring program had a positive impact on the mentored teachers' attitudes towards teaching science.

To assess the impact of an innovative teacher development program (based on the Integrated Science Learning Environment, ISLE, model) in classrooms, Nix, Fraser and Ledbetter (2005) developed a new form of the 30-item CLES, namely, the CLES–Comparative Student version, and administrated it to a diverse sample of 1,079 students in 59 science classes taught by 12 teachers in North Texas. This led to the validation of this version of the CLES in terms of factorial validity, internal consistency reliability and discriminant validity. Data analyses also revealed that students whose science teacher had attended the ISLE program perceived a more positive classroom learning environment, especially in terms of Personal Relevance and Uncertainty of Science, than other students whose science teacher had attended alternative field trip programs (non-ISLE). In a follow-up study, Nix and Fraser (2010) used Johnson and McClure's (2004) 20-item version of the CLES to evaluate the implementation of the ISLE model over three semesters involving 17 teacher and 845 students. The study revealed that using the ISLE model in teacher education program cultivated a more positive learning environment in their middle-school science classrooms.

2.5 Associations between Learning Environments and Student Outcomes

The strongest tradition in past classroom environment research has involved investigation of associations between students' cognitive and affective learning outcomes and their perceptions of psychosocial characteristics of their classrooms (Fraser, 2012). Numerous research programs have shown that student perceptions on questionnaires similar to the one employed in my study account for appreciable amounts of variance in learning outcomes, often beyond that attributable to background student characteristics. Fraser's (1994) tabulation of 40 past studies showed that associations between outcome measures and classroom environment perceptions have been replicated for a variety of cognitive and affective outcome measures, a variety of classroom environment instruments and a variety of samples (ranging across numerous countries and grade levels). This section reviews past studies involving associations between the learning environment and students' cognitive and affective learning outcomes.

Table 2.4 summarizes 10 studies that have established associations between students' cognitive and affective learning outcomes and their learning environments. In Australia, using the SLEI, associations of learning environment with enquiry skills and attitudes have been established for a sample of 1,549 senior high school chemistry students (Fraser & McRobbie, 1995; McRobbie & Fraser, 1993). Fisher, Henderson and Fraser (1997) used the SLEI and QTI with a sample consisting of 489 senior high school students in 28 biology classes in investigating associations between students' perceptions of the laboratory classroom learning environment and student outcomes in three distinct areas: student attitudes, achievement in a written examination, and practical performance.

In Goh, Young and Fraser's (1995) study with 1,512 fifth-grade mathematics students in 39 classes, scores on a modified version of the MCI were related to students' achievement, enjoyment and attitudes. In Wong, Young and Fraser's (1997) study involving 1,592 grade 10 students in 56 chemistry classes, associations were investigated between three student attitude measures (Attitudes to Scientific Inquiry in Chemistry, Adoption of Scientific Attitudes in Chemistry and Enjoyment of Chemistry Lesson) and a modified version of the SLEI. In addition to using conventional multiple regression analysis in these two studies, multilevel analysis was also used to clarify environment–attitude relations. Positive associations emerged between the nature of the chemistry laboratory classroom environment and the students' attitudinal outcomes.

In Turkey, Telli, den Brok and Cakiroglu (2010) used a translated version of the QTI together with four scales from the TOSRA in an investigation of associations between teacher–student interpersonal behavior and students' attitudes to science among 7,484 grade 9 to 11 students from 278 classes in 55 public schools in 13 major Turkish cities. The use of multilevel analysis of variance revealed that the influence dimension of the QTI was related to student enjoyment, while proximity was associated with attitudes towards inquiry and enjoyment.

In Florida, USA, using the SLEI, associations with students attitudes and achievement have been established for a sample of 761 high-school students in 25 biology classes (Lightburn & Fraser, 2007). All outcome–environment associations were positive and stronger outcome–environment associations were found for attitudes than for achievement, which replicates previous studies with the SLEI (Fraser, Giddings, & McRobbie, 1995; McRobbie & Fraser, 1993; Wong & Fraser, 1996).

In Brunei Darussalam, Scott and Fisher (2004) used a Standard Malay translation of the QTI with 3,104 upper primary students in 136 elementary-school classrooms. Associations between students' perceptions of their teachers' interpersonal behaviors, their end-of-year results on an external science examination and enjoyment of science lessons were investigated. The study showed that students' cognitive achievement had a positive relationship with cooperative behaviors and negative relationship with submissive behaviors.

Haertel, Walberg, and Haertel (1981) conducted a meta-analysis of past studies of outcome–environment associations involving 17,805 elementary to high school students in 823 classes of eight subject areas from the USA, Canada, Australia and India. The analysis revealed that student achievement was consistently higher in classes that were more organised, cohesive, and goal-directed and had less friction.

Previously, in Section 2.3.10 of this chapter, Table 2.3 listed 22 studies that involved the validation and the use of the WIHIC and shows that 14 of these studies included investigation of associations between classroom learning environment and various student outcomes (attitudes, achievement, enjoyment, and academic efficacy). Overall, this set of studies replicates evidence from past research (Fraser, 2012) of associations between student outcomes and the nature of the learning environment for a variety of classroom environment questionnaires, student outcomes, countries, languages, grade levels and subject areas.

2.6 Attitudes towards Mathematics and Academic Efficacy

In addition to cross-validating the WIHIC, the present study also investigated connections between the learning environment and students' attitudes towards mathematics and academic efficacy. This was accomplished by using two scales, Attitudes towards Mathematical Inquiry and Enjoyment of Mathematics from the Test of Mathematics-Related Attitudes (TOMRA), together with an academic efficacy scale from Jinks and Morgan's (1999) instrument. The previous section reviewed past studies involving associations between the learning environment and students' cognitive and affective learning outcomes, whereas this section specifically describes the TOMRA, including its evolution and validation, studies that investigated associations between the classroom learning environment and attitudes (Section 2.6.1), background of academic efficacy and past studies involving associations between the learning environment and academic efficacy (Section 2.6.2).

2.6.1 Attitudes towards Mathematics

Attitudes have been contemplated as a main concept in the field of social psychology for a long period of time (Schwarz & Bohner, 2001). Prominent psychologist, Allport (1935), noted that "this concept is probably the most distinctive and indispensable concept in contemporary American social psychology" (p. 43). The concept of attitudes has been associated with varied meanings over the years. An attitude can be defined as "a psychological tendency that is expressed by evaluating a particular entity with some degree of favor or disfavor" (Eagly & Chaiken, 1993, p. 1). Attitudes can be described in terms of three components: 1) a cognitive component, which involves thoughts, beliefs, or ideas about an attitude object; 2) an affective component which feelings or emotions that the attitude object evokes, and 3) a behavioral component which involves a tendency or disposition to act in certain ways toward the attitude object (McGuire, 1969).

In the field of mathematics education, McLeod (1992) defined attitudes as a construct that represents an individual's degree of affect associated with a certain subject. According to this point of view, attitude towards mathematics is an emotional disposition toward mathematics, such as the likes and dislikes of students, the enjoyment that they feel during lessons, and the preferences that they have during mathematics instruction (Aiken, 2002; Haladyna, Shaughnessy, & Shaughnessy, 1983).

A number of instruments have been designed to elicit students' attitudes towards mathematics (Dutton & Blum, 1968; Fennema & Sherman, 1976; Gladstone, Deal, & Drevdahl, 1960; Haladyna, Shaughnessy, & Shaughnessy, 1983; Sandman, 1980; Tapia & Marsh, 2004). One of the most widely-used scales for assessing mathematics attitudes is the Fennema–Sherman Mathematics Attitude Scales which was developed in 1976 for studying gender differences in attitudes towards mathematics. This instrument consists of nine scales: Attitude Toward Success in Mathematics Scale, Mathematics as a Male Domain Scale, Mother Scale, Father Scale, Teacher Scale, Confidence in Learning Mathematics Scale, Mathematics Anxiety Scale, Effectance Motivation Scale in Mathematics, and Mathematics Usefulness Scale.

Sandman (1980) developed the Mathematics Attitude Inventory to measure attitudes with six scales: Value of Mathematics, Self-concept in Mathematics, Anxiety towards Mathematics, Enjoyment of Mathematics, Motivation in Mathematics, and Perceptions of Mathematics Teachers. Earlier studies focused on attitudes toward mathematics in terms of gender difference and achievement in mathematics. The scale of Enjoyment of Mathematics was a new concept to be measured.

At about the same time and based on Klopfer's (1971) taxonomy of the affective domain, Fraser (1978, 1981) developed the Test of Science Related Attitudes (TOSRA) to measure seven science-related attitudes among secondary school students. The scales of the TOSRA are Social Implications of Science, Attitudes to Scientific Inquiry, Adoption of Scientific Attitudes, Enjoyment of Science Lessons, Leisure Interest in Science, Normality of Scientists, and Career Interest in Science. TOSRA was field tested in Sydney with a sample of 1,337 students from 44 grade 7 to 10 classes. TOSRA has been frequently used in past studies to explore associations between the classroom learning environment and the student outcome of attitudes (Aldridge, Fraser, & Fisher, 2003; Fraser, Aldridge, & Adolphe, 2010; Pickett & Fraser, 2009; Wong & Fraser, 1996; Wong, Young, & Fraser, 1997). Several studies have modified the TOSRA for use in subject areas other than the science, such as geography (Walker, 2006) and Spanish (Adamski, Fraser, & Peiro, 2013). To assess mathematics-related attitudes instead of science-related attitudes, the Test of Mathematics Related Attitudes (TOMRA), a modified version of the TOSRA, has been evolved. The wording of items in the TOMRA has been changed from 'science' to 'mathematics'. For example, "Science lessons are fun" was changed to "Mathematics lessons are fun". The response alternatives for the TOMRA, in terms of a five-point Likert scale, are Strongly Disagree, Disagree, Not Sure, Agree, and Strongly Agree. The scoring direction is reversed for some items.

Several studies have used the TOMRA to assess student attitudes towards their mathematics classrooms (Campbell, 2009; Ogbuehi & Fraser, 2007; Spinner & Fraser, 2005; B. A. Taylor & Fraser, 2013).

To assess the effectiveness of an innovative mathematics program, the Class Banking System (CBS), which enables teachers to use constructivist ideas and approaches, Spinner and Fraser (2005) used ICEQ, CLES, TOMRA, and concept map tests with two groups of fifth grade students (N=53 and N=66) as pretests and posttests over an academic year in Miami-Dade County. Satisfactory internal consistency and discriminant validity for each ICEQ, CLES, and TOMRA scale were reported. To enrich the data collected from those questionnaires, three case studies (one for the experimental group and two for the control group) were undertaken based on observations and interviews with selected students. CBS students experienced more favorable changes in terms of mathematics concept development, attitudes to mathematics, and perceived classroom environments on several dimensions of the CLES.

The effectiveness of using innovative teaching strategies for enhancing the classroom environment, students' attitudes and conceptual development was evaluated at four inner-city middle-school schools in California with 661 mathematics students from 22 classes by using three instruments: CLES, WIHIC and TOSRA (Ogbuehi & Fraser, 2007). Data analyses attested to satisfactory factor structure, internal consistency reliability, discriminant validity and the ability to distinguish between different classes for these questionnaires. The study also revealed moderate positive associations between the learning environment and students' attitudes to mathematics for this group of middle-school students.

Table 2.4 A Sample of Studies of Associations Between Learning Environments and Student Outcomes

Reference(s)	Country(ies)	Language(s)	Sample(s)	Learning Environment Instrument	Student Outcome(s)
Fraser & McRobbie (1995); McRobbie & Fraser (1993)	Australia	English	1,594 senior high school chemistry students	SLEI	Enquiry skills Attitudes
Fisher, Henderson & Fraser (1997)	Australia	English	489 senior high school biology students	SLEI QTI	Attitudes Achievement
Webster & Fisher (2003)	Australia	English	4645 secondary mathematics students and 620 teachers	SLEQ	Attitudes Achievement Career aspirations Academic efficacy
Teh & Fraser (1995)	Singapore	English	671 high school geography students	GCEI	Attitudes Achievement
Goh, Young & Fraser (1995)	Singapore	English	1,512 grade 5 mathematics students	MCI QTI	Attitudes Enjoyment Achievement
Wong, Young & Fraser (1997)	Singapore	English	1,592 grade 10 chemistry students	SLEI	Attitudes Enjoyment
Telli, den Brok, & Cakiroglu (2010)	Turkey	Turkish	7,484 grade 9–11 science students	QTI	Attitudes Enjoyment
Lightburn & Fraser (2007)	Florida, USA	English	761 high-school biology students	SLEI	Attitudes Achievement
Scott & Fisher (2004)	Brunei Darussalam	Malay	3,104 upper primary students	QTI	Enjoyment Achievement
Haertel, Walberg & Haertel (1981)	USA Canada Australia India	English	17,805 elementary, junior high and high school students in 823 classes of eight subject areas	LEI	Attitudes Behavior Achievement

A study using the What Is Happening In this Class? (WIHIC), Test of Mathematics-Related Attitudes (TOMRA), and Revised Mathematics Anxiety Ratings Scale (RMARS) involved associations between classroom learning environment dimensions and the level of mathematics anxiety and attitudes toward mathematics with 745 grade 9–12 students from 34 mathematics classes in four high schools in Southern California (B. A. Taylor & Fraser, 2013). The study also examined gender differences in students' perceptions of learning environments, attitudes towards mathematics, and mathematics anxiety. Factor analyses revealed that two out of four attitude scales, namely, Enjoyment of Mathematics Lessons and Normality of Mathematicians used in this study, were factorially valid and reliable. Results indicated that students had a relatively favorable view of mathematicians and were generally positive towards them. However, the level of enjoyment of mathematics lessons was relatively low for these same students. The findings also showed no significant gender differences for attitudes towards mathematics and mathematics anxiety.

The What Is Happening In this Class? (WIHIC) and Test of Mathematics-Related Attitudes (TOMRA) were used for evaluating the effectiveness the use of hands-on manipulatives in terms of classroom environment, attitudes, and achievement (Campbell, 2009) in 15 mathematics classes with 470 students in Miami-Dade County, Florida. Analyses revealed that students using hands-on manipulatives perceived a more favorable learning environment and had more positive attitude and achievement scores than students from the comparison group.

A review of literature revealed a range of attitudes scales. Of particular interest to this study is the Test of Mathematics-Related Attitudes (TOMRA). Two TOMRA scales, namely, Attitudes Towards Mathematical Inquiry and Enjoyment of Mathematics, were incorporated into this study to investigate associations between students' perceptions of mathematics classroom learning environment and their attitudes towards mathematics.

2.6.2 Academic Efficacy

While attitude is one of the affective outcomes that has been identified as important in mathematics education, another affective outcome included in the present study was 'academic efficacy', which has been used to investigate associations with the classroom environment and mathematics achievement (Aldridge & Fraser, 2008; Castillo, Peiro, & Fraser, 2006; Dorman, 2001; Multon, Brown, & Lent, 1991; Schunk, 1989; Zimmerman, Bandura, & Martinez-Pons, 1992).

The broad psychological concept of self-efficacy is defined as the belief that one is capable of performing in a certain manner to attain certain goals (Bandura, 1994). Bandura (1986) defines the construct as:

> People's judgments of their capabilities to organize and execute courses of action required to attain designated types of performances. It is concerned not with the skills one has but with the judgments of what one can do with whatever skills one possesses. (p. 391)

This core belief is the foundation of human motivation, performance accomplishments, and emotional well-being (Bandura, 1997, 2006, 2010). Self-efficacy influences several aspects of behavior that are important to learning. Within this field, one particularly strong area of interest is that of academic efficacy, which refers to an individual's judgments of his or her capabilities to organize and execute courses of action to master designated types of educational performances (Zimmerman, 1995). In other words, academic efficacy involves an individual's conviction in his or her competence in specific academic subject areas.

Bandura’s conclusion that “what people think, believe, and feel affects how they behave” (Bandura, 1986, p. 25) has been supported by many studies which have revealed that academic efficacy is positively related to academic motivation (Schunk & Hanson, 1985), persistence (Bandura, 1997; Lyman, Prentice-Dunn, Wilson, & Bonfilio 1984; Multon, Brown, & Lent, 1991), memory performance (J. M. Berry, 1987), and academic performance (Multon, Brown, & Lent, 1991; Schunk, 1989; Zimmerman, Bandura, & Martinez-Pons, 1992). For example, Multon, Brown and Lent (1991) conducted a meta-analytic investigation that related academic efficacy to academic performance and persistence. Academic efficacy was found to be a consistent and positive predictor of academic performance and persistence outcomes across a wide variety of subjects, experimental designs, and assessment methods.

In a study of the influence of peer models on students' self-efficacy and achievement, Schunk and Hanson (1985) found that perceived self-efficacy for learning correlates positively with students' rate of solution of arithmetic problems. Schunk (1995) also noted that academic efficacy influences persistence provided that the task is sufficiently difficult. In this situation, students with low self-efficacy opt out whereas students with high academic efficacy persevere with the task and have the confidence to try different strategies.

Similarly, Pajares (1996) investigated the academic efficacy associated with mathematical tasks. Students with a strong sense of efficacy were more likely to challenge themselves with difficult tasks and to be intrinsically motivated. These students exerted a high degree of effort and persistence in order to meet their commitments, and they attributed failure to things which were within their control, rather than blaming external factors (Pajares, 1996). Students who believe that they cannot be successful are less likely to make a concerted, extended effort and could consider challenging tasks as threats that are to be avoided. Thus, students with poor self-efficacy have low aspirations which can result in disappointing academic performances becoming part of a self-fulfilling feedback cycle (Zimmerman, 1998).

Furthermore, Lorsbach and Jinks (1999) pointed out that academic self-efficacy beliefs are "strongly linked to perceptions of the learning environment" (p. 159). The concept of self-efficacy was illustrated as an important component of all three of Moos' dimensions for classifying human environments, but few past studies in mathematics have explored associations between classroom learning environment and academic efficacy. Dorman (2001) combined the seven scales from the WIHIC and three scales from the CLES with a seven-item scale developed by Midgley and Urdan (1995), Midgley et al. (1997), and Roeser, Midgley and Urdan (1996) to form an instrument that was used to investigate associations between student academic efficacy and classroom environment among a sample of 1,055 mathematics students from nine Australian secondary schools. Overall, this research showed that classroom environment related positively with academic efficacy. However, commonality analysis showed that the three CLES scales did not contribute much to explaining variance in academic efficacy beyond that attributed to the seven WIHIC scales.

In a cross-national study involving associations between classroom learning environment in mathematics, an instrument consisting of seven scales from the WIHIC, three scales from the CLES and a seven-item scale developed by Midgley and Urdan (1995), Midgley et al. (1997), and Roeser, Midgley and Urdan (1996) was used with a sample of 3,602 grades 8, 10 and 12 mathematics students from 9 Australian, 4 Canadian and 10 British secondary schools (Dorman, Adams, & Ferguson, 2003). The analyses revealed statistically significant and positive associations between these classroom environment dimensions and academic efficacy.

A review of literature identified a variety of academic efficacy scales which have been developed over the years for many different areas in education, including mathematics (Betz & Hackett, 1983; Dowling, 1978), science (Baldwin, Ebert-May, & Burns, 1999; Morgan & Jinks, 1996; Smist, 1992; Tippins, 1991), and teacher efficacy (Gibson & Dembo, 1984; Hillman, 1986; Kushner, 1993; Pontius, 1998; Riggs & Enochs, 1990). Drawing from mathematics problems created for the National Longitudinal Study of Mathematical Abilities (NLSMA), Dowling (1978) was the first researcher to develop a confidence measure, namely, the Mathematics Confidence Scale (MCS), that specifically corresponds with a performance assessment in which students were asked to solve the same or similar mathematics problems on which their confidence was based. Subsequently, Betz and Hackett (1983) developed the Mathematics Self-Efficacy Scale (MSES) which incorporated as one subscale a measure similar to Dowling's MCS and added two subscales, one to assess students' confidence to perform certain mathematics-related tasks and another to assess their confidence to earn an A or B grade in certain mathematics-related courses.

Of particular interest to this study was the Morgan-Jinks Student Efficacy Scale (MJSES; Jinks & Morgan, 1999) which was designed to gain insight into children's perceptions of their own self-efficacy regarding academic performance. The MJSES consists of 53 items in the four scales of talent, effort, task difficulty, and context. It was field-tested with nearly 900 seventh and eighth grade students from three different demographic schools in Midwestern United States. A sample item from the MJSES reads "I am good at mathematics". The response alternatives for the MJSES involved a four-interval Likert scale, consisting of really agree, kind of agree, kind of disagree, and really disagree.

In 2001, Fisher, Aldridge, Fraser, and Wood employed an adapted version of the MJSES to investigate students' beliefs about their academic competence with a sample of 2,317 students from 166 grade 11 and 12 classes in Western Australia and Tasmania (Aldridge & Fraser, 2008). The TROFLEI, TOSRA, Computer Attitude Scale (CES; Loyd & Gressard, 1984; Newhouse, 2001) and an academic-efficacy scale from the MJSES were used to examine associations between students' perceptions of their academic competence and their perceptions of the learning environment. All of the 10 TROFLEI scales were statistically significantly and positively related to academic efficacy. A noteworthy result was that students enrolled in wholly school-assessed subject had statistically higher academic efficacy scores than those students enrolled in university-entrance examination subjects (with an effect size for the difference of 0.45 standard deviations).

More recently, Castillo, Peiro and Fraser (2006) used the WIHIC, TOMRA and academic efficacy scales adapted from MJSES to investigate the influence of factors (grade-level, gender and ethnicity) on the attitudes, academic efficacy, and learning environment perceptions of a sample of 600 grade 9 and 10 mathematics students from 30 classes in Miami-Dade County, Florida. Statistical analyses supported the factor structure and internal consistency reliability of the WIHIC, attitude, and academic efficacy questionnaires. Strong positive associations between students' attitudes/ academic efficacy and the learning environment were found. The research also reported grade-level differences, including an increase in Student Cohesiveness, Attitude to Inquiry, and Equity scores and a decline in Teacher Support, Task Orientation, and Academic Efficacy between grades 9 and 10.

2.7 Summary of Literature Review

The main goal of this cross-national study was to compare mathematics classes in Hong Kong and the USA in terms of classroom learning environment, attitudes toward mathematics, and academic efficacy. The literature reviewed in this chapter related to all of these three areas under seven sections. Section 2.2 entitled Historical Background of Classroom Learning Environments provided a descriptive definition for the term 'learning environment' and an overview of the history and development of research on classroom learning environments. Beginning with Lewin's (1936) studies and following Walberg and Anderson's pioneering evaluation of Harvard Project Physics program and Moos' scheme of classifying human environment in the USA, the focus of learning environments research shifted to Australia and the Netherlands. Section 2.3 – Development of Learning Environment Instruments – highlighted 12 noteworthy questionnaires that have been developed, validated and used in research over the past 40 years:

- Learning Environment Inventory (LEI)
- Classroom Environment Scale (CES)
- My Class Inventory (MCI)
- Individualised Classroom Environment Questionnaire (ICEQ)
- College and University Classroom Environment Inventory (CUCEI)
- Questionnaire on Teacher Interaction (QTI)
- Science Laboratory Environment Inventory (SLEI)
- Constructivist Learning Environment Survey (CLES)
- Technology-based Classroom Learning Environment Questionnaires
  - Computer Laboratory Environment Inventory (CLEI)
  - Distance and Open Learning Environment Scale (DOLES)
  - Technology-Rich Outcomes-Focused Learning Environment Inventory (TROFLEI)
- What Is Happening In this Class? (WIHIC).

Several studies that used each of these instruments were briefly reviewed. Because the What Is Happening In this Class? (WIHIC) questionnaire was the primary research instrument in the present study, an in-depth review of studies involving the historical background and development of the WIHIC was included in this section as well. Table 2.3 summarizes 22 studies and their unique contributions in terms of using the WIHIC in various countries and in various languages.

Section 2.4 – Use of Learning Environment Scales in Evaluation of Educational Innovations – focused on past studies using learning environment instruments to evaluate educational innovations, including the use of technology in the classroom, innovative curricula, and innovative approaches for teacher education.

The present study also investigated associations between students’ perceptions of mathematics classroom learning environment and two types of student outcomes, namely, attitudes to mathematics and academic efficacy related to mathematical tasks by using two scales (eight items each) from the Test of Mathematics-Related Attitudes (TOMRA) and an academic efficacy scale based on Aldridge and Fraser’s (2008) adaptation of Jinks and Morgan’s (1999) MJSES instrument. Ten studies that reported associations between students' cognitive and affective learning outcomes and their learning environments were reviewed in Section 2.5. Considerable detail was provided about the historical background and development of instruments for assessing attitudes towards mathematics and academic efficacy in Section 2.6.

Through this comprehensive review of the literature, researchers can have a clearer understanding of the areas involved in this research, as well as potential areas for further research. This review provided a better understanding of associations between students’ perceptions of mathematics classroom learning environment and students' learning outcomes, as well as illustrating the importance of the three instruments (WIHIC, TOMRA, MJSES) used in this study and their past use in the variety of educational settings and countries.

Chapter 3

RESEARCH METHODOLOGY

3.1 Introduction

Research methodology is a description of process or procedures of inquiry in a study. It is crucial for the validity of the research because it allows others to understand the infrastructure of the research and it provides meaning and credibility to the results. This chapter discusses the research methods of the present study and thereby enhances its credibility.

The present study compared mathematics classes in Hong Kong and the USA in terms of classroom learning environments, attitudes toward mathematics, and academic efficacy. The following three research questions were developed to guide the entire research process:

1. Is it possible to develop valid and reliable measures of mathematics students' perceptions of classroom learning environments, attitudes toward mathematics, and academic efficacy in the USA and Hong Kong?

2. Are there differences between students in the USA and Hong Kong in terms of perceptions of the learning environment, attitudes towards mathematics, and academic efficacy?

3. Are there associations between students' perceptions of their mathematics classroom learning environment and two types of student outcomes (attitudes and academic efficacy related to mathematics)?

This chapter contains three sections which describe the instruments used in the present study to assess students' perceptions of the learning environment, attitudes towards mathematics and academic efficacy, the procedures of data collection and the methods of data analysis. Section 3.2 – Instruments Used for Data Collection –

provides a detailed description of the What Is Happening In this Class? (WIHIC) questionnaire (Section 3.2.1), Test of Mathematics-Related Attitudes (TOMRA) (Section 3.2.2), Morgan-Jinks Student Efficacy Scale (MJSES) (Section 3.2.3), and the development of a Chinese version of these questionnaires (Section 3.2.4). Section 3.3 – Data Sources and Sample – details the data sources, sample and procedures for data collection. The methods of data analysis are discussed in Section 3.4 using three subsections. Section 3.4.1 explains how the validity and reliability of the instruments were evaluated. Analyses used to identify differences between USA and Hong Kong in learning environments, attitudes towards mathematics and academic efficacy, and associations between learning environment and student outcomes of attitudes to mathematics and academic efficacy are discussed in Section 3.4.2 and Section 3.4.3, respectively. The chapter concludes with an overview of potential limitations of the present study in Section 3.5, as well as a summary in Section 3.6.

3.2 Instruments Used for Data Collection

The questionnaire used to measure students' perceptions of their mathematics classroom environment in the present study consisted of parts of three previously-validated and reliable instruments, making a total of 56 items. The learning environment was assessed using four eight-item scales from the What Is Happening In this Class? (WIHIC). In addition, two eight-item scales for assessing students' attitudes towards mathematical inquiry and enjoyment of mathematics were based on scales from the Test of Mathematics-Related Attitudes (TOMRA) (Fraser, 1981). Another eight-item scale, Academic Efficacy, from Aldridge and Fraser’s (2008) adaptation of Morgan-Jinks Student Efficacy Scale (MJSES), was included to measure students’ self-concept as it relates to their mathematics ability. An overview of the seven scales used in this study is provided in Table 3.1. The frequency response alternatives for the modified instrument involved a five-point scale: Almost Never; Seldom; Sometimes; Often; and Almost Always. Appendix B includes a copy of the modified learning environment, attitude and efficacy questionnaire used in this study.

Table 3.1 Overview of Scales Used to Assess Mathematics Learning Environment

Instrument	Scales	No. of Items
WIHIC	Teacher Support − TS	8
	Involvement − INV	8
	Cooperation − CO	8
	Equity − E	8
TOMRA	Attitudes towards mathematical inquiry − INQ	8
	Enjoyment of mathematics − ENJ	8
MJSES	Academic Efficacy − AE	8

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

The What Is Happening In this Class? (WIHIC) was developed by Fraser, Fisher, and McRobbie (1996) to bring parsimony to the field of learning environments by combining the most salient scales from a wide range of existing questionnaires with additional scales that accommodate contemporary educational concerns, such as equity and constructivism (Fraser, 2012). The original WIHIC questionnaire contains 56 items in seven scales which are Student Cohesiveness, Teacher Support, Involvement, Investigation, Task Orientation, Cooperation and Equity The frequency response alternatives for each statement on a five-point scale are Almost Never, Seldom, Sometimes, Often, and Very Often.

As previously discussed in Section 2.3.10 of Chapter 2, the WIHIC is a validated and robust instrument. It has been used at all educational levels and in a variety of classrooms: the elementary level (Allen & Fraser, 2007), high schools (Dorman, 2003), teacher education programs (Martin-Dunlop & Fraser, 2008), middle-school geography and/or mathematics classes (Chionh & Fraser, 2009; Ogbuehi & Fraser, 2007), the higher-education level (Khoo & Fraser, 2008), science classes (Aldridge & Fraser, 2000; Riah & Fraser, 1998; Wolf & Fraser, 2008) and technology-rich classes (Khoo & Fraser, 2008; Fraser & Raaflaub, 2013; Zandvliet & Fraser, 2004). In addition, the WIHIC has been cross-validated and translated into five languages: Chinese (Aldridge, Fraser, & Huang, 1999), Spanish (Allen & Fraser, 2007), Indonesian (Fraser, Aldridge, & Adolphe, 2010), Korean (Kim, Fisher, & Fraser, 2000), and Arabic (Afari et al., 2013; MacLeod & Fraser, 2010).

The WIHIC has also been used in numerous studies to determine possible associations between attitudes towards science or mathematics and the perceived learning environment (Castillo, Peiro, & Fraser, 2006; Chionh & Fraser, 2009; Kim, Fisher, & Fraser, 2000; Landon & Fraser, 2011; Ogbuehi & Fraser, 2007; B. A. Taylor & Fraser, 2013; Wolf & Fraser, 2008). These studies pursued research questions similar to the one in the present study regarding associations between students' attitudes and the learning environment.

Based on its cross-validated factor structure and reliability and acceptance in the study of learning environments by other researchers, the WIHIC was chosen for the present study to assess students' perceptions of their mathematics classroom environment. In order to provide a comprehensive assessment of classroom learning environment and yet keep the study manageable, the 56-item version of the WIHIC was modified to make its length more suitable for the seventh and eighth grade students who participated. Only four of a possible seven scales from the WIHIC were used: Teacher Support, Involvement, Cooperation, and Equity. These scales provided an overview of the more-salient aspects of the learning environment in each country, as well as a starting point from which comparisons could be made.

3.2.2 Test of Mathematics-Related Attitudes (TOMRA)

The Test of Mathematics-Related Attitudes (TOMRA), a mathematics-specific version of Fraser's (1978, 1981) Test of Science Related Attitudes (TOSRA), was used in the present study to measure students' attitudes related to the learning of mathematics. The original TOSRA contains 70 items in the seven scales of Social Implications of Science, Attitudes to Scientific Inquiry, Adoption of Scientific Attitudes, Enjoyment of Science Lessons, Leisure Interest in Science, Normality of Scientists, and Career Interest in Science. TOSRA was field tested in Sydney with a sample of 1,337 students from 44 grade 7 to 10 classes. As previously discussed in Section 2.6.1 of Chapter 2, the TOSRA has been frequently used in past studies to explore associations between the classroom learning environment and the student outcome of attitudes (Fraser, Aldridge, & Adolphe, 2010; Pickett & Fraser, 2009; Wong & Fraser, 1996; Wong, Young, & Fraser, 1997).

Several researchers have modified the TOSRA for use in subject areas other than science, such as geography (Walker, 2006) and Spanish (Adamski, Fraser, & Peiro, 2013). To assess mathematics-related instead of science-related attitudes, the Test of Mathematics Related Attitudes (TOMRA), a modified version of the TOSRA, was developed by changing ‘science’ to ‘mathematics’ (Ogbuehi & Fraser, 2007). For example, “Science lessons are fun” was changed to “Mathematics lessons are fun”. The response alternatives for the original TOMRA, in terms of a five-point Likert scale, are Strongly Disagree, Disagree, Not Sure, Agree, and Strongly Agree. The scoring direction is reversed for some items.

Several studies have used both TOMRA and WIHIC to investigate possible associations between students’ perceptions of their mathematics classroom learning environment and their attitudes towards mathematics (Campbell, 2009; Castillo, Peiro, & Fraser, 2006; Ogbuehi & Fraser, 2007; Spinner & Fraser, 2005; B. A. Taylor & Fraser, 2013). Based on the similarity between previous research and my study, TOMRA was chosen to assess students' attitudes related to the learning of mathematics. 16 items from two of a possible seven scales from the TOMRA were considered as the most relevant to this study: Attitudes Towards Mathematical Inquiry and Enjoyment of Mathematics. To align with other scales used in my study, I changed the response alternatives for the TOMRA to the five-point frequency scale of Almost Never, Seldom, Sometimes, Often, and Almost Always. The scoring direction is positively worded for all selected items. TOMRA was used to provide a good overview of students' attitudes towards mathematics in each county and also of the relationship between students’ perceptions of their mathematics classroom learning environment and their attitudes towards mathematics.

3.2.3 Morgan-Jinks Student Efficacy Scale (MJSES)

As mentioned in Chapter 2 Section 2.6.2, the Morgan-Jinks Student Efficacy Scale (MJSES) was developed by Jinks and Morgan (1999) to gain information about student efficacy beliefs that might relate to school success. The MJSES consists of 53 items in the four scales of talent, effort, task difficulty, and context. It was field-tested with nearly 900 seventh and eighth grade students from three different schools in Midwestern of the United States (Jinks & Morgan, 1999). A sample item from the

MJSES reads "I am good at mathematics". The response alternatives for the MJSES involved a four-interval Likert scale consisting of really agree, kind of agree, kind of disagree, and really disagree.

A few previous studies have used the MJSES to investigate possible associations between students' perceptions of their classroom learning environment and their academic efficacy (Aldridge & Fraser, 2008; Castillo, Peiro, & Fraser, 2006).

One of the scales that was used in my study was based on Aldridge, Fraser, and Fisher's (2003) adaptation of the Morgan-Jinks Student Efficacy Scale for investigating student self-efficacy beliefs regarding their academic performance and whether associations exist between students' perceptions of their competence and their perceptions of the learning environment. To align with other scales used in this study, the response alternatives for the MJSES were changed to a five-point frequency scale consisting of Almost Never, Seldom, Sometimes, Often, and Almost Always.

3.2.4 Development of a Chinese Version of the Questionnaire

Although the medium of instruction in Hong Kong is mainly English, some terms and phrases within the questionnaire are unlikely to be understood by the average student. Therefore, the modified questionnaire was translated into Chinese to accommodate the language needs of students in Hong Kong. After translation into Chinese, the modified questionnaire was then back translated into English by a mathematics teacher who was not involved in the original translation, as recommended by Brislin (1970). Modifications were made before the administration of the Chinese version of the questionnaire in this study. Also, to make the WIHIC more suitable for use in 'mathematics' classes, the phrase "In this mathematic class..." was added preceding each scale of the Chinese version of the WIHIC. Appendix B includes a copy of the Chinese version of the modified questionnaire used in this study.

3.3 Data Sources and Sample

After presenting the research proposal to school district officials and school principals, permission to proceed was granted in April 2011. An invitation email was sent to all 7th and 8th grade mathematics teachers of the participating schools. 14 of the 30 teachers contacted agreed to their classes participating during the last week of the school year. Parent consent forms, shown in Appendix A, were distributed to students a day prior to the day of administering the questionnaires. The modified questionnaires were administered by students' own mathematics teachers in each country.

Hong Kong is a cosmopolitan city with a population of seven million people in 426 square miles of hilly terrain. Its territory consists of Hong Kong Island, the Kowloon Peninsula, and the New Territories. In Hong Kong, students completed the Chinese version of the modified questionnaire. For the most part, junior high schools are combined with high schools (called 'secondary schools') and range from Grade 7 to 12 (13−18 years of age). A sample of secondary schools, considered representative of schools in Hong Kong, was drawn from two different areas. Two schools were selected from Kowloon and one was selected from New Territories. A total of 23 seventh and eighth grade mathematics classes participated in the present study, providing a total sample from Hong Kong of 699 students. Those students were taught by 3 female and 3 male teachers.

In the USA, an English version of the modified questionnaire was administered to seventh and eighth grade mathematics classes at three public junior high schools (Grades 7−8 or 13−14 year-old students) from one school district in Clovis, California during the last week of 2010−2011 school year. The school district is located in a typical suburban city of Central California with a high percentage of students coming from White/Caucasian or Latino/Hispanic cultures and being of middle-to-low socioeconomic status. The schools selected in the USA were restricted to those in which teachers were willing to participate. A total of 35 seventh and eighth grade mathematics classes participated in the present study, providing a total sample from the USA of 610 students. Those students were taught by 7 female and 2 male teachers.

A total of 1,309 seventh and eighth grade students from both countries participated in a one-time data collection. Figure 3.1 shows the percentage of the sample from each grade level and country. The sample also was balanced in terms of student gender. Just over half of the sample identified themselves as female (51.3%), while 48.7% were male. This even gender division of the sample is likely to minimize any possible gender biases in the data.

3.4 Methods of Data Analysis

All data collected from the modified questionnaire were included in a spreadsheet and checked for accuracy by myself. Any questionnaires that were not completed correctly, because of either unmarked answers or double marked answers, were withdrawn from the spreadsheet to produce 1309 completed sets of data for further processing. Student identification number, gender, grade-level, and class identification code were also input for each student who had fully completed the questionnaire.

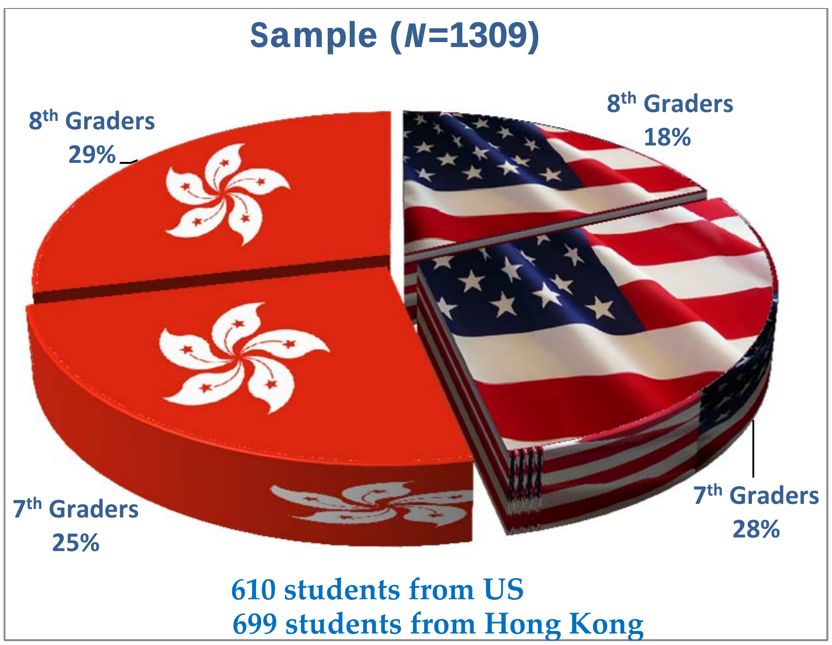

Figure 3.1 Percentage of the Sample from Each Grade Level and Country

To answer the three research questions of this study (see Section 3.1), statistical analyses (e.g. factor analyses) were conducted to determine the validity and reliability of the modified questionnaire (Section 3.4.1). Once the scales from the questionnaire were shown to be valid and reliable, differences between the USA and Hong Kong in terms of learning environment, attitudes towards mathematics and academic efficacy were investigated for each scale using multivariate analysis of variance and effect sizes (Section 3.4.2). Finally, associations between the learning environment and the student outcomes of attitudes towards mathematics and academic efficacy were analysed using simple correlation and multiple regression techniques (Section 3.4.3).

3.4.1 Validity and Reliability of Questionnaires

The modified questionnaire used in the present study included scales from the WIHIC, TOMRA, and MJSES, making a total of 56 items. Although these three instruments have been used extensively in the past, their use in this cross-national study involving the USA and an Asian country is distinctive. Because none of these instruments were used in their entirety as the original researchers had developed them, it was necessary to investigate whether combining four of the seven original WIHIC scales, two of the seven TOMRA scales, and one of the four MJSES scales would still produce a valid and reliable instrument for this cross-national study. Moreover, to determine whether both English and Chinese versions of the modified questionnaire exhibited essentially the same coherence and structure across the two cultures, the questionnaire was assessed for validity and reliability.

The validity of an instrument refers to the degree to which it measures what it is supposed to measure. The data from a valid instrument are meaningful and enable researchers to draw sound conclusions from the sample (Creswell, 2002). One method that is commonly used to determine the internal structure of an instrument is factor analysis. Using mathematical models, factor analysis allows researchers to reduce a large set of variables to a smaller, more manageable set of 'common' factors. The reliability of an instrument refers to the degree to which the data from an instrument are stable and consistent in measuring constructs. These measures of validity and reliability help to decide the level of confidence that researchers can have in the results obtained from using the instrument. Comparing the validity for an instrument for one sample with previous analyses from different samples enhances the credibility of the results based on data obtained from the instrument.

To determine the validity of measures of mathematics students' perceptions of classroom learning environments, attitudes toward mathematics, and academic efficacy in the USA and Hong Kong, quantitative data from the sample of 1,309 seventh and eighth grade mathematics students in 35 classes in the USA and 23 classes in Hong Kong were subjected to separate principal axis factoring with varimax rotation and Kaiser normalization for the modified questionnaire used in this study. This statistical analysis was conducted by using the IBM SPSS Statistics (2010) computer program. Varimax rotation (orthogonal factor rotation) with Kaiser normalization is a statistical technique used to identify potential factors by maximizing the variance and then isolating the factors for easy identification; hence, it yields information about the internal structure of an instrument. Factor loadings for individual items, which are the correlation coefficients between the variables and factors, were calculated to determine whether the majority of items belonged to one and only one of the scales. The criteria for an item to be retained were that it must have a factor loading of at least 0.40 on its own scale and less than 0.40 on all other scales. In addition, eigenvalues and the total percentage of variance from each scale were calculated to measure the amount of variation in scores accounted for by each factor and to determine the proportional contribution of each individual scale to the collective variance of all scales, respectively.

The reliability of a scale indicates how free it is from random error. The reliability of each scale in the present study was determined in terms of internal consistency, which refers to the degree to which the items that make up a scale are all measuring the same underlying attribute. Cronbach's alpha coefficient, one of the most commonly used indicators of internal consistency, was calculated in this study to provide an indication of the average correlation among all of the items that make up the scale (Pallant, 2007). The formula for the Cronbach's alpha coefficient is:

$$\alpha = \frac{N \bullet \overline{c}}{1 + (N-1) \bullet \overline{c}}$$

where N is the number of total items and $\overline{C}$ is the average of the correlation between each pair of items. Its value ranges from 1 to 0, with higher values indicating greater reliability.

The discriminant validity of each WIHIC, TOMRA and Academic Efficacy scale was measured by using the mean correlation of a scale with the other scales as a convenient index.

3.4.2 Investigation of Differences between USA and Hong Kong in Learning Environments, Attitudes towards Mathematics and Academic Efficacy

To investigate differences between students in the USA and Hong Kong in terms of their perceptions of the learning environment, attitudes towards mathematics, and academic efficacy, both descriptive and inferential statistics were used.

Descriptive statistics involved the average item mean (scale mean divided by the number of items in that scale) and average item standard deviation for the USA and Hong Kong for each learning environment, attitude and academic efficacy scale. The average item mean was used to enable meaningful comparisons of scales with different numbers of items. Its values range from 1 (almost never) to 5 (almost always) and indicate the frequency with which students perceive that practices related to each variable occur in the classroom.

Inferential statistics in terms of one-way multivariate analysis of variance (MANOVA), using the individual student as the unit of analysis, was used to investigate the statistical significance of differences between the USA and Hong Kong for set of the four WIHIC, two TOMRA and one academic efficacy scales. Because the multivariate test yielded statistically significant differences for the whole set of dependant variables using Wilks' lamda criterion, the univariate ANOVA was interpreted separately for each learning environment, attitude and academic efficacy scale. An F ratio was calculated, which represents the variance between students in the USA and students in Hong Kong, divided by the variance within the two countries. A large F ratio indicates that there is more variability between two countries (caused by the independent variable) than there is within each country (referred to as the error term). A significant F test indicates that the null hypothesis, which states that population means are equal (Pallant, 2007), can be rejected.

In addition, effect sizes were used to provide information about the magnitude of differences between the two groups. The effect size is computed by dividing the difference between the means for the two countries by the pooled standard deviation. Effect sizes can be interpreted as small (≤ 0.2 standard deviations), medium (0.5), or large (≥0.8) (Cohen, 1988).

3.4.3 Investigation of Associations between Learning Environment and Student Outcomes of Attitudes to Mathematics and Academic Efficacy

Associations between students' perceptions of the mathematics classroom learning environment and two types of student outcomes (attitudes and academic efficacy related to mathematics) were examined using simple correlation and multiple regression analyses. All analyses were performed separately for the two countries (the USA and Hong Kong). Simple correlation (r) analysis provided information about the bivariate association between each dependent variable of attitude and academic efficacy, and each independent variable of learning environment. Its value ranges from −1 to 1, with the size of the absolute value (ignoring the sign) providing an indication of the strength of the relationship (i.e. 1 means strong correlation, and 0 means no correlation). The sign in the front indicates whether there is a positive relationship (as one variable increases, the other increase as well) or a negative relationship (as one variable increase, the other decreases) (Pallant, 2007).

Multiple regression analysis was used to investigate the multivarite associations between the set of all learning environment scales and either attitudes towards mathematics or academic efficacy. The multiple regression analysis provided a test of the combined influence of the four correlated independent learning environment variables on each attitude and academic efficacy scale. This analysis provides an indication of the strength of the multivariate association between learning environment scales and either attitude or academic efficacy scales, and reduces the risk of a Type I error linked with the simple correlation analysis. Additionally, the standardized regression coefficients (β) were examined in order to determine which specific learning environment scales accounted for most of the variance in attitudes towards mathematics and academic efficacy when the other environment scales were mutually controlled.

3.5 Limitations

To assure manageability of the collected data, the instruments used in this study involved only closed-choice items and did not include open-ended response items. Critics of this quantitative research method would claim that the use of standardized measures, a limited number of predetermined response categories and rigidly-structured questionnaires provide only a broad overview of the learning environment (Patton, 2002, p. 14). There was a guarantee neither that students understood the meaning of questionnaire items exactly as the researchers intended, nor that they were attentive and honest when responding. Also, because the questionnaire was administrated by students' own mathematics teachers during the last week of school, it is possible that students were still worried about the confidentiality of their responses, and that therefore they were not completely honest and serious in responding. This led to a potential limitation with regard to the quantitative data-gathering method of the present study, namely, a possible lack of validity of the data obtained. With questionnaires, there is no opportunity to qualify students' answers or to explain their opinions more precisely (Barker, Pistrang, & Elliott, 2002).

Moreover, the sample in my study was not a true random sample as only classes from those teachers who were willing to participate in the study were used at each school. This also applies to the students as well. Only those students who had parental consent were used in the study. A true random sample is always an ideal in data collection, but realistically this is impossible in nearly all educational research studies because of the obligation of ethical conduct, such as parental consent and teachers' approval.

However, the modified learning environment, attitude and academic efficacy questionnaire used in the present study was based on What Is Happening In this Class? (WIHIC), Test of Mathematics-Related Attitudes (TOMRA), and Morgan-Jinks Student Efficacy Scale (MJSES), which have proven to be highly valid and reliable instruments when used previously with thousands of students at the elementary, secondary, and university levels, in many countries of the world, and across a wide range of subjects (Aldridge & Fraser, 2008; Aldridge, Fraser, & Huang, 1999; Allen & Fraser, 2007; Chionh & Fraser, 2009; Dorman, 2003; Kim, Fisher, & Fraser, 2000; B. A. Taylor & Fraser, 2013; Zandvliet & Fraser, 2004). Investigating students' perceptions of the learning environment through such previously-validated and reliable instruments in my study potentially could lead to many insights about what is happening within the walls of a mathematics classroom in the USA and Hong Kong. As well, using rigorous statistical procedures and having a relatively large sample size enhanced the credibility of my study. Besides, with regard to students' honesty, seriousness, and interest in the research, participant information sheets for both teachers and students, shown in Appendix A, were provided and explained clearly the purposes, procedures, voluntary participation and confidentiality of the research before the questionnaires were distributed. A sweet treat was given to those students who completed the questionnaire as a small token of appreciation for their participation.

Another limitation of the present study was the absence of a measure of achievement as a student outcome. As mentioned in Section 1.1 of Chapter 1, the Trends in International Mathematics and Science Study (TIMSS) (2012) indicated that students in Hong Kong generally had higher achievement in mathematics that did the students in the USA. However, my study involved no comparison of students in Hong Kong and the USA in terms of the mathematics achievement. In future research, it would be interesting to investigate associations between students' perceptions of the classroom environment and the outcome of achievement in both countries.

Lastly, because of the complexity of human experience in terms of students' perceptions of the learning environment, as well as differences between eastern and western cultures, it is difficult to rule out or control for all of the extraneous variables. Examples of some of the extraneous variables include the mood, fatigue or stress levels of the students when completing the questionnaires, cultural, social and pedagogical differences between the USA and Hong Kong, and teachers' convictions about the importance of establishing a positive learning environment. It should also be borne in mind that the mathematics curriculum, as well as the teaching approach, is quite different in these two countries. In the light of these factors, attempts were made to ensure that the samples selected in each of Hong Kong and the USA were as similar as possible, particularly with respect to students' ages. Nevertheless, as in all cross-national studies, the equivalence of the samples in two different countries cannot be guaranteed.

3.6 Summary

This chapter described the research methodology used in the present study, including the instruments for assessing students' perceptions of their mathematics classroom learning environments, attitudes towards mathematics and academic efficacy in the USA and Hong Kong, the procedures for data collection, and the data analysis methods.

Section 3.2 – Instruments Used for Data Collection – provided a detailed review of instruments. Four scales of the What Is Happening In this Class? (WIHIC) questionnaire (Section 3.2.1), two scales of the Test of Mathematics-Related Attitudes (TOMRA) (Section 3.2.2), and an academic self-efficacy scale from the Morgan-Jinks Student Efficacy Scale (MJSES) (Section 3.2.3) were used to assess, respectively, perceptions of the learning environment, attitudes towards mathematics, and academic efficacy. The modified questionnaire was translated into Chinese and then back translated into English by a mathematics teacher who was not involved in the original translation (as recommended by Brislin, 1970) in order to accommodate students' language needs (Section 3.2.4).

Section 3.3 entitled Data Sources and Sample clarified the procedures of data collection and the sources of the data. Data were collected from a sample of 610 students from the USA and 699 from Hong Kong, making of a total 1,309 seventh and eighth grade students in 58 classes at three junior high schools in the Clovis Unified School District in California, USA and three secondary schools in Hong Kong.

Section 3.4 – Methods of Data Analysis – described statistical analyses conducted in this study. To answer the first research question of this study (Is it possible to develop valid and reliable measures of mathematics students' perceptions of classroom learning environments, attitudes toward mathematics, and academic efficacy in the USA and Hong Kong?), data derived from the modified questionnaire involving scales from the WIHIC, TOMRA and MJSES were subjected to separate factor analysis, reliability analysis, and discriminant validity analysis to determine the validity and reliability of the modified questionnaire (Section 3.4.1).

To answer the second research question of this study (Are there differences between students in the USA and Hong Kong in terms of perceptions of the learning environment, attitudes towards mathematics, and academic efficacy?), both descriptive statistics (in terms of the average item mean and average item standard deviation) and inferential statistics (in terms of analysis of variance) were used (Section 3.4.2). Moreover, effect sizes were calculated to provide information about the magnitude of differences between the two groups expressed in standard deviation units.

To answer the third research question of this study (Are there associations between students' perceptions of their mathematics classroom learning environment and two types of student outcomes – attitudes and academic efficacy related to mathematics?), simple correlation and multiple regression analyses were carried out, using the individual student as the unit of analysis (Section 3.4.3).

Some of the study's potential limitations were addressed in Section 3.5. The findings from each statistical analysis are reported in the next chapter to provide answers to my research questions.

Chapter 4

ANALYSES AND RESULTS

4.1 Introduction

The main objective of the present study was to compare mathematics classes in Hong Kong and the USA in terms of classroom learning environments, attitudes toward mathematics, and academic efficacy. As previously discussed in Chapter 3 — Research Methodology, the questionnaire used in the present study consisted of parts of three previously-validated and reliable instruments, making a total of 56 items. The learning environments were assessed using four scales from the What Is Happening In this Class? (WIHIC): Teacher Support, Involvement, Cooperation, and Equity. Attitudes towards mathematics were quantified by using two scales from the Test of Mathematics-Related Attitudes (TOMRA): Attitudes Towards Mathematical Inquiry and Enjoyment of Mathematics. Another scale, Academic Efficacy, from Aldridge and Fraser's (2008) adaptation of Morgan-Jinks Student Efficacy Scale (MJSES), was included to measure students' self-concept as it relates to their mathematics ability.

The questionnaire was translated into Chinese to accommodate the language needs of students in Hong Kong. During the development of the Chinese version of the questionnaires, a back-translation check (as described and recommended by Brislin, 1970) was used to achieve linguistic equivalence with the English version (see Section 3.2.4). Before valid comparisons could be made between the two countries based on the WIHIC, attitudes, and academic efficacy scales, it was important to establish the conceptual equivalence (J. W. Berry, 1980) between the two versions of the questionnaires. To determine whether the two versions of the questionnaire exhibited essentially the same coherence and structure across the two cultures, the data collected from seventh and eighth grade students (N = 1309) from 35 classes in the USA and 23 classes in Hong Kong were analyzed to investigate the validity and reliability.

This chapter describes the data analyses and discusses the findings under four sections. Section 4.2 – Validity and reliability of the learning environment, attitudes towards mathematics and academic efficacy scales – provides the results of a principal axis factor analysis for the learning environment (Section 4.2.1), attitudes towards mathematics and academic efficacy (Section 4.2.2) scales. This section also reports internal consistency reliability and discriminant validity for the learning environment, attitude towards mathematics and academic efficacy scales (Section 4.2.3). Section 4.3 – Differences between USA and Hong Kong in learning environments, attitudes towards mathematics and academic efficacy – reports differences between USA and Hong Kong classrooms for the learning environment, attitudes towards mathematics and academic efficacy scales. Associations between the learning environment and attitudes towards mathematics and academic efficacy are reported in Section 4.4. Lastly, Section 4.5 provides a summary and conclusion of this chapter.

4.2 Validity and Reliability of the Learning Environment, Attitude and Academic Efficacy Scales

To answer the first research question of this study (*Is it possible to develop valid and reliable measures of mathematics students' perceptions of classroom learning environments, attitudes toward mathematics, and academic efficacy in the USA and Hong Kong?*), quantitative data from the sample of 1,309 Grade 7 and 8 mathematics students in 35 classes in the USA and 23 classes in Hong Kong were subjected to separate principal axis factoring with varimax rotation and Kaiser normalization for the modified questionnaire used in this study. This technique has the ability to identify factors by maximizing the variance and then isolating the factors for easy identification. Eigenvalues and the total percentage of variance from the factor analyses were used to determine factor strength as well. In addition, internal consistency reliability was measured by using Cronbach's alpha coefficient and discriminant validity was measured by using the mean correlation of a with the other scales in that instrument.

4.2.1 Validity of WIHIC Scales

Table 4.1 shows the factor analysis results for the 32 items in four modified WIHIC scales (Teacher Support, Involvement, Cooperation, and Equity). A factor analysis was conducted separately for the classes from the USA and Hong Kong. Principal axis factor analyses with varimax rotation and Kaiser normalization confirmed that the majority of items belonged to one and only one of the four scales. The two criteria for the retention of any item were that it must have a factor loading of at least 0.40 on its own scale and less than 0.40 on all other three scales. The *a priori* factor structure of both the English and Chinese versions of the questionnaire was replicated in both countries, with 29 out of the 32 items having a factor loading above 0.04 on their *a priori* scales and no other scale (see Table 4.1). The three items that had factor loadings less than 0.04 were omitted from the questionnaire for all subsequent analyses. These items were #3 ("The teacher would consider my feelings") in Teacher Support, #15 ("Students would discuss with me how to go about solving problems") and #16 ("I would be asked to explain how I solve problems") in Involvement.

The percentage of variance for the USA reported in Table 4.1 ranged from 4.81% to 33.59% for different scales, with a total variance of 56.06%. For Hong Kong, the percentage of variance for different scales ranged from 4.87% to 40.25%, with a total variance of 60.52%. Eigenvalues associated with each factor ranged from 1.54 to 10.59 and from 1.56 to 12.88 for the USA and Hong Kong, respectively.

The results of the factor analysis for my study are comparable to those of previous studies that demonstrated similar factor structures using the WIHIC questionnaire, thus supporting this factor structure. For example, a cross-national study that utilized the WIHIC with 1,879 Taiwanese students and 1,081 Australian students in 50 junior high school science classes in each country (Aldridge, Fraser, & Huang, 1999) revealed average factor loadings for Teacher Support, Involvement, Cooperation, and Equity of 0.61, 0.54, 0.55, and 0.66, respectively. In the present study, the average factor loadings were somewhat higher at 0.61, 0.60, 0.68, and 0.69 for different scales. The percentage of variance in Aldridge et al.'s study for Australia ranged from 1.70% to 27.30% for different scales, with a total variance of 50.00%.

For Taiwan, the percentage of variance for different scales ranged from 1.50% to 29.20%, with a total variance of 49.30%. Eigenvalues associated with each factor ranged from 0.97 to 15.27 and from 0.82 to 16.35 for Australia and Taiwan, respectively.

Table 4.1 Factor Analysis Results for the WIHIC in USA and Hong Kong

Item	Factor Loadings							
	Teacher Support		Involvement		Cooperation		Equity	
	USA	HK	USA	HK	USA	HK	USA	HK
TS1	0.63	0.67						
TS2	0.61	0.66						
TS4	0.42	0.55						
TS5	0.69	0.64						
TS6	0.73	0.74						
TS7	0.56	0.62						
TS8	0.44	0.57						
IN9			0.72	0.63				
IN10			0.78	0.76				
IN11			0.49	0.42				
IN12			0.67	0.64				
IN13			0.52	0.47				
IN14			0.56	0.51				
CO17					0.66	0.64		
CO18					0.64	0.60		
CO19					0.66	0.70		
CO20					0.59	0.71		
CO21					0.58	0.69		
CO22					0.76	0.77		
CO23					0.77	0.76		
CO24					0.66	0.66		
EQ25							0.70	0.50
EQ26							0.72	0.70
EQ27							0.72	0.70
EQ28							0.74	0.67
EQ29							0.73	0.70
EQ30							0.72	0.67
EQ31							0.61	0.71
EQ32							0.68	0.71
% Variance	4.81	8.86	8.41	4.87	9.25	40.25	33.59	6.54
Eigenvalue	1.54	2.84	2.69	1.56	2.97	12.88	10.59	2.09

N= 1309 students (USA=610, HK=699)
Factor loadings less than 0.40 have been omitted from the table.
Principal axis factoring with varimax rotation and Kaiser normalization.
Items TS3, IN15 and IN16 were omitted.

Another cross-national study conducted by Dorman (2003) used confirmatory factor analysis with WIHIC data with a sample of 3,980 grades 8, 10 and 12 mathematics students from England, Canada and Australia. When Dorman selected six items from each WIHIC scale, the high average factor loadings for Teacher Support, Involvement, Cooperation, and Equity were 0.85, 0.87, 0.81, and 0.88, respectively.

In a more recent cross-national study with a sample of 594 Indonesian students and 567 Australian students, Fraser, Aldridge and Adolphe (2010) used the modified WIHIC in both English and Bahasa Indonesian languages and reported that average factor loadings were 0.60, 0.55, and 0.65, respectively, for Teacher Support, Involvement, and Equity (Cooperation was not used in their study). The total percentage of variance was 40.69% for Australia and 46.25% for Indonesia. Eigenvalues associated with each factor ranged from 1.88 to 10.44 and from 1.75 to 14.44 for the Australia and Indonesia, respectively.

4.2.2 Validity of Attitude and Academic Efficacy Scales

Table 4.2 shows the factor analysis results for the 24 items in two TOMRA scales and one MJSES scale (Attitudes towards Mathematical Inquiry, Enjoyment of Mathematics, and Academic Efficacy). A factor analysis was conducted separately for the classes from the USA and Hong Kong. Principal axis factor analysis with varimax rotation and Kaiser normalization confirmed that the majority of items belonged to one of the three scales and eigenvalues were above unity.

The *a priori* factor structure of both English and Chinese versions of the questionnaire was replicated in both countries, with 23 out of the 24 items having a factor loading above 0.40 on their *a priori* scales and no other scale (see Table 4.2). Item #54 ("I have to work hard to pass mathematics") in the Academic Efficacy, that had a factor loading less than 0.40 on its own scale, was omitted. The percentage of variance for different scales for the USA ranged from 10.71% to 38.47%, with a total variance of 60.35%. For Hong Kong, the percentage of variance ranged from 6.08% to 46.49%, with a total variance of 66.27%. Eigenvalues associated with each factor ranged from 2.57 to 9.23 and from 1.45 to 11.16 for the USA and Hong Kong, respectively.

Table 4.2 Factor Analysis Results for Attitude Questionnaire in USA and Hong Kong

Item	Factor Loadings					
	Attitude to Inquiry		Enjoyment		Academic Efficacy	
	USA	HK	USA	HK	USA	HK
INQ33	0.57	0.62				
INQ34	0.48	0.68				
INQ35	0.65	0.71				
INQ36	0.62	0.67				
INQ37	0.61	0.73				
INQ38	0.67	0.68				
INQ39	0.62	0.65				
INQ40	0.42	0.69				
ENJ41			0.82	0.82		
ENJ42			0.85	0.85		
ENJ43			0.74	0.80		
ENJ44			0.72	0.83		
ENJ45			0.83	0.86		
ENJ46			0.83	0.82		
ENJ47			0.86	0.70		
ENJ48			0.79	0.77		
AE49					0.75	0.65
AE50					0.85	0.71
AE51					0.70	0.68
AE52					0.79	0.72
AE53					0.78	0.73
AE55					0.56	0.48
AE56					0.58	0.66
% Variance	10.71	13.70	38.47	46.49	11.17	6.08
Eigenvalue	2.57	3.28	9.23	11.16	2.86	1.45

N= 1309 students (USA=610, HK=699)
Factor loadings less than 0.40 have been omitted from the table.
Principal axis factoring with varimax rotation and Kaiser normalization.
Items AE54 was omitted.

The results of the factor analysis for this study are comparable to those of previous studies that demonstrated similar factor structures using the attitude and academic efficacy scales, thus supporting this factor structure. In a similar study with a sample of 600 grade 9 and 10 mathematics students from 30 classes in Miami-Dade County, Florida, Castillo, Peiro and Fraser (2006) reported that average factor loadings were 0.73, 0.68 and 0.63 for Attitude to Inquiry, Enjoyment and Student Self-Efficacy, respectively. The total percentage of variance accounted for by these three scales was 62.50%. In contrast to the present study, the total percentages of variance for the USA and Hong Kong were 60.35% and 66.27%, respectively.

In a large study in Western Australia and Tasmania, the attitude and academic efficacy scales were administered to a sample of 2,317 students from 166 grade 11 and 12 classes (Aldridge & Fraser, 2008). The average factor loadings for Attitude to Subject and Academic Efficacy were 0.71 and 0.74, respectively. The percentages of variance for these two scales were 16.1% and 25.46%.

4.2.3 Internal Consistency Reliability and Discriminant Validity of WIHIC, Attitude towards Mathematics and Academic Efficacy Scales

Cronbach's alpha coefficient was used as an index of the internal consistency reliability of the refined questionnaire scales after the factor analyses led to the removal of Items TS3, IN15 and IN16. Table 4.3 shows that Cronbach's alpha coefficient was high (≥0.80) for all the WIHIC, Attitude and Academic Efficacy scales. Using the individual as the unit of analysis, the reliability coefficients ranged from 0.82 (Inquiry) to 0.95 (Enjoyment) for the USA and from 0.85 (Involvement) to 0.96 (Enjoyment) for Hong Kong. This supports the strong internal consistency reliability of all scales in both countries.

Table 4.3 Internal Consistency Reliability (Cronbach's Alpha Coefficient) and Discriminant Validity (Mean Correlation with Other Scales) for Learning Environment, Attitude and Academic Efficacy Scales

Scale	No. of Items	Alpha Reliability		Mean Correlation	
		USA	HK	USA	HK
Learning Environment					
Teacher Support	7	0.86	0.87	0.37	0.45
Involvement	6	0.84	0.85	0.36	0.51
Cooperation	8	0.89	0.91	0.33	0.39
Equity	8	0.91	0.91	0.38	0.45
Attitudes towards Mathematics					
Inquiry	8	0.82	0.89	0.30	0.31
Enjoyment	8	0.95	0.96	0.34	0.47
Academic Efficacy	7	0.91	0.92	0.33	0.44

N=1309 students (USA=610, HK=699)

The mean correlation of a scale with the other scales was used as a convenient index of discriminant validity, or independence, of each WIHIC, Attitude and Academic

Efficacy scale. The discriminant validity for the WIHIC ranged from 0.33 to 0.38 in the USA and from 0.39 to 0.51 in Hong Kong. The discriminant validity for the Attitude and Academic Efficacy scale ranged from 0.30 to 0.34 in the USA and from 0.31 to 0.47 in Hong Kong. These confirm a reasonable level of independence among scales between raw scores on the WIHIC, Attitude and Academic Efficacy scales, with the factor analyses attesting to the independence of factor scores.

4.3 Differences between USA and Hong Kong in Learning Environments, Attitudes towards Mathematics and Academic Efficacy

To answer the second research question of this study (*Are there differences between students in the USA and Hong Kong in terms of perceptions of the learning environment, attitudes towards mathematics, and academic efficacy?*), descriptive statistics, inferential statistics and effect sizes were used.

Descriptive statistics in terms of the average item mean and average item standard deviation for each country are provided in Table 4.4 for each scale. Figure 4.1 graphically compares the average item mean (scale mean divided by the number of items in that scale) for the USA and Hong Kong for each learning environment, attitude and academic efficacy scale. The average item mean was used to enable meaningful comparisons of scales with different numbers of items. For all learning environment, attitudes towards mathematics and academic efficacy scales, scores greater that '3' indicate that students perceived practices related to each variable as occurring more frequently than *sometimes* and in the direction of *often* or *almost always*. Scores of less than '3' indicate that these practices were perceived as happening less frequently than *sometimes* and in the direction of *seldom* or *almost never*.

Inferential statistics involving one-way multivariate analysis of variance (MANOVA), using the individual student as the unit of analysis, were used to investigate the statistical significance of differences between the USA and Hong Kong for each learning environment, attitude and academic efficacy scale scores. Because the multivariate test yielded statistically significant of differences for the whole set of dependent variables using Wilks' lamda criterion, the univariate

ANOVA was interpreted separately for each learning environment, attitude and academic efficacy scale. The ANOVA results recorded in the second last column of Table 4.4 indicate that differences between students in the USA and students in Hong Kong were statistically significant (p<0.01) for: the three WIHIC scales of Teacher Support, Cooperation, and Task Orientation; the two attitudes towards mathematics scales of Inquiry and Enjoyment; and academic self-efficacy scale.

Table 4.4 Average Item Mean, Average Item Standard Deviation and Difference (ANOVA Result and Effect Size) between the USA and Hong Kong for each Learning Environment, Attitude and Academic Efficacy Scale

Scale	Average Item Mean		Average Item SD		Difference	
	USA	HK	USA	HK	*F*	Effect size
Learning Environment						
Teacher Support	3.67	3.21	0.83	0.77	3.19**	0.56
Involvement	2.97	2.94	0.88	0.81	0.72	0.02
Cooperation	3.93	3.01	0.84	0.80	3.69**	0.75
Equity	4.19	3.23	0.85	0.84	4.52**	1.13
Attitudes towards Mathematics						
Inquiry	3.39	2.84	0.86	0.85	3.39**	0.64
Enjoyment	2.65	3.07	1.14	1.11	2.61**	– 0.38
Academic Efficacy	3.63	2.82	0.98	0.99	3.83**	0.82

**p<0.01
N=1309 students (USA=610, HK=699)

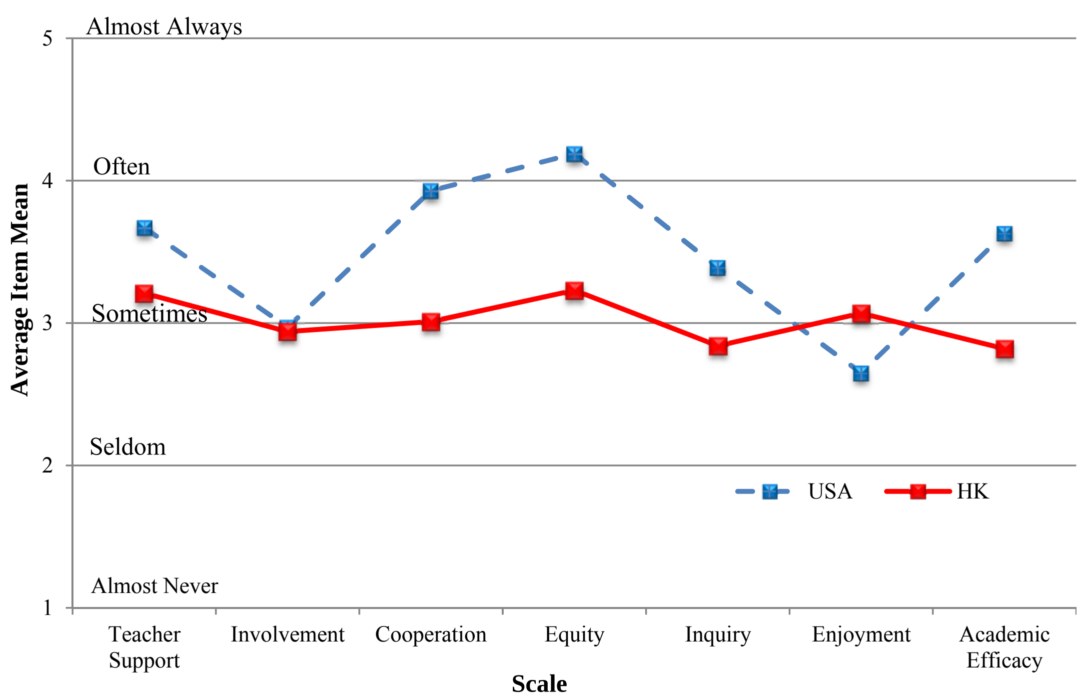

Figure 4.1 Average Item Mean for USA and Hong Kong for Each Learning Environment, Attitude and Academic Efficacy Scale

In order to estimate the magnitudes of the differences between students in the USA and Hong Kong (in addition to their statistical significance), effect sizes ware calculated and recorded in the last column of Table 4.4. The effect size is computed by dividing the difference between the means of the two countries by the pooled standard deviation. Effect sizes, which express a difference in standard deviation units, can be interpreted as small (≤ 0.2), medium (between 0.2 and 0.5), or large (≥ 0.8) (Cohen, 1988).

With effect sizes of over half of a standard deviation, the differences between two countries were sizeable in magnitude for nearly all scales for which differences were statistically significant. For the three learning environment scales, effect sizes ranged from 0.56 standard deviations (Teacher Support) to 1.13 standard deviations (Equity). The effect size for each of attitude and academic efficacy scale was over one third of a standard deviations, ranging from –0.38 standard deviations (Enjoyment) to 0.82 standard deviations (Academic Efficacy), also indicating a medium to large difference between countries.

The results reveal that USA students consistently perceived their learning environments more favorably than did the Hong Kong students, but an interesting anomaly arose in that students in Hong Kong expressed significantly more enjoyment of their mathematics classes than did students in the USA ($p<0.01$). The effect size for Enjoyment was over one third of a standard deviations (0.38), also suggesting a medium difference between countries. This finding showed a similar pattern to a cross-cultural study conducted by Aldridge and Fraser (2000) with 1,879 Taiwanese students and 1,081 Australian students in 50 junior high school science classes. Aldridge and Fraser reported that Australian students perceived their learning environments more positively than did Taiwanese student, but students in Taiwan had more positive attitudes towards science classes than students in Australia.

4.4 Associations between Learning Environment and Student Outcomes of Attitudes towards Mathematics and Academic Efficacy

The third research question of this study was: *Are there associations between students' perceptions of their mathematics classroom learning environment and two types of student outcomes (attitudes and academic efficacy related to mathematics)?* In order to answer this question, simple correlation and multiple regression analyses were carried out, using the individual student as the unit of analysis.

The results of the simple correlation and multiple regression analyses are reported in Table 4.5. Simple correlations (*r*) describe the bivariate association between the dependent variables of attitude and academic efficacy, and each of the four learning environments scales. Table 5.2 shows that the correlation of every learning environment scale with every attitude and academic efficacy scale was statistically significant ($p<0.01$).

Table 4.5 Simple Correlation and Multiple Regression Analyses for Associations between Learning Environment and Attitude Scales

Scale	Country	Inquiry		Enjoyment		Academic Efficacy	
		r	β	*r*	β	*r*	β
Teacher Support	USA	0.24**	0.02	0.31**	0.09	0.23**	-0.05
	Hong Kong	0.25**	0.03	0.47**	0.21**	0.34**	0.02
Involvement	USA	0.26**	0.15**	0.32**	0.22**	0.30**	0.20**
	Hong Kong	0.33**	0.26**	0.51**	0.29**	0.51**	0.45**
Cooperation	USA	0.25**	0.09*	0.18**	-0.04	0.27**	0.10*
	Hong Kong	0.17**	0.06	0.36**	0.05	0.30**	0.00
Equity	USA	0.29**	0.19**	0.32**	0.21**	0.32**	0.23**
	Hong Kong	0.29**	0.16**	0.42**	0.08*	0.35**	0.07
Multiple Correlation (*R*)	USA		0.35**		0.40**		0.39**
	Hong Kong		0.36**		0.56**		0.51**

$*p<0.05, **p<0.01$

N=1309 students (USA=610, HK=699)

The multiple correlation (*R*) analysis provides a test of the combined influence of the four independent learning environment variables on attitudes and academic efficacy. This analysis provides an indication of the strength of the multivariate association between learning environment scales and attitude and academic efficacy scales, and reduces the risk of a Type I error linked with simple correlation analysis. The multiple correlations between the set of four learning environment scales and the three scales of Attitudes towards Mathematical Inquiry (R= 0.35 for the USA and R=0.36 for Hong Kong), Enjoyment of Mathematics (R=0.40 for the USA and R=0.56 for Hong Kong), and Academic Efficacy (R=0.39 for the USA and R=0.51 for Hong Kong) were statistically significant (p<0.01) for both countries, as shown in Table 4.5.

The regression coefficients (β) were examined in order to determine which specific learning environment scales accounted for most of the variance in attitudes towards mathematics and academic self-efficacy when the other environment scales were mutually controlled. For the USA, the learning environment scale of Equity had the largest independent influence (β=0.19; p<0.01) on Attitudes towards Mathematical Inquiry, although Involvement and Cooperation were also significant independent predictors (β=0.15; p<0.01 and β=0.09; p<0.05, respectively). For Hong Kong, the learning environment scale of Involvement had the largest independent influence (β=0.26; p<0.01) on Attitudes towards Mathematical Inquiry, although Equity was also significant independent predictor (β=0.16; p<0.01).

For Enjoyment of Mathematics, Involvement was a significant independent predictor (β=0.22; p<0.01 and β=0.29; p<0.01, respectively) in the both countries, Equity was a significant independent predictor in both countries and Teacher Support was a significant independent predictor (β=0.20; p<0.01) in Hong Kong.

When using Academic Efficacy as the dependent variable, the learning environment scale of Involvement was significant independent predictor (β=0.20; p<0.01 and β=0.45; p<0.01, respectively) in both countries, while Cooperation (β=0.10; p<0.05) and Equity (β=0.23; p<0.01) were significant independent predictor in the USA.

It is interesting to consider differences between the USA and Hong Kong in terms of the strength of the multivariate association between the set of learning environment scales and each attitude scale.

For Attitudes towards Mathematical Inquiry, Table 4.5 shows that the magnitude of the multivariate association with learning environment scales was highly similar for the USA (R= 0.35) and Hong Kong (R= 0.36).

For Enjoyment of Mathematics, the magnitude of the multivariate association with learning environment scales was stronger for Hong Kong (R= 0.56) than for the USA (R= 0.40). Although both Involvement and Equity were significant independent predictors of Enjoyment in both countries, Teacher Support was a significant independent determinant of Enjoyment in Hong Kong but not in the USA. See Table 4.5.

For Academic Efficacy, the magnitude of the multivariate association with learning environment scales also was stronger for Hong Kong (R= 0.51) than for the USA (R= 0.39). Although Involvement was a significant independent predictor of Academic Efficacy in both countries, Involvement was a stronger independent determinant of Academic Efficacy in Hong Kong (β=0.45) than in the USA (β=0.20)

The direction of all statistically significant bivariate and multivariate relationships in Table 4.5 clearly indicates that a positive association between learning environment and students' attitudes towards mathematics/academic self-efficacy existed. This replicates considerable prior research (Fraser, 2012; Fraser, Aldridge, & Adolphe, 2010; Kim, Fisher, & Fraser, 2000) that has established links between a positive classroom environment and positive student attitudes.

4.5 Summary and Conclusion

The chapter reported the analyses and results for the three research questions of the present study:

1) *Is it possible to develop valid and reliable measures of mathematics students' perceptions of classroom learning environments, attitudes toward mathematics, and academic efficacy in the USA and Hong Kong?*

2) *Are there differences between students in the USA and Hong Kong in terms of perceptions of the learning environment, attitudes towards mathematics, and academic efficacy?*

3) *Are there associations between students' perceptions of their mathematics classroom learning environment and two types of student outcomes (attitudes to mathematics and academic self-efficacy related to mathematical tasks)?*

Quantitative data were collected from a sample of 610 students from the USA and 699 from Hong Kong, making of a total 1,309 seventh and eighth grade students in 58 classes at three junior high schools in the Clovis Unified School District in California, USA and three secondary schools in Hong Kong. Data were derived from a questionnaire involving scales from the What Is Happening In this Class? (WIHIC), Test of Mathematics-Related Attitudes (TOMRA) and Morgan-Jinks Student Efficacy Scale (MJSES). The questionnaire was offered in English and Chinese to accommodate students' language needs.

Section 4.2 provided the results of factor analysis for the learning environment (Section 4.2.1) and attitudes towards mathematics and academic efficacy scales (Section 4.2.2). A factor analysis was conducted separately for the classes from the USA and Hong Kong. Principal axis factor analyses with varimax rotation and Kaiser normalization confirmed that the majority of items belonged to one and only one of the seven scales. Table 4.1 showed the factor analysis results for the 32 items in four modified WIHIC scales (Teacher Support, Involvement, Cooperation, and Equity), whereas Table 4.2 showed the factor analysis results for the 24 items in two TOMRA scales and one MJSES scale (Attitudes towards Mathematical Inquiry, Enjoyment of Mathematics, and Academic Efficacy). Together, the four learning environment scales accounted for a total proportion of variance of 56.06% for the USA and 60.52% for Hong Kong. For the three attitude/efficacy scales, the total proportion of variance was 60.35% for the USA and 66.27% for Hong Kong.

Section 4.2 also reported internal consistency reliability and discriminant validity for the learning environment, attitude towards mathematics and academic efficacy scales (Section 4.2.3). Cronbach's alpha coefficient, used as an index of the internal consistency reliability, was high (≥0.80) for all the WIHIC, Attitude and Academic Efficacy scales, which supported the strong internal consistency of all scales in both countries. The mean correlation of a scale with the other scales, used as a convenient index of discriminant validity, confirmed a reasonable level of independence among raw scores on the WIHIC, Attitude and Academic Efficacy scales, with the factor analyses attesting to the independence of factor scores.

The results of the factor analyses, internal consistency reliability and discriminant validity provided strong evidence supporting the validity and reliability of measures of students' perceptions of the learning environment, attitudes towards mathematics, and academic efficacy. Although scales came from three different instruments, the modified questionnaire was suitable and applicable to different countries. This is supported by the fact that 52 out of the 56 items had factor loadings greater than 0.40 on their *a priori* scales and no other scale, very high Cronbach's alpha coefficients for all scales, and satisfactory discriminant validity results,

Section 4.3 – Differences between USA and Hong Kong in learning environments, attitudes towards mathematics and academic efficacy – reported that differences between the USA and Hong Kong for each learning environment, attitudes towards mathematics and academic efficacy scale were statistically significant. Students in the USA perceived their learning environments significantly more positively than did the Hong Kong students, but Hong Kong students enjoyed their classes more than USA students. For the scales for which between-country differences were statistically significant, effect sizes ranged from 0.38 to 1.13 standard deviations.

The present study also investigated associations between students' perceptions of mathematics classroom learning environment and two types of student outcomes, namely, attitudes to mathematics and academic efficacy (Section 4.4). Data analyses indicated that a positive association existed between learning environment and students' attitudes to mathematics/academic efficacy. The simple correlation was statistically significant ($p<0.01$) between each learning environment scale and each attitude to mathematics and academic efficacy scale for both countries. The multiple correlation (R) between the set of four learning environment scales and each attitude to mathematics and academic efficacy scale was statistically significant for both countries as well.

In conclusion, the three research questions of the present study have been adequately answered. The modified questionnaire was found to exhibit sound factorial validity and reliability for measuring students' perceptions classroom learning environments, attitudes toward mathematics, and academic efficacy in both the USA and Hong Kong (Research Question #1). Statistically significant and sizeable differences emerged between the USA and Hong Kong classrooms for most environment and attitude scales (Research Question #2). Statistically significant and positive associations were found between the learning environment and the student outcomes of attitudes towards mathematics and academic efficacy (Research Question #3).

Chapter 5

DISSCUSSION AND CONCLUSION

5.1 Introduction

"Students' success in mathematics depends on the teacher more than on any other factor. Teachers must strive to create an environment that enhances the mathematical understanding of all students" (Curriculum Development and Supplemental Materials Commission (California), 2005, p. 241). Research has been conducted in the learning environments field for over 40 years (Fraser, 2012), but relatively few studies have been conducted in mathematics classes. My study is distinctive in that it was the first cross-national study of mathematics classroom learning environments, attitudes towards mathematics, and academic efficacy involving the USA and Hong Kong.

This chapter begins with a summary of the thesis and the research questions which guided the present study in Section 5.2. A discussion of the major findings from the data analyses are provided in Section 5.3. Section 5.4 reviews distinctive contributions of my study, including its significance and implications. Section 5.5 identifies the limitations and constraints of this study. Recommendations for future research follow in Section 5.6. Finally, concluding remarks are provided in Section 5.7.

5.2 Summary of Thesis

The purpose of the present cross-national study was to compare mathematics classes in Hong Kong and the USA in terms of classroom learning environment, attitudes toward mathematics, and academic efficacy. The following three objectives governed my study:

1. To validate learning environment, attitude and academic efficacy questionnaires for use in mathematics classes in the USA and Hong Kong

2. To investigate differences between the USA and Hong Kong in terms of students':
   - Perceptions of the learning environment
   - Attitudes towards mathematics
   - Academic efficacy
3. To explore associations between students' perceptions of mathematics classroom learning environment and the student outcomes of attitudes towards mathematics and academic efficacy.

Chapter 1 provided an introduction and overview of the thesis. The background, purposes and research questions for the present study were identified in this initial chapter. The significance of the study was also stated, as well as an overview of the thesis being provided.

Chapter 2 included comprehensive literature reviews of three main areas of my study: learning environments, attitudes toward mathematics, and academic efficacy. This chapter was divided into seven major sections — Section 2.1: Introduction; Section 2.2: Historical Background of Classroom Learning Environments; Section 2.3: Development of Learning Environment Instruments; Section 2.4: Use of Learning Environment Scales in Evaluation of Educational Innovations; Section 2.5: Associations between Learning Environments and Student Outcomes; Section 2.6: Attitudes towards Mathematics and Academic Efficacy; and Section 2.7: Summary of Literature Review.

Sections 2.1 and 2.2 reviewed literature describing the term 'learning environment' and its historical background, beginning with the pioneering work in the field of social sciences by Lewin (1936) and Murray (1938), who first investigated the effect of psychosocial environments, and followed by the work of Walberg and Moos specifically on perceptions of classroom environment in the late 1960s. Their work led to the development of the first learning environment instruments used in school settings, namely, the Learning Environment Inventory (Walberg & Anderson, 1968), Classroom Environment Scale (CES, Moos, 1974; Moos & Trickett, 1974, 1987), My Class Inventory (Fisher & Fraser, 1981), Individualised Classroom Environment Questionnaire (Rentoul & Fraser, 1979), and College and University Classroom

Environment Inventory (Fraser & Treagust, 1986). Throughout the 1990s and 2000s, at least seven more important instruments were developed to assess unique settings and purposes, such as teacher–student interaction, science and computer laboratories, constructivist learning environments, and web-based and technology-rich outcomes-focused learning environments.

Twelve learning environment instruments were summarized in Section 2.3 and Table 2.1. Section 2.3 also reviewed noteworthy studies associated with each instrument. Because the What Is Happening In this Class? (WIHIC) questionnaire was the primary research instrument in the present study, considerable detail on past research utilizing the WIHIC at different grade levels, as well as cross-national studies, was provided in this section. Section 2.4 specifically reviewed the use of learning environment scales in the evaluation of educational innovations and Section 2.5 focused on past studies involving associations between the learning environment and students' cognitive and affective learning outcomes.

Section 2.6 reviewed the development and validation of TOMRA, which is a modified version of the Test of Science-Related Attitudes (TOSRA) developed by Fraser (1978, 1981) to assess science-related attitudes among secondary school students. Also, this section defined the term 'academic efficacy' and reviewed past research involving associations between the learning environment and academic efficacy.

Chapter 3 described the methods of the present study. The questionnaire that I used to measure students' perception of their mathematics classroom environment in the present study consisted of parts of three previously-validated and reliable instruments:

1) What Is Happening In this Class? (WIHIC) questionnaire (Section 3.2.1)
2) Test of Mathematics-Related Attitudes (TOMRA) (Section 3.2.2)
3) Morgan-Jinks Student Efficacy Scale (MJSES) (Section 3.2.3).

The development of a Chinese version of the questionnaire for this study was described in Section 3.2.4. The sample comprised 610 students in 35 classes from the USA and 699 students in 23 classes from Hong Kong, making of a total 1,309 seventh and eighth grade students in 58 classes, at three junior high schools in the Clovis Unified School District in California, USA and three secondary schools in Hong Kong. The details of the data sources, the sample and the procedures for data collection were provided in Section 3.3.

After the questionnaire scales were selected and the data were collected, statistical analyses were undertaken in order to answer the research questions. Section 3.4 provided details about how I used factor analyses to validate the modified questionnaire and how internal consistency reliability and discriminant validity were determined.

To investigate the statistical significance of differences between the USA and Hong Kong for the four WIHIC scales, the two TOMRA attitude scales and an academic efficacy scale as the set of seven dependent variables, MANOVA was used. In addition, the effect size was used to provide information about the magnitude of differences between the two groups.

Associations between students' perceptions of the mathematics classroom learning environment and two types of student outcomes (attitudes to mathematics and academic efficacy) were examined using simple correlation and multiple regression analyses. Multiple regression analysis was used to identify the multivarite associations between the set of all learning environment scales and either attitudes towards mathematics or academic efficacy.

Chapter 3 was concluded by discussing some limitations associated with the methods used in this study.

All the results for each statistical test were reported in Chapter 4, including the validity and reliability of the learning environment, attitudes towards mathematics and academic efficacy scales; differences between USA and Hong Kong in learning environments, attitudes towards mathematics and academic efficacy in terms of statistical significance and effect sizes; and associations between the learning environment and attitudes towards mathematics and academic efficacy in terms of simple correlation and multiple regression coefficients. The major finding are summarized and discussed in the next section.

5.3 Major Findings of the Study

The major findings of my study are summarized below in three areas, with each relating to one of the research objectives guiding the entire research process. Section 5.3.1 focuses on the results for factor analysis, internal consistency reliability, and discriminant validity for each of the instruments used in my study. Section 5.3.2 reports between-country comparisons in terms of effect sizes and inferential statistics from one-way multivariate analysis of variance. Section 5.3.3 reviews the findings for the simple correlation and multiple regression analyses for associations between students' perceptions of their mathematics classroom learning environments and two types of student outcomes (attitudes towards mathematics and academic efficacy).

5.3.1 Validity and Reliability of Instruments

To validate the learning environment, attitude and academic efficacy questionnaires for use in mathematics classes in the USA and Hong Kong, quantitative data from the sample of 1,309 Grade 7 and 8 mathematics students in 35 classes in the USA and 23 classes in Hong Kong were subjected to separate principal axis factoring with varimax rotation and Kaiser normalization for the modified questionnaires used in this study. The two criteria for the retention of any item were that it must have a factor loading of at least 0.40 on its own scale and less than 0.40 on all other three scales. Eigenvalues and percentages of variance from the factor analyses were used to determine factor strength as well. Based on the factor analysis, each scale of the modified questionnaire indeed did assess a unique aspect of the learning environment, attitudes and academic efficacy. In addition, internal consistency reliability was measured using Cronbach's alpha coefficient and discriminant validity was measured by using the mean correlation with the other scales in that instrument.

5.3.1.1 Validity and Reliability of the WIHIC Scales

Factor analysis for the WIHIC scales (Teacher Support, Involvement, Cooperation, and Equity) revealed that the *a priori* factor structure for both the English and Chinese versions of the questionnaire was replicated in both countries, with nearly all items having a factor loading above 0.40 on their a *priori* scales and no other scale. One item from the Teacher Support scale and two items from the Involvement scale did not meet the criteria and were omitted from the questionnaire prior to all subsequent analyses. For each country, the total percentage of variance was nearly 60% and all scales had an eigenvalue of greater than 1.

Cronbach's alpha coefficient was used as an index of the internal consistency reliability of the refined questionnaire scales after the factor analyses led to the removal of 3 items. Using the individual as the unit of analysis, the reliability coefficients ranged from 0.84 (Involvement) to 0.91 (Equity) for the USA and from 0.85 (Involvement) to 0.91 (Cooperation and Equity) for Hong Kong. This supports the strong internal consistency reliability of all scales in both countries.

The mean correlation of a scale with the other scales was used as a convenient index of discriminant validity, or independence, of each WIHIC scale. The discriminant validity for WIHIC scales ranged from 0.33 to 0.38 in the USA and from 0.39 to 0.51 in Hong Kong. These values confirm a reasonable level of independence among raw scores on the WIHIC scales, with the factor analyses attesting to the independence of factor scores.

The findings for the validity and reliability of the modified learning environment questionnaire used in the present study are comparable to those of past studies that showed satisfactory factorial validity and internal consistency reliability at all educational levels and in a variety of classrooms: the elementary level (Allen & Fraser, 2007), high schools (Dorman, 2003), teacher education programs (Martin-Dunlop & Fraser, 2008), middle-school geography and/or mathematics classes (Chionh & Fraser, 2009; Ogbuehi & Fraser, 2007), the higher-education level (Khoo & Fraser, 2008), science classes (Aldridge & Fraser, 2000; Riah & Fraser, 1998; Wolf & Fraser, 2008) and technology-rich classes (Fraser & Raaflaub, 2013; Khoo

& Fraser, 2008; Zandvliet & Fraser, 2004). In addition, the WIHIC has been cross-validated and translated into five languages: Chinese (Aldridge, Fraser, & Huang, 1999), Spanish (Allen & Fraser, 2007), Indonesian (Fraser, Aldridge, & Adolphe, 2010), Korean (Kim, Fisher, & Fraser, 2000), and Arabic (Afari et al., 2013; MacLeod & Fraser, 2010). In cross-national studies involving large samples of secondary-school students, the WIHIC has been validated in Australia and Taiwan (Aldridge, Fraser, & Huang, 1999), in England, Canada and Australia (Dorman, 2003), in Australia and Indonesia (Fraser, Aldridge, & Adolphe, 2010), and in Australia and Canada (Zandvliet & Fraser, 2004, 2005).

5.3.1.2 Validity and Reliability of the Attitude and Academic Efficacy Scales

Factor analysis for the two TOMRA scales and one MJSES scale (Attitudes towards Mathematical Inquiry, Enjoyment of Mathematics, and Academic Efficacy) revealed that the *a priori* factor structure of both the English and Chinese versions of the questionnaire was replicated in both countries, with all items having a factor loading above 0.40 on their *a priori* scales and no other scale, except for one item from the Academic Efficacy scale did not meet the criteria and was omitted from the questionnaire for all subsequent analyses. For both countries, the total percentages of variance for both the USA and Hong Kong was over 60% and all scales had an eigenvalue of greater than 1.

Cronbach's alpha coefficient was used as an index of the internal consistency reliability of the refined attitude and academic efficacy questionnaire scales after the factor analyses led to the removal of one item. Using the individual as the unit of analysis, the reliability coefficients ranged from 0.82 (Inquiry) to 0.95 (Enjoyment) for the USA and from 0.89 (Inquiry) to 0.96 (Enjoyment) for Hong Kong. This supports the strong internal consistency reliability of all scales in both countries.

The discriminant validity for the Attitude and Academic Efficacy scales (using the mean correlation of a scale with the other scales) ranged from 0.30 to 0.34 in the USA and from 0.31 to 0.47 in Hong Kong. These confirm a reasonable level of independence among scales between raw scores on the Attitude and Academic

Efficacy scales, with the factor analysis attesting to the independence of factor scores.

The findings for the validity and reliability of the modified questionnaire used in this study are comparable to those of previous studies that demonstrated similar factor structures and reliabilities for attitude and academic efficacy scales, thus supporting their validity (Aldridge & Fraser, 2008; Castillo, Peiro, & Fraser, 2006).

5.3.2 Differences between USA and Hong Kong in Learning Environments, Attitudes towards Mathematics and Academic Efficacy

To investigate differences between students in the USA and Hong Kong in terms of their perceptions of the learning environment, attitudes towards mathematics, and academic efficacy, both effect sizes and inferential statistics (in terms of multivarite and univariate analyses of variance) were used. USA students consistently perceived their learning environments more favorably than did the Hong Kong students, but an interesting anomaly arose in that students in Hong Kong expressed more enjoyment of their mathematics classes than did students in the USA. Using ANOVA, statistically significant differences between students in the USA and students in Hong Kong were identified for all learning environment, attitudes towards mathematics and academic efficacy scales, except the Involvement scale. With effect sizes of over one third of a standard deviation, ranging from –0.38 standard deviations (Enjoyment) to 1.13 standard deviations (Equity), the difference between two countries were sizeable in magnitude for all learning environment, attitudes towards mathematics and academic efficacy scales (with the exception of the Involvement scale).

The findings for my study showed a similar pattern to a cross-cultural study conducted by Aldridge and Fraser (2000) with 1,879 Taiwanese students and 1,081 Australian students in 50 junior high school science classes in each country. Aldridge and Fraser reported that Australian students perceived their learning environments more positively than did Taiwanese student, but that students in Taiwan had more positive attitudes towards science classes than students in Australia.

5.3.3 Associations between Learning Environment and Student Outcomes of Attitudes towards Mathematics and Academic Efficacy

To explore associations between students' perceptions of mathematics classroom learning environment and the student outcomes of attitudes towards mathematics and academic efficacy, simple correlation and multiple regression analyses were conducted using the individual student as the unit of analysis.

A statistically significant and positive correlation was found between each learning environment and each student attitudes towards mathematics/academic self-efficacy scale. The multiple correlation between the set of learning environment scales and each attitude/efficacy scale was statistically significant. The learning environment scales of Involvement and Equity had a significant independent influence on Attitudes towards Mathematical Inquiry for both the USA and Hong Kong. For Enjoyment of Mathematics, although the learning environment scale of Involvement was a significant independent predictor in the both countries, it is interesting that Teacher Support was a significant independent determinant of Enjoyment in Hong Kong but not in the USA. This could be related to the teacher-centered classroom environments and teacher-dominant classroom context in Hong Kong where, for example the teacher is an authority rather than a friend. When using academic efficacy as the dependent variable, the learning environment scale of Involvement was a significant independent predictor in both countries. Interestingly, Involvement was a stronger independent determinant of Academic Efficacy in Hong Kong than in the USA. This could be explained by the Confucian-heritage culture which emphasizes effort and the strong belief that one's failure is not attributable to one's internal make-up or ability, but to one's effort and will power.

The findings of this study replicate considerable prior research (Fraser, 2012; Fraser, Aldridge, & Adolphe, 2010; Kim, Fisher, & Fraser, 2000) that has established links between a positive classroom environment and positive student attitudes.

5.4 Distinctive Contributions, Significance and Implications of Study

My study has made several distinctive contributions to the field of learning environments. First, it was the first mathematics learning environment study in Hong Kong, as well as the first cross-national study of learning environments involving the USA and Hong Kong. It was also one of the few cross-national studies involving validation of a questionnaire assessing learning environment, attitudes to mathematics inquiry and academic efficacy, comparing classroom learning environments, and investigating associations between classroom learning environment, students' attitudes and academic efficacy. Second, although research has been conducted in the learning environments field for over 40 years (Fraser, 2012), relatively few studies have been conducted specifically in mathematics classes. Third, this study is distinctive in the choice of the specific instruments for investigating associations between classroom learning environment and student outcomes of attitudes and academic efficacy. It is the first time that the WIHIC, attitudes towards mathematics scales form the TOMRA, and an academic efficacy from MJSES were used to determine outcome–environment associations form secondary-school mathematics students.

In addition, a significant contribution made by the present study was through translating and validating a widely-applicable questionnaire to assess students' perceptions of the learning environment for future use by researchers and teachers in Hong Kong and other Chinese-speaking countries. Careful translation (and back translation) into Chinese was undertaken to ensure that individual questionnaire items retained their original intention.

A unique finding of my study was that USA students consistently perceived their learning environments more favorably than did the Hong Kong students, but that students in Hong Kong expressed significantly more enjoyment of their mathematics classes than did students in the USA. Whilst large class sizes and teacher-centered classroom environments prevail in Hong Kong, students in Hong Kong were not as unhappy with mathematics classes as I had imagined. In fact, Hong Kong students enjoyed their classes more than students in the USA. These results are likely to have practical implications for teachers, administrators and educators in both countries.

For example, teachers in Hong Kong might consider introducing new strategies to enhance Teacher Support, including giving more rewards and recognition to students who make improvements and providing advice to students about setting learning targets. This cross-national study could provide new insights for educators, broaden their pedagogical perspectives and strengthen their sensitivity to distinctive features of their own educational system. It could also provide greater variation in variables of interest, such as teaching practices and students' attitudes, and hence yield a better understanding of the relative influence of a number of significant variables in the teaching and learning process. My research could encourage collaboration across countries to help to advance the efforts and accomplishments of educators worldwide (Ferguson & Meyer, 1998).

5.5 Limitations and Constraints

Whilst attempts were made to ensure that the processes of inquiry in my study, such as research design, data collection, data analysis and interpretation, were free from errors, certain inherent limitations and constraints could still exist, especially because my research involved humans. There are several limitation and constraints that should be mentioned. The first limitation of my research was that is involved only quantitative data-gathering method. Because the questionnaire used in this study involved only closed-choice items and did not include any open-ended response items, there was no opportunity for students to explain their opinions more precisely (Barker, Pistrang, & Elliott, 2002). Also, there was no guarantee that students understood the meaning of questionnaire items exactly as the researchers intended, or that they were attentive and honest about their responses. Moreover, because the questionnaires were administrated by students' own mathematics teachers during the last week of school, it is possible that some students were worried about the confidentiality of their responses to the questionnaire, and that therefore they were not completely honest and serious in responding.

Moreover, the sample for my study was not a true random sample because only classes from those teachers who were willing to participate in the study were included at each school. This also applied to the students as well. Only those student who had parental consent were included in the study. A true random sample is always an ideal in data collection, but realistically this is impossible in nearly all educational research because of the obligation for ethical conduct, such as obtaining parental consent and teachers' approval.

Another possible limitation of the present study was the lack of achievement data. There was no comparison of students' mathematics achievement in Hong Kong and the USA in the present study.

Lastly, because of the complexity of human experience in term of students' perceptions of the learning environment, as well as the differing influences of social and cultural factors in eastern and western countries, it is impossible to rule out or control for all of the extraneous variables. Examples of some of the extraneous variables include the mood, fatigue or stress levels of the students when completing the questionnaires, cultural, social and pedagogical differences between the USA and Hong Kong, and teachers' convictions about the importance of establishing a positive learning environment. It should also be borne in mind that the nature of the mathematics curriculum in each country is quite different, as well as the teaching approach. In the light of these factors, attempts were made to ensure that the samples selected in each of Hong Kong and the USA were as similar as possible, particularly with respect to students' ages. Nevertheless, as in all cross-national studies, the equivalence of the samples in two different countries cannot be guaranteed.

5.6 Recommendations for Future Research

Because the present research was the first mathematics learning environment study in Hong Kong, as well as the first cross-national study of learning environments involving the USA and Hong Kong, there are a number of further research opportunities that can grow out of my study. This section makes recommendations for future research into both learning environments and mathematics education.

To build upon my study involving students in Clovis, California and Hong Kong and to add greater confidence in my findings, future research could be undertaken with a larger sample size and involving more schools from other states in the USA, as well as more Asian countries, such as Japan, Korea, Singapore, Taiwan.

To minimize validity threats during data gathering, the person who administers the questionnaire should be a school administrator or the researcher. This would reduce students' fear or worry about the confidentiality of their responses to the questionnaire, and thus more honest and serious responses could be obtained.

Another area of research that stems from my study would be an investigation into the relationship between the perceived learning environment and another prominent student outcome, namely, achievement. Although TIMSS provides comprehensive data about the mathematics achievement of USA fourth and eighth grade students compared to that of students in other countries, it did not explore possible relationships between the learning environment and student achievement. Because the TIMSS report shows that Hong Kong students had higher average mathematics achievement and my study revealed that Hong Kong students enjoyed their classes more than students in the USA, it could also benefit to the educational community to investigate relationships between student achievement and students' level of enjoyment.

A more comprehensive assessment of attitudes towards mathematics should be conducted in the future. My use of two scales of attitudes towards mathematical inquiry and enjoyment of mathematics provided only a somewhat narrow view of important affective outcomes. A broader variety of scales from TOMRA or other questionnaires could be used to shed further light on the differences in attitudes between the USA students and Hong Kong students, as well as the relationship between learning environments and attitudes.

Last but not the least, I would recommend using a multi-method approach for future research, including the use of qualitative research methods such as observations, interviews and narrative stories, to augment questionnaire data and to provide insights into patterns that emerged from the quantitative data as recommended by Tobin and Fraser (1998). Consequently, the interpretations of the data are likely to become more meaningful and enhance the credibility to a study.

5.7 Concluding Remarks

The research described in this thesis is different from the large majority of studies in mathematics education in that it extended beyond the confines of student achievement as the outcome to involve the psychological context of a classroom — students' perceptions of learning environment and their attitudes towards mathematics and academic efficacy. This study is also distinctive in that it went beyond past cross-national studies to involve validation of a modified questionnaire assessing learning environments, attitudes to mathematics inquiry and academic efficacy, compare countries in terms of classroom learning environments, and investigate associations between classroom learning environment, students' attitudes and academic efficacy.

The quantitative data, collected using the What Is Happening In this Class? (WIHIC), attitude and academic efficacy scales in this study, supported the validity and reliability of both the English and Chinese versions of all scales. The *a priori* factor structure was replicated with nearly all of the items loadings on their own factor and no other factor. Internal consistency reliability and ability to differentiate between classrooms were found to be satisfactory. Overall, this study provided strong support for the validity and reliability of the modified questionnaire for use in two countries and in two languages.

A comparison of the two countries revealed interesting anomalies in that USA students consistently perceived their classroom environments more favorably than did student in Hong Kong on all scales but, in contrast, Hong Kong students expressed more enjoyment of their mathematics classes. Statistically significant and positive associations were also found between learning environment and students' attitudes towards mathematics/academic self-efficacy. To explore these findings in more depth, I suggest the use of a multi-method approach in future research which involves the use of qualitative research methods, such as observations, interviews and narrative stories, to augment questionnaire data and to provide richer interpretations and insights.

Each country in my study has much to learn from the other with regard to the development of learning environments which foster positive attitudes and a love of learning mathematics. The comparative nature of the present study of learning environments in the USA and Hong Kong made it possible to examine differences between countries in classroom learning environment, attitudes toward mathematics, and academic efficacy. This cross-cultural comparative study has the potential to provide a better understanding of educational systems as seen by the students within the culture, generating new insights for teachers and educators, broadening their perspectives on teaching and learning and, hopefully, initiating collaboration across countries in an attempt to advance the efforts and accomplishments of educators worldwide.

REFERENCES

Adamski, A., Fraser, B. J., & Peiro, M. M. (2013). Parental involvement in schooling, classroom environment and student outcomes. *Learning Environments Research*, *16*, 315−328.

Afari, E., Aldridge, J. M., Fraser, B. J., & Khine, M. S. (2013). Students' perceptions of the learning environment and attitudes in game-based mathematics classrooms. *Learning Environments Research*, *16*, 131−150.

Aiken, L. R. (2002). *Attitudes and related psychosocial constructs*. Thousand Oaks, CA: Sage Publications, Inc.

Aldridge, J. M., Dorman, J. D., & Fraser, B. J. (2004). Use of multitrait-multimethod modelling to validate actual and preferred forms of the Technology-Rich Outcomes-Focused Learning Inventory (TROFLEI). *Australian Journal of Educational and Developmental Psychology, 4*, 110−125.

Aldridge, J. M., & Fraser, B. J. (2000). A cross-cultural study of classroom learning environments in Australia and Taiwan. *Learning Environments Research, 3*, 101−134.

Aldridge, J. M., & Fraser, B. J. (2008). *Outcomes-focused learning environments: Determinants and effects* (Advances in Learning Environments Research series). Rotterdam: Sense Publishers.

Aldridge, J. M., Fraser, B. J., & Fisher, D. L. (2003). Investigating student outcomes in an outcomes-based, technology-rich learning environment. In D. L. Fisher & T. Marsh (Eds.), *Making science, mathematics and technology education accessible to all* (pp. 167−178). Perth, Australia: Curtin University of Technology.

Aldridge, J. M., Fraser, B. J., & Huang, T. C. I. (1999). Investigating classroom environments in Taiwan and Australia with multiple research methods. *Journal of Educational Research, 93*, 48−62.

Aldridge, J. M., Fraser, B. J., & Ntuli, S. (2009). Utilising learning environment assessments to improve teaching practices among in-service teachers undertaking a distance education programme. *South African Journal of Education, 29*, 147−170.

Aldridge, J. M., Fraser, B. J., & Sebela, M. P. (2004). Using teacher action research to promote constructivist learning environments in South Africa. *South African Journal of Education, 24*, 245−253.

Aldridge, J. M., Fraser, B. J., Taylor, P. C., & Chen, C. C. (2000). Constructivist learning environments in a cross-national study in Taiwan and Australia. *International Journal of Science Education, 22*, 37−55.

Allen, D., & Fraser, B. J. (2007). Parent and student perceptions of classroom learning environment and its association with student outcomes. *Learning Environments Research, 10*, 67−82.

Allport, G. W. (1935). Attitudes. In C. Murchison (Ed.), *Handbook of social psychology* (pp. 798–844). Worcester, MA: Clark University Press.

Anderson, G. J., & Walberg, H. J. (1972). Class size and the social environment of learning: A mixed replication and extension. *Alberta Journal of Educational Research, 18*, 277−286.

Anonymous. (2007). A digital decade. *Education Week, 26*(30), 8−9.

Asghar, M., & Fraser, B. J. (1995). Classroom environment and attitudes to science in Brunei Darussalam. *Journal of Science and Mathematics Education in Southeast Asia, XVIII*, 41−47.

Baldwin, J. A., Ebert-May, D., & Burns, D. J. (1999). The development of a college biology self-efficacy instrument for nonmajors. *Science Education, 83*, 397−408.

Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Englewood Cliffs, NJ: Prentice Hall

Bandura, A. (1994). Self-efficacy. In V. S. Ramachaudran (Ed.), *Encyclopedia of human behavior* (Vol. 4, pp. 71−81). New York: Academic Press.

Bandura, A. (1997). *Self-efficacy: The exercise of control*. New York: Freeman.

Bandura, A. (2006). Toward a psychology of human agency. *Perspectives on Psychological Science, 1*(2), 164−180.

Bandura, A. (2010). Self-efficacy. *The Corsini encyclopedia of psychology* (Vol. 1–3). New York: John Wiley & Sons, Inc.

Barker, C., Pistrang, N., & Elliott, R. (2002). *Research methods in clinical psychology: An introduction for students and practitioners* (2nd ed.). Chichester, UK: John Wiley & Sons, Ltd.

Berry, J. M. (1987, April). *A self-efficacy model of memory performance.* Paper presented at the annual meeting of the American Educational Research Association, New York.

Berry, J. W. (1980). Introduction to methodology. In H. C. Triandis & J. W. Berry (Eds.), *Handbook of cross-cultural psychology: Methodology* (Vol. 2, pp. 1−28). London: Allyn and Bacon.

Betz, N. E., & Hackett, G. (1983). The relationship of mathematics self-efficacy expectations to the selection of science-based college majors. *Journal of Vocational Behavior, 23*, 329−345.

Biggs, E. M. (2009). *Evaluation of professional development on integrating technology: Classroom environment and student attitudes in middle schools.* Saarbrucken, Germany: VDM Verlag.

Brislin, R. (1970). Back translation for cross-cultural research. *Journal of Cross-Cultural Psychology, 1*, 185−216.

Campbell, M. (2009). *Effectiveness of using manipulatives in secondary mathematics in terms of learning environment, attitudes and achievement*. Unpublished PhD thesis, Curtin University of Technology, Perth, AU.

Castillo, G. E., Peiro, M. M., & Fraser, B. J. (2006). Grade-level, gender and ethnic differences in attitudes and learning environments in high school mathematics. In D. L. Fisher, D. B. Zandvliet, I. W. Gaynor & R. B. Koul (Eds.), *Sustainable communities, sustainable environments: Envisioning a role for science, mathematics and technology education: Proceedings of the Fourth International Conference on Science, Mathematics and Technology Education* (pp. 58−68). Perth: Curtin University.

Chang, V., & Fisher, D. L. (2003). The validation and application of a new learning environment instrument for online learning in higher education. In M. S. Khine & D. L. Fisher (Eds.), *Technology rich learning environments: A future perspective* (pp. 1−20). Singapore: World Scientific Publishing.

Chionh, Y. H., & Fraser, B. J. (2009). Classroom environment, achievement, attitudes and self-esteem in geography and mathematics in Singapore. *International Research in Geographical and Environmental Education, 18*, 29−44.

Cohen, J. (1988). *Statistical power analysis for the behavioral sciences*. Hillsdale, NJ: Lawrence Erlbaum Associates.

Cort, H. R., Jr. (1979). A social studies evaluation. In H. J. Walberg (Ed.), *Educational environments and effects: Evaluation, policy, and productivity* (pp. 235−257). Berkeley, CA: McCutchan.

Creswell, J. W. (2002). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research.* (2nd ed.). Upper Saddle River, NJ: Prentice Hall.

Créton, H., Hermans, J., & Wubbels, T. (1990). Improving interpersonal teacher behaviour in the classroom: A systems communication perspective. *South Pacific Journal of Teacher Education, 18*, 85−94.

Curriculum Development and Supplemental Materials Commission (California). (2005). *Mathematics framework for California public schools, kindergarten through grade twelve*. Sacramento, CA: California Department of Education.

den Brok, P., Fisher, D. L., Rickards, T., & Bull, E. (2006). Californian science students' perceptions of their classroom learning environments. *Educational Research and Evaluation, 12*, 3−25.

Dorman, J. P. (2001). Associations between classroom environment and academic efficacy. *Learning Environments Research, 4*, 243−257.

Dorman, J. P. (2003). Cross-national validation of the What Is Happening In this Class? (WIHIC) questionnaire using confirmatory factor analysis. *Learning Environments Research, 6*, 231−245.

Dorman, J. P. (2008). Use of multitrait-multimethod modelling to validate actual and preferred forms of the What Is Happening In this Class? (WIHIC) questionnaire. *Learning Environments Research, 11*, 179−197.

Dorman, J. P., Adams, J. D., & Ferguson, J. M. (2003). A cross-national investigation of students' perceptions of mathematics classroom environment and academic efficacy in secondary schools. *International Journal for Mathematics Teaching and Learning*. Retrieved from http://www.cimt.plymouth.ac.uk/Journal/dormanj.pdf

Dorman, J. P., Aldridge, J. M., & Fraser, B. J. (2006). Using students' assessment of classroom environment to develop a typology of secondary school classrooms. *International Education Journal, 7*, 909−915.

Dorman, J. P., & Fraser, B. J. (2009). Psychosocial environment and affective outcomes in technology-rich classrooms: Testing a causal model. *Social Psychology of Education, 12*, 77−99.

Dowling, D. M. (1978). *The development of a mathematics confidence scale and its application in the study of confidence in women college students.* Unpublished doctoral dissertation, Ohio State University, Columbus.

Dutton, W. H. (2005). The internet and social transformation: Reconfiguring access. In W. Dutton, B. Kahin, R. O'Callaghan & A. Wykoff (Eds.), *Transforming enterprise: Economic and social implications of information technology* (pp. 375−394). Cambridge, MA: MIT Press.

Dutton, W. H., & Blum, M. P. (1968). The measurement of attitudes toward arithmetic with a Likert-type test. *Elementary School Journal, 38*, 259−264.

Eagly, A. H., & Chaiken, S. (1993). *The psychology of attitudes*. Fort Worth, TX: Harcourt Brace Jovanovich.

Fennema, E., & Sherman, J. A. (1976). Fennema-Sherman Mathematics Attitudes Scales: Instruments designed to measure attitudes toward the learning of mathematics by males and females. *Catalog of Selected Documents in Psychology, 6*, 31.

Ferguson, D. L., & Meyer, G. (1998). Talking across borders and languages: Encouraging international research discussions and collaboration. *International Journal of Educational Research, 29*, 89−93.

Fisher, D. L., & Cresswell, J. (1998). Actual and ideal principal interpersonal behaviour. *Learning Environments Research, 1*, 231-247.

Fisher, D. L., & Fraser, B. J. (1981). Validity and use of the My Class Inventory. *Science Education, 65*, 145−156.

Fisher, D. L., & Fraser, B. J. (1983a). Validity and use of the Classroom Environment Scale. *Educational Evaluation and Policy Analysis, 5*, 261−271.

Fisher, D. L., & Fraser, B. J. (1983b). A comparison of actual and preferred classroom environments as perceived by science teachers and students. *Journal of Research in Science Teaching, 20*, 55−61.

Fisher, D. L., Henderson, D., & Fraser, B. J. (1995). Interpersonal behaviour in senior high school biology classes. *Research in Science Education, 25*, 125−133.

Fisher, D. L., Henderson, D., & Fraser, B. J. (1997). Laboratory environments & student outcomes in senior high school biology. *American Biology Teacher, 59*, 214−219.

Fraser, B. J. (1978). Development of a test of science related attitudes. *Science Education, 62*, 509−515.

Fraser, B. J. (1979). Evaluation of a science-based curriculum. In H. J. Walberg (Ed.), *Educational environments and effects: Evaluation, policy, and productivity* (pp. 218−234). Berkeley, CA: McCutchan.

Fraser, B. J. (1981). *Test of Science-Related Attitudes*. Melbourne, Australia: Australian Council for Educational Research.

Fraser, B. J. (1982). Differences between student and teacher perceptions of actual and preferred classroom learning environment. *Educational Evaluation and Policy Analysis, 4*, 511−519.

Fraser, B. J. (1990). *Individualised Classroom Environment Questionnaire*. Melbourne, Australia: Australian Council for Educational Research.

Fraser, B. J. (1994). Research on classroom and school climate. In D. Gabel (Ed.), *Handbook of research on science teaching and learning* (pp. 493−541). New York: Macmillan.

Fraser, B. J. (1998a). The birth of a new journal: Editor's introduction. *Learning Environments Research, 1*, 1−5.

Fraser, B. J. (1998b). Classroom environment instruments: Development, validity and applications. *Learning Environments Research, 1*, 7−33.

Fraser, B. J. (1998c). Science learning environments: Assessment, effects and determinants. In B. J. Fraser & K. G. Tobin (Eds.), *International handbook of science education* (pp. 527−564). Dordrecht, The Netherlands: Kluwer.

Fraser, B. J. (2001). Twenty thousand hours: Editor's introduction. *Learning Environments Research*, *4*, 1−5.

Fraser, B. J. (2002). Learning environment research: Yesterday, today and tomorrow. In S. C. Goh & M. S. Khine (Eds.), *Studies in educational learning environments: An international perspective* (pp. 1−25). Singapore: World Scientific Publishing.

Fraser, B. J. (2007). Classroom learning environments. In S. K. Abell & N. G. Lederman (Eds.), *Handbook of research on science education* (pp. 103−124). London: Lawrence Erlbaum Associates.

Fraser, B. J. (2012). Classroom learning environments: Retrospect, context and prospect. In B. J. Fraser, K. G. Tobin & C. J. McRobbie (Eds.), *Second international handbook of science education* (pp. 1191−1239). New York: Springer.

Fraser, B. J., Aldridge, J. M., & Adolphe, F. (2010). A cross-national study of secondary science classroom environments in Australia and Indonesia. *Research in Science Education, 40*, 551−571.

Fraser, B. J., Aldridge, J. M., & Soerjaningsih, W. (2010). Instructor-student interpersonal interaction and student outcomes at the university level in Indonesia. *The Open Education Journal, 3*, 32−44.

Fraser, B. J., Anderson, G. J., & Walberg, H. J. (1982). *Assessment of learning environments: Manual for Learning Environment Inventory (LEI) and My Class Inventory (MCI)*. Retrieved from http://www.eric.ed.gov/ERICWebPortal/contentdelivery/servlet/ERICServlet?accno=ED223649

Fraser, B. J., & Butts, W. L. (1982). Relationship between perceived levels of classroom individualisation and science-related attitudes. *Journal of Research in Science Teaching, 19*, 143−154.

Fraser, B. J., & Fisher, D. L. (1982a). Effects of classroom psychosocial environment on student learning. *British Journal of Educational Psychology, 52*, 374−377.

Fraser, B. J., & Fisher, D. L. (1982b). Predicting students' outcomes from their perceptions of classroom psychosocial environment. *American Educational Research Journal, 19*, 498−518.

Fraser, B. J., & Fisher, D. L. (1982c). Predictive validity of My Class Inventory. *Studies in Educational Evaluation, 8*, 129−140.

Fraser, B. J., Fisher, D. L., & McRobbie, C. J. (1996, April). *Development, validation and use of personal and class forms of a new classroom environment instrument.* Paper presented at the annual meeting of the American Educational Research Association, New York.

Fraser, B. J., Giddings, G. J., & McRobbie, C. J. (1995). Evolution and validation of a personal form of an instrument for assessing science laboratory classroom environments. *Journal of Research in Science Teaching, 32*, 399−422.

Fraser, B. J., & Lee, S. S. U. (2009). Science laboratory classroom environments in Korean high schools. *Learning Environments Research, 12*, 67−84.

Fraser, B. J., & McRobbie, C. J. (1995). Science laboratory classroom environments at schools and universities: A cross-national study. *Educational Research and Evaluation, 1*, 289−317.

Fraser, B. J., McRobbie, C. J., & Giddings, G. J. (1993). Development and cross-national validation of a laboratory classroom environment instrument for senior high school science. *Science Education, 77*, 1−24.

Fraser, B. J., Nash, R., & Fisher, D. L. (1983). Anxiety in science classrooms: Its measurement and relationship to classroom environment. *Research in Science and Technological Education, 1*, 201−208.

Fraser, B. J., & O'Brien, P. (1985). Student and teacher perceptions of the environment of elementary school classrooms. *The Elementary School Journal, 85*, 567−580.

Fraser, B. J., Pearse, R., & Azmi. (1982). A study of Indonesian students' perceptions of classroom psychosocial environment. *International Review of Education, 28*, 337−355.

Fraser, B. J. & Raaflaub, C. A. (2013). Subject and sex differences in the learning environment – Perceptions and attitudes of Canadian mathematics and science students using laptop computers. *Curriculum and Teaching, 28,* 57−78.

Fraser, B. J., & Tobin, K. G. (Eds.). (1998). *International handbook of science education*. Dordrecht, The Netherlands: Kluwer.

Fraser, B. J., & Treagust, D. F. (1986). Validity and use of an instrument for assessing classroom psychosocial environment in higher education. *Higher Education, 15*, 37-57.

Fraser, B. J., Williamson, J. C., & Tobin, K. G. (1987). Use of classroom and school climate scales in evaluating alternative high schools. *Teaching & Teacher Education, 3*, 219-231.

Gerst, M., & Moos, R. H. (1972). The psychological environment of university student residences. In W. A. Mitchell (Ed.), *Environmental design: Research and practice* (Proceedings of the Environmental Design Research Association Conference). Los Angeles: University of California.

Gibson, S., & Dembo, M. H. (1984). Teacher efficacy: A construct validation. *Journal of Educational Psychology, 76*, 569−582.

Gladstone, R., Deal, R., & Drevdahl, J. E. (1960). Attitudes toward mathematics. In M. E. Shaw & J. M. Wright (Eds.), *Scales for the measurement of attitudes* (pp. 237−242). New York: McGraw Hill.

Goh, S. C., & Fraser, B. J. (1996). Validation of an elementary school version of Questionnaire on Teacher Interaction. *Psychological Reports, 79*, 512−522.

Goh, S. C., & Fraser, B. J. (1998). Teacher interpersonal behaviour, classroom environment and student outcomes in primary mathematics in Singapore. *Learning Environments Research, 1*, 199−229.

Goh, S. C., Young, D. J., & Fraser, B. J. (1995). Psychosocial climate and student outcomes in elementary mathematics classrooms: A multilevel analysis. *The Journal of Experimental Education, 64*, 29−40.

Haertel, G. D., Walberg, H. J., & Haertel, E. H. (1981). Socio-psychological environments and learning: A quantitative synthesis. *British Educational Research Journal, 7*, 27−36.

Haladyna, T., Shaughnessy, J., & Shaughnessy, J. M. (1983). A causal analysis of attitude toward mathematics. *Journal for Research in Mathematics Education, 14*, 19−29.

Helding, K. A., & Fraser, B. J. (2013). Effectiveness of NBC (National Board Certified) teachers in terms of learning environment, attitudes and achievement among secondary school students. *Learning Environments Research, 16*, 1−21.

Hillman, S. (1986, April). *Measuring self-efficacy: Preliminary steps in the development of a multi-dimensional instrument.* Paper presented at the annual meeting of the American Educational Research Association, San Francisco, CA.

Hofstein, A., Gluzman, R., Ben-Zvi, R., & Samuel, D. (1979). Classroom learning environment and student attitudes towards chemistry. *Studies in Educational Evaluation, 5*, 231−236.

Holsinger, D. B. (1973). The elementary school as modernizer: A Brazilian study. *International Journal of Comparative Sociology, 14*, 180−202.

Houts, P. S., & Moos, R. H. (1969). The development of a ward initiative scale for patients. *Journal of Clinical Psychology, 25*, 319−322.

Jegede, O. J., Fraser, B. J., & Fisher, D. L. (1995). The development and validation of a distance and open learning environment scale. *Educational Technology Research and Development, 43*, 90−93.

Jinks, J. L., & Morgan, V. (1999). Children's perceived academic self-efficacy: An inventory scale. *Clearing House, 72*, 224−230.

Johnson, B., & McClure, R. (2004). Validity and reliability of a shortened, revised version of the Constructivist Learning Environment Survey (CLES). *Learning Environments Research, 7*, 65−80.

Khine, M. S., & Fisher, D. L. (2001, December). *Classroom environment and teachers' cultural background in secondary science classroom in an Asian context.* Paper presented at the annual conference the Australian Association for Research in Education, Perth, Australia.

Khine, M. S., & Fisher, D. L. (2002, April). *Analysing interpersonal behaviour in science classrooms: Associations between students' perceptions and teachers' cultural background.* Paper presented at the annual meeting of the National Association for Research in Science Teaching, New Orleans, LA.

Khoo, H. S., & Fraser, B. J. (2008). Using classroom psychosocial environment in the evaluation of adult computer application courses in Singapore. *Technology, Pedagogy and Education, 17*, 67−81.

Kim, H. B., Fisher, D. L., & Fraser, B. J. (1999). Assessment and investigation of constructivist science learning environments in Korea. *Research in Science & Technological Education, 17*, 239−249.

Kim, H. B., Fisher, D. L., & Fraser, B. J. (2000). Classroom environment and teacher interpersonal behaviour in secondary school classes in Korea. *Evaluation and Research in Education, 14*, 3−22.

Klopfer, L. E. (1971). Evaluation of learning in science. In B. S. Bloom, J. T. Hastings & G. F. Madaus (Eds.), *Handbook on summative and formative evaluation of student learning* (pp. 559−641). New York: McGraw-Hill.

Koul, R. B., & Fisher, D. L. (2005). Cultural background and students' perceptions of science classroom learning environment and teacher interpersonal behaviour in Jammu, India. *Learning Environments Research, 8*, 195−211.

Kushner, S. (1993). *Teacher efficacy and pre-service teachers: A construct validation.* Paper presented at the annual meeting of the Eastern Educational Research Association, Sarasota, FL.

Landon, K. L., & Fraser, B. J. (2011, April). *Is Success Lab an effective Algebra 1 intervention?* Paper presented at the annual meeting of the American Educational Research Association, New Orleans, LA.

Lawrenz, F. P., & Welch, W. W. (1983). Student perceptions of science classes taught by males and females. *Journal of Research in Science Teaching, 20*, 655−662.

Lee, S. S. U., & Fraser, B. J. (2002, April). *High school science classroom learning environments in Korea.* Paper presented at the annual meeting of the American Educational Research Association, New Orleans, LA.

Lee, S. S. U., Fraser, B. J., & Fisher, D. L. (2003). Teacher−student interactions in Korean high school science classrooms. *International Journal of Science and Mathematics Education, 1*, 67−85.

Lewin, K. (1936). *Principles of topological psychology*. New York: McGraw.

Lightburn, M. E., & Fraser, B. J. (2007). Classroom environment and student outcomes among students using anthropometry activities in high school science. *Research in Science and Technological Education, 25*, 153−166.

Logan, K. A., Crump, B. J., & Rennie, L. J. (2006). Measuring the computer classroom environment: Lessons learned from using a new instrument. *Learning Environments Research, 9*, 67−93.

Lorsbach, A., & Jinks, J. (1999). Self-efficacy theory and learning environment research. *Learning Environments Research, 2*, 157−167.

Loyd, B. H., & Gressard, C. (1984). Reliability and factorial validity of Computer Attitude Scales. *Educational and Psychological Measurement, 44*, 501−505.

Lyman, R. D., Prentice-Dunn, S., Wilson, D. R., & Bonfilio, S. A. (1984). The effect of success or failure on self-efficacy and task persistence of conduct-disordered children. *Psychology in the Schools, 21*, 516−519.

MacDowell-Goggin, M., & Fraser, B. J. (2004, April). *Effects of using a graphic organizer on science students' attitudes and classroom learning environments.* Paper presented at the annual meeting of the American Educational Research Association, San Diego.

MacLeod, C., & Fraser, B. (2010). Development, validation and application of a modified Arabic translation of the What Is Happening In this Class? (WIHIC) questionnaire. *Learning Environments Research, 13*, 105−125.

Majeed, A., Fraser, B. J., & Aldridge, J. M. (2002). Learning environment and its association with student satisfaction among mathematics students in Brunei Darussalam. *Learning Environments Research, 5*, 203−226.

Maor, D., & Fraser, B. J. (1996). Use of classroom environment perceptions in evaluating inquiry-based computer assisted learning. *International Journal of Science Education, 18*, 401−421.

Margianti, E. S. (2002). Learning environment research in Indonesia. In S. C. Goh & M. S. Khine (Eds.), *Studies in educational learning environments: An international perspective* (pp. 153−167). Singapore: World Scientific.

Margianti, E. S., Fraser, B. J., & Aldridge, J. M. (2002, April). *Learning environment, attitudes and achievement: Assessing the perceptions of Indonesian university students.* Paper presented at the annual meeting of the American Educational Research Association, New Orleans, LA.

Martin-Dunlop, C., & Fraser, B. J. (2008). Learning environment and attitudes associated with an innovative science course designed for prospective elementary teachers. *International Journal of Science and Mathematics Education, 6*, 163−190.

McGuire, W. J. (1969). The nature of attitudes and attitude change. In G. Lindzey & E. Aronson (Eds.), *The handbook of social psychology* (Vol. 3, pp. 136−314). Reading, MA: Addison-Wesley.

McLeod, D. (1992). Research on affect in mathematics education: A reconceptualization. In D. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 575−596). New York: Macmillan Publishing Company.

McRobbie, C. J., & Fraser, B. J. (1993). Associations between student outcomes and psychosocial science environment. *The Journal of Educational Research, 87*, 78−85.

Midgley, C., Maehr, M., Hicks, L., Roeser, R., Urdan, T., Anderman, E. M., & Kaplan, A. (1997). *Manual for the patterns of adaptive learning survey*. Ann Arbor, MI: University of Michigan.

Midgley, C., & Urdan, T. (1995). Predictors of middle school students' use of self-handicapping strategies. *Journal of Early Adolescence, 15*, 389–411.

Mink, D. V., & Fraser, B. J. (2005). Evaluation of a K−5 mathematics program which integrates children's literature: Classroom environment and attitudes. *International Journal of Science and Mathematics Education, 3*, 59−85.

Moos, R. H. (1974). *The Social Climate Scales: An overview*. Palo Alto, CA: Consulting Psychologists Press.

Moos, R. H. (1979). *Evaluating educational environments: Procedures, measures, findings, and policy implications*. San Francisco, CA: Jossey-Bass.

Moos, R. H., & Houts, P. S. (1968). Assessment of the social atmospheres of psychiatric wards. *Journal of Abnormal Psychology, 73*, 595−604.

Moos, R. H., & Moos, B. S. (1978). Classroom social climate and student absences and grades. *Journal of Educational Psychology, 70*, 263−269.

Moos, R. H., & Trickett, E. J. (1974). *Classroom Environment Scale manual*. Palo Alto, CA: Consulting Psychologists Press.

Moos, R. H., & Trickett, E. J. (1987). *Classroom Environment Scale manual* (2nd ed.). Palo Alto, CA: Consulting Psychologists Press.

Morgan, V. L., & Jinks, J. (1996). Students' sense of academic self-efficacy and achievement in science: A useful new direction for research regarding science literacy? *Electronic Journal of Science Education, 1*. Retrieved from http://wolfweb.unr.edu/homepage/jcannon/ejse/jinksmor.html

Mullis, I. V. S., Martin, M. O., & Foy, P. (2008). *TIMSS 2007 international mathematics report*. Chestnut Hill, MA: TIMSS & PIRLS International Study Center, Boston College.

Mullis, I. V. S., Martin, M. O., Foy, P., & Arora, A. (2012). *TIMSS 2011 international results in mathematics*. Chestnut Hill, MA: TIMSS & PIRLS International Study Center, Boston College.

Multon, K. D., Brown, S. D., & Lent, R. W. (1991). Relation of self-efficacy beliefs to academic outcomes: A meta-analytic investigation. *Journal of Counseling Psychology, 18*, 30−38.

Murray, H. A. (1938). *Explorations in personality*. New York: Oxford University Press.

National Academy of Sciences. (1997). *Preparing for the 21st century: The education imperative*. Retrieved from http://www.nas.edu/21st/education/education.html

National Governors Association Center for Best Practices, & Council of Chief State School Officers. (2010). *Common Core State Standards Initiates Mission Statement*. Retrieved from http://www.corestandards.org/

Newby, M. (2002). An empirical study comparing the learning environments of open and closed computer laboratories. *Journal of Information Systems Education, 13*, 303−314.

Newby, M., & Fisher, D. L. (1997). An instrument for assessing the learning environment of a computer laboratory. *Journal of Educational Computing Research, 16*, 179−190.

Newhouse, C. P. (2001). Development and use of an instrument for computer-supported learning environments. *Learning Environments Research, 4*, 115−138.

Nix, R. K., & Fraser, B. J. (2010). Using computer-assisted teaching to promote constructivist practices in teacher education. In B. A. Morris & G. M. Ferguson (Eds.), *Computer-assisted teaching: New developments* (pp. 93−115). New York: Nova Science Publisher.

Nix, R. K., Fraser, B. J., & Ledbetter, C. E. (2005). Evaluating an integrated science learning environment using the Constructivist Learning Environment Survey. *Learning Environments Research, 8*, 109−133.

Ogbuehi, P. I., & Fraser, B. J. (2007). Learning environment, attitudes and conceptual development associated with innovative strategies in middle-school mathematics. *Learning Environments Research, 10*, 101−114.

O'Reilly, R. (1975). Classroom climate and achievement in secondary school mathematics classes. *Alberta Journal of Educational Research, 21*, 241−248.

Pajares, F. (1996). Self-efficacy beliefs and mathematical problem solving of gifted students. *Contemporary Educational Psychology, 21*, 325−344.

Pallant, J. (2007). *SPSS survival manual* (3rd ed.). New York: Open University Press.

Patton, M. Q. (2002). *Qualitative evaluation and research methods* (3rd ed.). Thousand Oaks, CA: Sage Publications, Inc.

Peiro, M. M., & Fraser, B. J. (2009). Assessment and investigation of science learning environments in the early childhood grades. In M. Ortiz & C. Rubio

(Eds.), *Educational evaluation: 21st century issues and challenges* (pp. 349−366). New York: Nova Science Publishers.

Pickett, L., & Fraser, B. J. (2009). Evaluation of a mentoring program for beginning teachers in terms of the learning environment and student outcomes in participants' school classrooms. In A. Selkirk & M. Tichenor (Eds.), *Teacher education: Policy, practice and research* (pp. 1−51). New York: Nova Science Publishers, Inc.

Plake, B., & Parker, C. (1982). The development and validation of a revised version of the mathematics anxiety rating scale. *Educational and Psychological Measurement, 42*, 551-557.

Pontius, R. (1998, April). *Correlation analysis and comparison of two self-efficacy instruments.* Paper presented at the annual meeting of the National Association for Research in Science Teaching, San Diego, CA.

Quek, C. L., Wong, A. F. L., & Fraser, B. J. (2005). Student perception of chemistry laboratory learning environments, student-teacher interactions and attitudes in secondary school gifted education classes in Singapore. *Research in Science Education, 35*, 299−321.

Rentoul, A. J., & Fraser, B. J. (1979). Conceptualization of enquiry-based or open classroom learning environments. *Journal of Curriculum Studies, 11*, 233−245.

Rentoul, A. J., & Fraser, B. J. (1981). Changes in beginning teachers' attitudes towards individualised teaching approaches during the first year of teaching. *Australian Journal of Teacher Education, 6*, 1−13.

Riah, H., & Fraser, B. J. (1998, April). *Chemistry learning environment and its association with students' achievement in chemistry.* Paper presented at the annual meeting of the American Educational Research Association, San Diego, CA.

Riggs, I., & Enochs, L. (1990). Towards the development of an elementary teacher's science teaching efficacy beliefs instrument. *Science Education, 74*, 625−637.

Robinson, E., & Fraser, B. J. (2013). Kindergarten students’ and parents’ perceptions of science classroom environments: Achievement and attitudes. *Learning Environments Research, 16*, 151−167.

Roeser, R. W., Midgley, C., & Urdan, T. (1996). Perceptions of the school psychological environment and early adolescents’ self-appraisals and academic engagement: The mediating role of goals and belonging. *Journal of Educational Psychology, 88*, 408–422.

Sandman, R. S. (1980). The mathematics attitude inventory: Instrument and user's manual. *Journal for Research in Mathematics Education, 11*, 148−149.

Schunk, D. H. (1989). Self-efficacy and cognitive skill learning. In C. Ames & R. Ames (Eds.), *Research on motivation in education. Vol. 3, Goals and cognitions* (pp. 13−44). Orlando, FL: Academic Press.

Schunk, D. H. (1995). Self-efficacy and education and instruction. In J. E. Maddux (Ed.), *Self -efficacy, adaptation, and adjustment: Theory, research, and application* (pp. 281−303). New York: Plenum.

Schunk, D. H., & Hanson, A. R. (1985). Peer models: Influence on children's self-efficacy and achievement. *Journal of Educational Psychology, 77*, 313−322.

Schwarz, N., & Bohner, G. (2001). The construction of attitudes. In A. Tesser & N. Schwarz (Eds.), *Blackwell handbook of social psychology: Intraindividual processes* (pp. 436−457). Oxford, UK: Blackwell.

Scott Houston, L., Fraser, B. J., & Ledbetter, C. E. (2008). An evaluation of elementary school science kits in terms of classroom environment and student attitudes. *Journal of Elementary Science Education, 20*, 29−47.

Scott, R. H., & Fisher, D. L. (2004). Development, validation and application of a Malay translation of an elementary version of the Questionnaire on Teacher Interaction. *Research on Science Education, 34*, 173−194.

Smist, J. M. (1992). *Science self-efficacy among high school students.* Paper presented at the annual meeting of the Northeastern Educational Research Association, Ellenvile, NY.

Soerjaningsih, W., Fraser, B. J., & Aldridge, J. M. (2001, April). *Achievement, satisfaction and learning environment among Indonesian computing students at the university level.* Paper presented at the annual meeting of the American Educational Research Association, Seattle, WA.

Spinner, H., & Fraser, B. J. (2005). Evaluation of an innovative mathematics program in terms of classroom environment, student attitudes, and conceptual development. *International Journal of Science and Mathematics Education, 3*, 267-293.

SPSS. (2010). *IBM SPSS Statistics for Windows. v.19.0.* Armonk, NY: IBM Corp.

Stern, G. G., Stein, M. I., & Bloom, B. S. (1956). *Methods in personality assessment*. Glencoe, IL: Free Press.

Stigler, J. W., & Heibert, J. (1999). *The teaching gap.* New York: The Free Press.

Tapia, M., & Marsh, G. E. (2004). An instrument to measure mathematics attitudes. *Academic Exchange Quarterly, 8*, 16−21.

Taylor, B. A., & Fraser, B. J. (2013). Learning environments, mathematics anxiety and sex differences. *Learning Environments Research, 16*, 297−313.

Taylor, P. C., Fraser, B. J., & Fisher, D. L. (1997). Monitoring constructivist classroom learning environments. *International Journal of Educational Research, 27*, 193−302.

Teh, G. P. L., & Fraser, B. J. (1994). An evaluation of computer-assisted learning in terms of achievement, attitudes and classroom environment. *Evaluation and Research in Education, 8*, 147−161.

Teh, G. P. L., & Fraser, B. J. (1995). Associations between student outcomes and geography classroom environment. *International Research in Geographical and Environmental Education, 4*, 3−18.

Telli, S., den Brok, P., & Cakiroglu, J. (2010). The importance of teacher-student interpersonal relationships for Turkish students' attitudes towards science. *Research in Science and Technological Education, 28*, 261−276.

Tippins, D. J. (1991, April). *The relationship of science self-efficacy and gender to ninth grade students' intentions to enrol in elective science courses.* Paper presented at the annual meeting of the American Educational Research Association, Chicago, IL.

Trickett, E. J., & Moos, R. H. (1974). Personal correlates of contrasting environments: Student satisfactions in high school classrooms. *American Journal of Community Psychology, 2*, 1−12.

U.S. Census Bureau. (2010). *American FactFinder fact sheet: Clovis*. Retrieved from http://factfinder2.census.gov/faces/nav/jsf/pages/community_facts.xhtml#none

Van De Walle, J. A. (2001). *Elementary and middle school mathematics: Teaching developmentally* (4th ed.). New York: Addison Wesley Longman.

Wahyudi, & Treagust, D. F. (2004). The status of science classroom learning environments in Indonesian lower secondary schools. *Learning Environments Research, 7*, 43−63.

Walberg, H. J. (1968). Teacher personality and classroom climate. *Psychology in the Schools, 5*, 163−169.

Walberg, H. J., & Anderson, G. J. (1968). Classroom climate and individual learning. *Journal of Educational Psychology, 59*, 414−419.

Walberg, H. J., Singh, R., & Rasher, S. P. (1977). Predictive validity of student perceptions: A cross-cultural replication. *American Educational Research Journal, 14*, 45−49.

Walker, S. L. (2006). Development and validation of the Test of Geography-Related Attitudes (ToGRA). *Journal of Geography, 105*, 175−181.

Webster, B. J., & Fisher, D. L. (2003). School-level environment and student outcomes in mathematics. *Learning Environments Research, 6*, 309-326.

Welch, A. G., Cakir, M., Peterson, C. M., & Ray, C. M. (2012). A cross-cultural validation of the Technology-Rich Outcomes-Focused Learning Environment Inventory (TROFLEI) in Turkey and the USA. *Research in Science & Technological Education, 30*, 49−63.

Wierstra, R. (1984). A study on classroom environment and on cognitive and affective outcomes of the PLON-curriculum. *Studies in Educational Evaluation, 10*, 273−282.

Wolf, S. J., & Fraser, B. J. (2008). Learning environment, attitudes and achievement among middle-school science students using inquiry-based laboratory activities. *Research in Science Education, 38*, 321−341.

Wong, A. F. L., & Fraser, B. J. (1995). Cross-validation in Singapore of the Science Laboratory Environment Inventory. *Psychological Reports, 76*, 907−911.

Wong, A. F. L., & Fraser, B. J. (1996). Environment-attitude associations in the chemistry laboratory classroom. *Research in Science & Technological Education, 14*, 91−102.

Wong, A. F. L., Young, D. J., & Fraser, B. J. (1997). A multilevel analysis of learning environments and student attitudes. *Educational Psychology, 17*, 449−468.

Wubbels, T. (1993). *Teacher-student relationships in science and mathematics classes* (What Research Says to the Science and Mathematics Teacher Vol. 11). Perth, Western Australia: Curtin University of Technology.

Wubbels, T., & Brekelmans, M. (2005). Two decades of research on teacher-student relationships in class. *International Journal of Educational Research, 43*, 6−24.

Wubbels, T., & Brekelmans, M. (2012). Teacher-students relationships in the classroom. In B. J. Fraser, K. G. Tobin & C. J. McRobbie (Eds.), *Second international handbook of science education* (pp. 1241−1255). New York: Springer.

Wubbels, T., Brekelmans, M., & Hooymayers, H. P. (1991). Interpersonal teacher behaviour in the classroom. In B. J. Fraser & H. J. Walberg (Eds.), *Educational environments: Evaluation, antecedents and consequences* (pp. 141−160). Oxford, England: Pergamon Press.

Wubbels, T., & Levy, J. (Eds.). (1993). *Do you know what you look like? Interpersonal relationships in education.* London, England: Falmer Press.

Zandvliet, D. B., & Fraser, B. J. (2004). Learning environments in information and communications technology classrooms. *Technology, Pedagogy and Education, 13*, 97−123.

Zandvliet, D. B., & Fraser, B. J. (2005). Physical and psychosocial environments associated with networked classrooms. *Learning Environments Research, 8*, 1−17.

Zimmerman, B. J. (1995). Self-efficacy and educational development. In A. Bandura (Ed.), *Self-efficacy in changing societies* (pp. 202−231). New York: Cambridge University Press.

Zimmerman, B. J. (1998). Developing self-fulfilling cycles of academic regulation: An analysis of exemplary instructional models. In D. H. Schunk & B. J. Zimmerman (Eds.), *Self-regulated learning: From teaching to self-reflective practice* (pp. 1−19). New York: Guilford Press.

Zimmerman, B. J., Bandura, A., & Martinez-Pons, M. (1992). Self-motivation for academic attainment: The role of self-efficacy beliefs and personal goal setting. *American Educational Research Journal, 29*, 663−676.

APPENDIX A

INFORMATION SHEETS AND CONSENT DOCUMENTS

Curtin University
Science and Mathematics Education Centre

Participant Information Sheet for Students

My name is Connie Yuen Ching Hanke and I am a mathematics teacher at Alta Sierra Intermediate School, located in Clovis, Central California. I am currently conducting research for my PhD (Doctor of Philosophy) in Mathematics Education at Curtin University.

Purpose of Research
I am using a questionnaire to investigate the perception of mathematics learning environments among junior high students in Hong Kong and the USA.

Your Role
You would need to complete a questionnaire which will take approximately 25 minutes, which will be administered by your teacher or me.

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

Confidentiality
All information provided by you will be kept confidential. The name of the school, teacher or student will not be included in any form in the published report. I will keep the response from the survey in a locked cabinet for five years and then I will destroy it. Digital records will be stored at Curtin University of Technology in Perth, Australia.

Further Information
This research has been reviewed and given approval by Curtin University Human Research Ethics Committee (Approval number SMEC-16-11). If you would like further information about the study, please feel free to contact me on my mobile at +001 559 916 3282 or by email: conniehanke@cusd.com.

Alternatively, you can contact my supervisor Professor Barry Fraser at B.Fraser@curtin.edu.au.

I would like to thank you for your involvement in this research and your participation is greatly appreciated.

Curtin University

CONSENT FORM FOR STUDENT PARTICIPANTS

- I understand the purpose and the procedures of the study.
- I have been provided with the participant information sheet.
- I understand that my involvement in this study itself might not benefit me.
- I understand that my involvement is voluntary and I can withdraw from it at any time without a problem.
- I understand that no personal identifying information will be used and that all information will be securely stored for 5 years before being destroyed.
- I have been given the opportunity to ask questions.
- I agree to participate in the study outlined to me.

Signature : ______________________ Date: ________________

Curtin University
Science and Mathematics Education Centre

Participant Information Sheet for Parents

My name is Connie Yuen Ching Hanke and I am a mathematics teacher at Alta Sierra Intermediate School, located in Clovis, Central California. I am currently conducting research for my PhD (Doctor of Philosophy) in Mathematics Education at Curtin University.

Purpose of Research

I am using a questionnaire to investigate the perception of mathematics learning environments among junior high students in Hong Kong and the USA.

Your Role

You would need to agree to allow your child to complete a questionnaire in class which will take approximately 25 minutes. This questionnaire will be administered by your child's teacher or me.

Consent to Participate

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

Confidentiality

All information provided by your child will be kept confidential. The name of the school, teacher or student will not be included in any form in the published report. I will keep the response from the survey in a locked cabinet for five years and then I will destroy it. Digital records will be stored at Curtin University of Technology in Perth, Australia.

Further Information

This research has been reviewed and given approval by Curtin University Human Research Ethics Committee (Approval number SMEC-16-11). If you would like further information about the study, please feel free to contact me on my mobile at +001 559 916 3282 or by email: conniehanke@cusd.com.

Alternatively, you can contact my supervisor Professor Barry Fraser at B.Fraser@curtin.edu.au.

I would like to thank you for your involvement in this research and your participation is greatly appreciated.

CONSENT FORM FOR PARENTS

- I understand the purpose and the procedures of the study.
- I have been provided with the participant information sheet.
- I understand that my child's involvement in this study itself might not benefit him/her.
- I understand that my child's involvement is voluntary and he/she can withdraw from it at any time without a problem.
- I understand that no personal identifying information will be used and that all information will be securely stored for 5 years before being destroyed.
- I agree to allow my child to participate in the study outlined to me.

Signature : ______________________ Date: ________________

Curtin University
Science and Mathematics Education Centre

Participant Information Sheet for Teachers

My name is Connie Yuen Ching Hanke and I am a mathematics teacher at Alta Sierra Intermediate School, located in Clovis, Central California. I am currently conducting research for my PhD (Doctor of Philosophy) in Mathematics Education at Curtin University.

Purpose of Research
I am using a questionnaire to investigate the perception of mathematics learning environments among junior high students in Hong Kong and the USA.

Your Role
You would need to provide me with a time (approximately 25 minutes) when I would be able to come into your classroom to administer the questionnaire to your students.

Consent to Participate
Your involvement in the research is entirely voluntary and you have the right to withdraw at any stage without it affecting your rights or my responsibilities. Your involvement in this research will not be used as an evaluation of you as a teacher. When you have signed the consent form I will assume that you have agreed to participate and allow me to invite your students' participation in this research.

Confidentiality
All information provided by you will be kept confidential. The name of the school, teacher or student will not be included in any form in the published report. I will keep the response from the survey in a locked cabinet for five years and then I will destroy it. Digital records will be stored at Curtin University of Technology in Perth, Australia.

Further Information
This research has been reviewed and given approval by Curtin University Human Research Ethics Committee (Approval number SMEC-16-11). If you would like further information about the study, please feel free to contact me on my mobile at +001 559 916 3282 or by email: conniehanke@cusd.com.

Alternatively, you can contact my supervisor Professor Barry Fraser at B.Fraser@curtin.edu.au.

I would like to thank you for your involvement in this research and your participation is greatly appreciated.

Curtin University

CONSENT FORM FOR TEACHER PARTICPANTS

- I understand the purpose and the procedures of the study.
- I have been provided with the participant information sheet.
- I understand that my involvement in this study itself might not benefit my students or me.
- I understand that my involvement is voluntary and I can withdraw from it at any time without a problem.
- I understand that no personal identifying information will be used and that all information will be securely stored for 5 years before being destroyed.
- I have been given the opportunity to ask questions.
- I agree to participate in the study outlined to me.

Signature : ______________________ Date: ________________

APPENDIX B

LEARNING ENVIRONMENT, ATTITUDES TOWARDS MATHEMATICS AND ACADEMIC EFFICACY QUESTIONNAIRE

(English and Chinese Versions)

Items 1–32 in this appendix are based on the What Is Happening In this Class? (WIHIC) questionnaire developed by Aldridge, Fraser and Huang (1999). Items 33–48 are based on the Test of Mathematics-Related Attitudes (TOMRA) developed by Fraser (1981). Items 49–56 are based on the Morgan-Jinks Student Efficacy Scale (MJSES) developed by Jinks and Morgan (1999). The WIHIC is discussed in Sections 2.3.10 and 3.2.1, the TOMRA is discussed in Sections 2.6.1 and 3.2.2, and MJSES is discussed in Sections 2.6.2 and 3.2.3 of this thesis. These questionnaires were used in my study with the permission of their authors.

Opinions About This Mathematics Class

Directions for Students

This questionnaire contains statements about this class and how you feel about mathematics. You will be asked how often you feel that each statement is true.

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. Your responses will be confidential.

Draw a circle around

1	if you feel this way	**Almost Never**
2	if you feel this way	**Seldom**
3	if you feel this way	**Sometimes**
4	if you feel this way	**Often**
5	if you feel this way	**Almost Always**

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

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

Practice Example

Suppose you were given the statement "I would choose my partners for group discussion."

You would need to decide whether this statement is true 'Almost always', 'Often', 'Sometimes', 'Seldom' or 'Almost never'.

If you selected **'Often',** then you would circle the number **4** on your questionnaire.

		Almost Never	Seldom	Some-times	Often	Almost Always
1.	I would choose my partners for group discussion.	1	2	3	(4)	5

Gender (Circle one): Male or Female **Grade: __________**

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
IN		**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
CO		**Almost Never**	**Seldom**	**Some-times**	**Often**	**Almost Always**
17.	I would cooperate with other students when doing assignment work.	1	2	3	4	5
18.	I would share my books and resources with other students when doing assignments.	1	2	3	4	5
19.	When I work in groups in this class, there would be teamwork.	1	2	3	4	5
20.	I would work with other students on projects in this class.	1	2	3	4	5

CO		Almost Never	Seldom	Some-times	Often	Almost Always
21.	I would learn from other students in this class.	1	2	3	4	5
22.	I would work with other students in this class.	1	2	3	4	5
23.	I would cooperate with other students on class activities.	1	2	3	4	5
24.	Students would work with me to achieve class goals.	1	2	3	4	5
E		**Almost Never**	**Seldom**	**Some-times**	**Often**	**Almost Always**
25.	The teacher would give as much attention to my questions as to other students' questions.	1	2	3	4	5
26.	I would get the same amount of help from the teacher as other students do.	1	2	3	4	5
27.	I would have the same amount of say in this class as other students.	1	2	3	4	5
28.	I would be treated the same as other students in this class.	1	2	3	4	5
29.	I would receive the same encouragement from the teacher as other students do.	1	2	3	4	5
30.	I would get the same opportunity to contribute to class discussions as other students.	1	2	3	4	5
31.	My work would receive as much praise as other students' work.	1	2	3	4	5
32.	I would get the same opportunity to answer questions as other students.	1	2	3	4	5
INQ		**Almost Never**	**Seldom**	**Some-times**	**Often**	**Almost Always**
33.	I would prefer to find out why something is true by doing a mathematics problem than by being told.	1	2	3	4	5
34.	I would prefer to do mathematics problems than read about them.	1	2	3	4	5
35.	I would prefer to investigate a mathematics problem to find out for myself than agree with people.	1	2	3	4	5
36.	I would prefer to do my own mathematics problems than to have a teacher explain them.	1	2	3	4	5

INQ		Almost Never	Seldom	Some-times	Often	Almost Always
37.	I would rather find out things by working on my own than asking an expert.	1	2	3	4	5
38.	I would rather solve a mathematics problem by experimenting than to be told the answer.	1	2	3	4	5
39.	It is better to find out by trying a mathematics problem than to ask the teacher.	1	2	3	4	5
40.	I would prefer to do a mathematics problem on a topic than to read about it in a textbook.	1	2	3	4	5
ENJ		**Almost Never**	**Seldom**	**Some-times**	**Often**	**Almost Always**
41.	Mathematics lessons are fun.	1	2	3	4	5
42.	I like mathematics lessons.	1	2	3	4	5
43.	School should have more mathematics lessons each week.	1	2	3	4	5
44.	Mathematics is one of the most interesting school subjects.	1	2	3	4	5
45.	I really enjoy going to mathematics lessons.	1	2	3	4	5
46.	The material covered in mathematics lessons is interesting.	1	2	3	4	5
47.	I look forward to mathematics lessons.	1	2	3	4	5
48.	I would enjoy school more if there were more mathematics lessons.	1	2	3	4	5
AE		**Almost Never**	**Seldom**	**Some-times**	**Often**	**Almost Always**
49.	I find it easy to get good grades in mathematics.	1	2	3	4	5
50.	I am good at mathematics.	1	2	3	4	5
51.	My friends ask me for help in mathematics.	1	2	3	4	5
52.	I find mathematics easy.	1	2	3	4	5
53.	I do better than most of my classmates in mathematics.	1	2	3	4	5
54.	I have to work hard to pass mathematics.	1	2	3	4	5
55.	I am an intelligent student.	1	2	3	4	5
56.	I help my friends with their homework in mathematics.	1	2	3	4	5

Thank you for your participation.

香港初中學生對數學課堂的意見

各位同學：
大家好！我是一位在美國加州中部任教初中的數學老師。現進行一項調查研究，探討「香港初中學生對數學課堂的意見」，因而制訂這份問卷以便蒐集資料，希望閣下抽空填寫。

這份問卷主要是調查你對數學課堂的感覺，每個問題並沒有對與錯的答案。問卷中有部分問題是很相似的，請各位同學不擔心，簡單地選擇你認為最切合你的答案。所有內容，絕對保密。

發卷人：甄婉晶

請在所選答案之號碼加上 [◯]號

性別 **(**請選擇**):** 男 / 女 班別**:** ________

TS	從來沒有	很少發生	偶而發生	經常發生	總是如此
在上數學課時：					
1. 老師會表現對我個人的關心。	1	2	3	4	5
2. 老師會停下進度來幫助我的問題。	1	2	3	4	5
3. 老師會關注我的感受。	1	2	3	4	5
4. 當我在功課上有問題時老師會幫助我。	1	2	3	4	5
5. 老師會和我談天。	1	2	3	4	5
6. 老師會關心我的問題 。	1	2	3	4	5
7. 老師會走到我的座位前和我說話。	1	2	3	4	5
8. 老師會用發問形式幫助我去理解。	1	2	3	4	5
IN	從來沒有	很少發生	偶而發生	經常發生	總是如此
在上數學課時：					
9. 我會在班上討論不同的想法。	1	2	3	4	5
10. 我會在班上討論時發表我的意見。	1	2	3	4	5
11. 老師會問我問題。	1	2	3	4	5
12. 在課堂討論時，我的想法和建議會被採用。	1	2	3	4	5
13. 我會向老師問問題。	1	2	3	4	5
14. 我會向其他同學解釋我的想法。	1	2	3	4	5
15. 同學們會和我討論如何去解決問題。	1	2	3	4	5
16. 老師會要求我解釋我是如何解決問題。	1	2	3	4	5

CO	從來沒有	很少發生	偶而發生	經常發生	總是如此
在上數學課時：					
17. 我會與其他同學合作共同完成指定作業。	1	2	3	4	5
18. 在做功課時，我會與其他同學分享我的書本和資料。	1	2	3	4	5
19. 當我在分組活動中，將有團隊精神。	1	2	3	4	5
20. 我會與其他同學一起完成課堂上的工作項目。	1	2	3	4	5
21. 在班上我會向其他同學學習。	1	2	3	4	5
22. 在班上我會與其他同學共同合作。	1	2	3	4	5
23. 我會與其他同學合作共同完成課堂上的學習活動。	1	2	3	4	5
24. 其他同學會與我共同達到班中的目標。	1	2	3	4	5
E	從來沒有	很少發生	偶而發生	經常發生	總是如此
在上數學課時：					
25. 與其他同學比較，老師會對我的問題給予同樣的關注。	1	2	3	4	5
26. 我會得到老師的幫助與其他同學一樣多。	1	2	3	4	5
27. 我在班上發言的機會與其他同學一樣多。	1	2	3	4	5
28. 我在班上受到的對待與其他同學一樣。	1	2	3	4	5
29. 我得到老師的鼓勵與其他同學一樣多。	1	2	3	4	5
30. 我在班上參與課堂討論的機會與其他同學一樣多。	1	2	3	4	5
31. 我會得到老師的稱讚與其他同學一樣多。	1	2	3	4	5
32. 我回答問題的機會與其他同學一樣多。	1	2	3	4	5
INQ	從來沒有	很少發生	偶而發生	經常發生	總是如此
33. 我寧願做數學問題去找出事物的因由，而不用別人告訴。	1	2	3	4	5
34. 我寧願做數學問題，而不用閱讀它們。	1	2	3	4	5
35. 我寧願自己去探討數學問題，而不會附和他人。	1	2	3	4	5
36. 我寧願做我自己的數學問題，而不用老師解釋。	1	2	3	4	5

37.	我寧願自己努力找出事物的因由，而不用詢問專家。	1	2	3	4	5
38.	我寧願去嘗試解決數學問題，而不是被告知答案。	1	2	3	4	5
39.	試圖找出數學問題的答案比問老師更好。	1	2	3	4	5
40.	我寧願做數學問題，而不用在教科書上閱讀有關的課題。	1	2	3	4	5
ENJ		從來沒有	很少發生	偶而發生	經常發生	總是如此
41.	數學課是很有趣。	1	2	3	4	5
42.	我喜歡數學課。	1	2	3	4	5
43.	每星期學校應該有更多的數學課。	1	2	3	4	5
44.	數學是我最感興趣的科目之一。					
45.	我真的很喜歡上數學課。	1	2	3	4	5
46.	在數學課上所提及的資料是很有趣。	1	2	3	4	5
47.	我期待著上數學課。	1	2	3	4	5
48.	如果有更多的數學課，我會更喜歡上學。	1	2	3	4	5
AE		從來沒有	很少發生	偶而發生	經常發生	總是如此
49.	我覺得很容易在數學上取得好成績。	1	2	3	4	5
50.	我擅長數學。	1	2	3	4	5
51.	我的朋友向我請教數學。	1	2	3	4	5
52.	我認為數學是容易的。	1	2	3	4	5
53.	在數學上我比大多數的同學較好。	1	2	3	4	5
54.	我要努力才能在數學取得合格成績。	1	2	3	4	5
55.	我是一個聰明的學生。	1	2	3	4	5
56.	我幫助我的朋友解決他們在數學功課上的問題。	1	2	3	4	5

多謝你的參與!