

Science and Mathematics Education Centre

**Learning Environment of University Business Studies Classrooms:
Its Assessment, Determinants and Effects on Student Outcomes**

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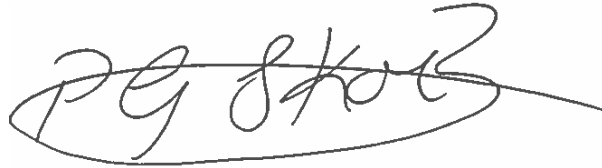
**This thesis is presented for the Degree of
Doctor of Philosophy
of
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July 2014

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:

A handwritten signature in black ink, appearing to read "P. G. Skov". The signature is written in a cursive style and is enclosed within a hand-drawn oval.

July, 2014

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Abstract

This study used the What Is Happening In this Class? (WIHIC) questionnaire, Revised Statistics Anxiety Rating Scale (RSARS) and Test of Statistics Related Attitudes (TOSrA) to assess perceptions of classroom environment, anxiety and attitudes among 375 students from 12 classes taking business statistics in Southern Californian universities. Students' achievement also was measured by the final score for the course. Analyses supported the *a priori* factor structure and internal consistency reliability of the seven-scale WIHIC, two-scale RSARS and a revised two-scale TOSrA for my sample.

When a three-way MANOVA revealed no interactions between three determinants (namely, sex, ethnicity and age) of student outcomes (anxiety, attitudes and achievement), sex, ethnic and age differences were interpreted independently. Relative to males, females had significantly higher scores for Task Orientation, Normality of Statisticians and the two anxiety scales. Relative to younger students (22 years or less), older students perceived significantly more classroom Teacher Support and Involvement, but had higher Learning Statistics Anxiety and lower achievement. Regarding statistically significant ethnic differences, Hispanics had lower achievement than Whites or Asians, and Asians perceived lower Task Orientation and Equity than Whites or Hispanics. Effect sizes for significant sex, ethnic and age differences typically ranged from approximately a quarter to a half a standard deviation (representing small to modest effects).

Simple correlation and multiple regression analyses revealed statistically-significant bivariate and multivariate associations between some of the WIHIC's learning environment scales and each of the student outcomes of statistics anxiety,

attitudes and achievement. In particular, with other WIHIC scales mutually controlled, regression coefficients revealed that specific WIHIC scales were significant independent predictors of student outcomes.

The main substantive contribution is that, for the first time, ideas from the field of learning environments were applied in university statistics classrooms. A methodological contribution is that several questionnaires were cross-validated for future use in research into university statistics education. Practical implications are that my findings of outcome–environment associations could guide statistics instructors in how to change their classrooms to reduce anxiety and promote positive attitudes and achievement, and my results for determinants of the learning environment and student outcomes could alert statistics instructors to differences between students of different sexes, ethnicities and ages that might be taken into account when planning differentiated statistics instruction.

Acknowledgements

This thesis would not have been possible under any circumstance without the support of my supervisor, Professor Barry Fraser. Apart from his immense help, several others from Curtin University contributed and helped me make it past the finish line.

My mother has been a constant cheerleader with encouragement every day since I embarked on this PhD. She has given me the energy to achieve so much in my life, kept me sane when the going was tough, never judged me and been a constant source of inspiration to me.

When my son is old enough and reads this thesis, I hope he can forgive me for the time I spent away from him to complete this work.

I dedicate this work to all of those whose potential was unjustly ripped away from them.

Chapter 1

INTRODUCTION AND RESEARCH OBJECTIVE

1.1 Introduction

This study makes a unique contribution because, for the first time, ideas from the field of learning environments were applied to university statistics classrooms. Through its results concerning determinants of classroom environment (student sex, ethnicity and age) and the effects of classroom environment on the student outcomes of attitudes and anxiety associated with learning statistics, this research potentially could offer important practical implications for improving university statistics education. The importance, contributions and significance of my study are elaborated in this introductory chapter in Sections 1.4 and 1.5.

In a recent edited book entitled *Leaders in Educational Research: Intellectual Self Portraits by Fellows of the International Academy of Education*, de Ibarrola and Phillips (2014) illustrate the value of 14 internationally-known researchers reflecting on the ways in which their careers had been shaped by early family influences, random events, surprise opportunities and nascent intellectual interests. Similarly, in this thesis, I consider it valuable to portray the many past experiences in my life that led me to my current employment and were catalysts for the initiation of my study.

My formative years were littered with violence, racism, ill-treatment, and discrimination from the ruling classes. Had it not been for my stable home environment, I might not be around today to undertake this study. Because I abhor injustice with a passion, my early childhood experiences were the catalysts which drove this research and my attempts to bring about change and ensure that other children are not subject to the bigotry that I endured as a child. Whereas Section 1.2

below describes my childhood, family, school, and early-adult experiences, Section 1.3 considers how some of these experiences motivated me to undertake this doctoral research.

This chapter comprises of the following sections:

- My Background (Section 1.2)
- Road to Research (Section 1.3)
- Statement and Importance of Problem (Section 1.4)
- Significance of this Study (Section 1.5)
- Overview of Research Methods (Section 1.6)
- Limitations of the Study (Section 1.7)
- Ethical Issues (Section 1.8)
- Chapters in Thesis (Section 1.9).

1.2 My Background

In this section I begin by laying out my childhood, family background (Section 1.2.1) and my school experiences (Section 1.2.2) as these were the most significant experiences of my life that influenced this study.

1.2.1 Childhood and Family Background

I was born and raised in London, England and have older twin siblings. Our parents were immigrants from the Greek island of Cyprus who met and married in London. For most of our formative years, we lived in an area called Brixton, which is in South-West London.

Brixton was an area with a large number of immigrants most of whom were from the Caribbean. It was a very lively and vibrant area full of color, with street markets and music blaring out of windows. On Thursdays when my father worked

for only half the day, he would take the afternoon off work and we would all go shopping to Brixton market as a family. I remember our stop at the butcher to buy meat and dairy products and my father's fondness for Edam and Blue Stilton cheeses. We would buy our Greek products, such as traditional Cypriot bread from the only Greek store around for miles, and we would buy fruit from the market stalls. On one occasion, I went shopping with only my mother and I recall passing by a music store which had what looked like a cloud inside and a very strange smell coming from it. Not knowing what this was, I asked my mother and she told me not to take any notice of the bad men. This made me even more curious, but she grabbed my hand and walked quickly past. It was many years later when I realized that the cloud was smoke and the odor was marijuana.

My father's mother was a candle maker and his father was the secretary of the town's social club. The youngest of five children, he was a very intelligent and well-rounded man whose family was not able to afford an education for him during the hard times of the Second World War. In Cyprus — which was under British rule at the time — students were sent to school at the government's expense until the age of 12 years. Beyond that point, education had been privatized. If a family could afford to send its children to school, then they would go, but otherwise they would learn a trade as an apprentice. The apprenticeship would start at the age of 12 years and continue until the age of 16. During this time, apprentices would receive no pay. My father could not afford to attend school despite the fact that his older brother, who had moved to England, was sending money so that my father could continue with his schooling. Unfortunately, my grandparents did not send my father for further education and had him serve an apprenticeship. Perhaps they believed that, if

my father obtained a good education, he too would leave and go to England and join his elder brother and leave them without either of their two sons.

My father ended up completing an apprenticeship as a barber after serving a few weeks apprenticeship as a carpenter, which he did not like. At 12 years of age, he was desperate for knowledge and struck a deal with the principal of the gymnasium school; in exchange for English lessons, my father would be the janitor of the school. Each day after he finished his apprenticeship work, he went to the school and cleaned. This must have been incredibly difficult given that his more affluent friends were now attending the school which he was then cleaning. My father told me that each day he would learn three new English words: what they meant, how to pronounce them – which he practised in front of a mirror – and how to use them in context. As the war was drawing to a close, my father tried to enlist in the British army, but my grandfather persuaded the recruitment officer not to accept him. This was perhaps another attempt to keep his son from leaving Cyprus.

As a blue-collar worker my father was attending a Labor Day rally in his hometown. There was much animosity between right-wing and left-wing political parties and the richest man in the town, who was right-wing, instructed the police to open fire into the crowd. He shouted “shoot the reds and don’t leave one of them alive”. The police opened fire into an unarmed crowd. The crowd ducked for cover but, when a boy of 12 years did not duck, a bullet struck him in the neck and he fell into a ditch and died. That boy was the only child of his parents. His father was the same man who instructed the police to open fire. My father had a lucky escape with a bullet passing through one of his trouser legs but it just grazed him. After this incident, my father was even more determined to leave Cyprus.

Despite all the obstacles, my father went to England after the Second World War. His English was so good that he worked as an interpreter in the courts when called upon, as well as working as a barber. People were actually surprised to find that he spoke Greek so well because they all assumed that he was either English or Irish based on his command of the English language and his pale complexion with rosy red cheeks.

My mother was one of eight children and the daughter of peasants who worked their land. Not much money would exchange hands, but rather more of a barter economy existed with her parents trading grains, fruits, vegetables, olive oil, milk, cheese, tobacco and livestock for items that they did not produce themselves. They even grew cotton and had a loom to turn it into fabric and then into clothes, bedding and curtains. My mother had but a few months of formal education because the demands on a family running a farm were immense. She was a God-fearing woman who was always around to help people. She visited sick people from our community in hospitals, took older people home after church, and spent our Sunday afternoons visiting the old people who were all alone. As a child, this was particularly boring and I always remember in the old people's homes the smell of burnt olive leaves and incense which they burnt as part of giving praise to God. One of the old ladies whom we would visit knew that we were bored and the poor soul would make jelly to keep us children happy. We had to call the old ladies 'auntie' so as not to make them feel old.

I did not go to kindergarten because my mother thought that people would judge her as being an unfit parent who did not care about her children and just sent them off at a very young age to have strangers to take care of them. Therefore, I did not go to school until the age of five. At that time, I could recite poetry, knew a lot of

folklore stories, and could read and write. The only problem was that this was all in Greek. I could not speak any English at all. I remember going to school and not having a clue what was going on when I was there. I could not take part in singing nursery rhymes as I did not know any. I did not know how to paint or the outcome of mixing two colors together. The food that we were given at lunch time was bewildering. I quickly started to learn English with the help of my first teacher, Miss Broom, who was a wonderful young teacher and who was very encouraging and very caring. I remember that she would always give me praise for trying.

My father had injured his back when working as a barber and ended up buying an ice-cream van. As an eight-year-old, I thought that this was magnificent. What I did not realize was that I would have to work with him from that tender age after school, on weekends and on holidays. A typical working day ran for 14 hours. My elder siblings had extremely poor excuses as to why they could not help, but still managed to get away with it and so it was just dad and me. I enjoyed being with him and finding out about his life and our relationship became one of friends rather than the more traditional father and son relationship. We actually sold icecream in very rough areas with high crime rates which were no-go areas for milkmen, staff of utility companies, postmen and even police, but we were unaware of any issues. Years later, after I had left those areas, I realized how lucky we were not to have had any major incidents.

During the winter when we were not selling ice cream, my brother and I would go to Brixton market on Saturdays to wash cars in the car park to earn some money. I remember one particular market trader, Mr Goldsmith, who drove a Jaguar and smoked big cigars. He had us clean his particularly filthy car and he would come back periodically throughout the day to make us redo parts. He had us cleaning his

car inside and out with polish and wax for the entire day. He said he would come to pay us as soon as the market closed. The whole market was packed away and everybody was gone. It was getting late, it was bitterly cold and it was dark. Only his car remained in the car park. We waited for as long as we could but he did not come to pay us. We had to go home. The following weekend, we went and found him in the market and asked for our money. His response was that he thought that we had forgotten about his car because it looked just the same as before we started, and that he would only pay us if we cleaned it again for free. We declined. From an early age, I was aware of how unfair people could be and this did not sit easily with me.

One final instance that stands out for me was our housing. We were living in part of an old Victorian house shared with an elderly German couple, Mr and Mrs Henderson. Mr Henderson was an avid gardener and the gardens really did smell of roses. He looked scary to us as kids but, every Saturday morning, he would have three comics waiting for us outside the front door. That environment was good and my parents decided to stay at that house and save enough money to build a house in my mother's village in Cyprus and move back once it was completed. On our return to Cyprus, my father was scheduled to join the police force and my mother was to be reunited with her family and the land that she loved so much. In 1974, with most of the building materials purchased, Turkey invaded Cyprus and my parents lost everything including some family members. To this day, Turkey occupies Northern Cyprus. Adding insult to injury, the local authority from which we were renting wanted us to vacate the property. We did not want to leave and the police were called in to evict us. My parents had decided not to leave because they were happy there. The police came in droves to evict us. When the senior officer approached, it happened to be one of my father's customers from his barber shop across the road

from Streatham police station, but not the local Brixton police station. We left quietly and were placed in temporary accommodation — a damp basement which had located inside our living area sewer manholes which would frequently overflow. The temporary accommodation ended up being not so temporary and it lasted for six years until my parents could muster the funds to put down a deposit to buy their own house.

During that time in the basement, I could see my parents' frustration at not being re-housed and my mother became clinically depressed. My father made many attempts to resolve this situation but all his requests fell on deaf ears. So I offered as a boy of ten or eleven years to go to the council with my mother to explain our plight. We were met by a pompous English man, who must have been nearing retirement age, with a receding hairline of white hair and a short white beard which was trimmed to a sharp point. We were escorted to a large hall where there were many sets of three chairs, each set placed in a circle, where meetings would take place, with several meetings going on at the same time. It was all highly impersonal. The council-man was very rude to us and was very dismissive of our plight. I told him that they had promised us adequate accommodation which we did not have, we were living in unhealthy damp conditions, the trash for the whole building was directly outside our bedroom window, my mother had to clean away excrement every time the drains for the entire building overflowed, and this was inhumane. He drew a line through our file with his pen and then proceeded to get up and walk out. As he walked away, I remember him muttering something under his breath about "you people". I believe that many of our trials and tribulations were racially motivated. At this time, I decided that I would always fight for what was right irrespective of the consequences. Injustice did not sit well with me.

1.2.2 School Experiences

I attended schools where around half the students were black. As a child, I was not aware of any stereotypes of black students being great athletes, lazy, and not so good at academic work. To me, they were all just classmates and friends. In fact, on the night before the final examinations at secondary school, my good friend Peter Hilton, who is of Caribbean extraction, spent three hours on the telephone explaining to me mathematics concepts that the teacher did not understand; I went on from that point to obtain a mathematics Bachelor's degree.

At school, I felt that I was different. My classes were fairly evenly split between black and white students. I was classified as white but that did not tell the whole story. I am of Greek Cypriot decent. As such, I did not look like the other white students, did not dress the same, could not relate to many aspects of class that the white teachers took for granted, and had a non-white, non-Anglo Saxon and non-protestant name. Teachers would refer to me as the Greek student and this made me feel even more like an outsider.

As I progressed through school and matured as a person, it became apparent that the school systems to which I had been exposed were institutionally racist. All teachers were white and most were rude and aggressive towards the ethnic minorities. The black kids were not victimized as much as might be anticipated because there were many of them and it was difficult to do so. The students who were singled out for the worst treatment were those like me who were classified as white, but not considered to be English. People at that time believed that racism was exclusively the domain of white against black, which is a misunderstanding. I could sense many teachers talking to me with disdain. I was physically assaulted twice by the same teacher in class at the age of eleven years old. The first time it happened, he

hit me on the head with the thin edge of a steel ruler. This became an issue and he begged my father not to do anything about it because he would lose his job. My father relented but, several months later, the same teacher walked up behind me as I was sitting in his class and he punched me in the back of the head. As I write this now, I am reliving the pain of my head being punched violently forward. He then convinced me that I would be expelled if I took the matter any further. I did not tell my father and, to this day, I regret not doing so. As a child of foreigners, my parents told me to always keep a low profile and not cause any trouble. Perhaps this was why I did not go further. The teacher's name was Murphy and he was my French teacher at Archbishop Tensions School in The Oval, London.

A black student was then punched to the ground by a different white teacher, but this was covered up by the corrupt administration of the school. Not long after, yet another white teacher attacked a black student in my class year. Unfortunately for that teacher, the boy's father worked around the corner from the school. The boy ran to his father's work and told him what had happened. His irate father went to the school, found that teacher in his next class and knocked him to the ground in a physical attack in front of the students. That teacher, Mr Shapter, did not return to work for around a year after that. The teachers' attacks were always brazen and in front of other students but, after Mr Shapter was hospitalized, the attacks stopped. In between my incident and Mr Shapter being hospitalized, there were many other incidents.

One day, I was attacked in the gymnasium by three students associating themselves with an extreme white Nazi party. I came to learn that this was a planned attack and it took place under the nose of the gym teacher, Mr Anderson, who sat in his office in the corner of the gymnasium where the attack took place, and

nonchalantly read his newspaper and did nothing to stop it. A short time later, when I was alone with one of my assailants, Tony, I can safely say that, after our 'meeting' ended, he was the worse for wear and regretted the initial attack. When it came to the attention of his group, they immediately set up a fight to take place between myself and Tony after school in the church graveyard about half a mile from the school. Fights there were brutal because there was nobody to stop them and they would go on until either somebody was unconscious or they had no more energy to strike out, with passers-by being too afraid to intervene. The word got around the school that a fight was to take place. I was full of dread during the long walk to the graveyard and there were around 100 students coming to see the spectacle. On the way, Tony tried to ambush me and so we did not make it to the graveyard. It was obvious that the ambush was premeditated but unfortunately for Tony he lived to regret it. His racist group took off and left him when they saw he was in trouble. I took mercy on him and allowed him to get up and go home even though the mob that had gathered were baying for a finish.

Apart from Mr Anderson allowing me to be attacked right in front of him and doing nothing about it, there were other incidences too. I was a good athlete but he refused to put me into any of the sports teams. I was always playing with the kids who really did not like sport. Every sports teacher whom we had would always recommend me to play on the school teams. Mr Anderson always refused. This was strange because I had always been on all the school teams of my previous school and I was also a member of other sports teams outside school. It got to the point where other students who were on the first team would ask him to put me on the first team but he still refused. On one occasion, they did not have enough players to play another school in a local football tournament and I told him that I was available. He

did not allow me to play and preferred to field only 10 men rather than let me play. We then had trials to establish who would compete in a national cross-country competition and he told all 200 students in my school year that the first 13 students to finish the trial run would then go on to represent the school. I came third in the trials but somehow he decided not to include me on the team even though I had earned my place. On another occasion, we had trials to select the best students to represent the school in a 200-meter race. I came first in my year, breaking records in the process, and he still did not include me in the team to compete with other schools. I asked him why I would not be included. He did not answer my question but did make a comment that I am a good runner as “Greeks are used to running away from Turks”.

Finally we had school sports day in my final year at this school and Mr Anderson was our house master. He knew that I was a good athlete and chose me to run the final leg of the 100-meter relay race. It was important to him to win so that he would have bragging rights. I remember that we were in the lead when I received the baton to run the last leg. For some reason, I managed to finish last. To this day, I do not know if this was deliberate on my part. After the race, he berated me and said that “you did that on purpose”. This was all the evidence I needed to confirm that everything that he had done was a conscious decision: not to include me in any of the sports teams and to stand by and do nothing while I was being physically assaulted.

Fr. Fullerton, who was an English teacher at the school while I attended, and also a priest, did not have any non-English students in his class who were in the ‘O’ level cohort. I ended up in an English class for under-achieving students run by a wonderful English teacher by the name of Mr Usher. He could not understand why I

was in his class and he told me that he would transfer me to the 'O' level cohort class where I belonged. Fr. Fullerton blocked this on several occasions. Mr Usher fought hard for me and, then one day, Fr. Fullerton said that I would be given an examination on the spot to see if I deserved to be in his class. I had no warning or idea that I would be taking a test let alone its subject matter. Other students who were taking this test had been in his class for many months preparing and I was brought in with no warning. I did well but, because I did not answer as he had trained his students to do, he did not allow me to enter the class.

Mr Gibbs was a music teacher in my secondary school. He was referred to as 'penguin' by the students because of his motion when walking. He had been banned from administering corporal punishment which consisted of being caned. This was because, on a previous occasion whilst caning somebody, he could not bring himself to stop and so the student ran away and Mr Gibbs gave chase around the school beating the boy as he ran. Despite this, one day when he was in a foul mood, he picked four of us after class to go to the medical room. We did not have any idea why we were there but we soon found out that we would be given three strokes of the cane. When we asked for the reason, he said that he was increasing it to six instead of the three he had planned, as we were being insolent for having the audacity to ask him why we were being punished. So we all lined up and he put all his might into caning us. The net result was that it gave us credibility with the other students. He then sent us to see the deputy headmaster, Mr Lewis. He was a Scottish man who would always have whiskey in his draw. He looked like Punch from Punch and Judy and we were all very scared of him. As we walked to Mr Lewis's office, Mr Gibbs told us that the Mr Lewis would now explain to us that this caning we had just received would ruin our entire lives and that we would not be able to enter any

other learning institution and we would not be able to get a job. As we entered the office, Mr Lewis had a shot of whiskey and put the bottle back in his desk draw and quickly pushed the draw closed. Mr Gibbs had gone by this time. Mr Lewis appeared to be jaded and just said to us not to worry about anything as this incident will have no bearing on anything. This came as great relief to us.

Looking back, I am surprised that I passed any 'O' levels as these examinations took place during April and May which were months when my father's ice-cream van business was in full swing. I had to work with my father. He was the driver and I would be the server. We would drive around different parts of London and stop for a while after ringing the chimes to inform people that we had arrived. The only chance I had to study was during the drive between the stops which would last 2-20 minutes. The days were very long and tiring, rendering study at home a futile exercise.

Mr Diamond, who was my mathematics teacher at Tottenham Technical College which I attended after leaving secondary-school at the age of 16 years, was a quiet middle-aged Cambridge University graduate with a very dry but very funny sense of humor. He addressed male students Mr and their last name and female students with their first name. After every examination, he would write every student's incorrect response on a sheet of A4 paper. He would then run through the examination during a class session and say things such as "what possessed you to write.....as your answer was". After a few weeks, the class made very few mistakes. On one occasion when he was explaining summation and the Greek letter sigma, he told us that he had no clue as to why some students are afraid of this letter. He proceeded to write the letter on the board and screamed obscenities at it. He then turned around and said "see, it can't hurt me". He then started attacking it with a

piece of chalk and making slashes across it. Then, for good measure, he spat on it. It was like a scene from Monty Python. I also remember that he told us that we could cheat..... but to make sure we did not get caught. This man had a higher pass rate for mathematics and further mathematics 'A' level than anywhere else where those examinations were taken. This included private as well as public institutions. His results were better than those achieved by schools such as Eton and Harrow and they were achieved in a school in a low-achievement area. He really was part of the establishment but decided to do his job diligently and conscientiously. He was a great inspiration to me. He gave to students from poor families and with little educational prowess the opportunity to be exposed to arguably the best mathematics teacher in England. I am sure he could have earned a lot more money if he had chosen to work in a more affluent school but he chose to help the underprivileged.

1.2.3 Early Adulthood Experiences

Many classmates, friends and relatives with whom I grew up had similar experiences to mine. We were surrounded by crime and drugs as a normal part of life. Several people from this group have already died, been murdered or spent time in prison. The demise of my god-brother, Steve Economou, who was a lifelong friend, was particularly poignant for me. Our families met when both our mothers were pregnant with each of us when living in what can be described as equivalent to the 'projects' in the USA. Steve was a kind-hearted soul, the eighth of ten children born to his parents. He ended up in prison because he confessed to a crime committed by one of his relatives because that relative was married with children and could not go to prison. After spending a few years in prison, the scrawny boy who entered prison came out as a muscular man who knew how to fight. He was still

the person who would give you the shirt from his back and was still very funny and very intelligent. At the time, when he was in prison, I was getting an education and, when I graduated from university, he came out of prison. I could not find a job after graduating and ended up working with Steve doing odd jobs such as construction, being a waiter, or buying and selling seasonal clothes, amongst others. We got into many scrapes with Steve, but as long as he was with me, his wife felt comfortable. At the time, I did not see her trust as a compliment. In 2008, I attended Steve's funeral. It was awful experience that was made even worse by seeing his mother bury her favorite son. The thought in my mind was "there but for the grace of God go I". I visited her after the funeral and she wanted me to have Steve's favorite boots. They were too small for me but it was very painful experience. Not long after, she died too. When times got hard for Steve, he did not have an education to fall back on.

Another friend, named Elvis, was a long-distance lorry driver who ended up being picked up by a modelling agency, then introduced to drugs and eventually addicted to crack-cocaine. Financially, he survived via dubious means to support his two young children. I was working in the City of London's Square Mile, which is the business district. I then had money, dressed well, and had a sports car and a good life. I noticed that Elvis was beginning to act strangely. I came to find out later that the drugs which he was taking were making him paranoid. During a conversation in my car when he was lucid, I asked him what the attraction was to a drug that has such bad side effects. I remember him tapping on the dashboard of my car and saying that, if I wanted to have this conversation, I could kiss goodbye to my car, my good clothes, having money, my job and anything else I value. Looking back, I see how honorable he was.

When I see students from poor neighborhoods, in gangs or affiliated to drugs, I do not condemn or judge them, but rather I want to help them. People from those neighborhoods might not be here today unless somebody had given them a chance.

Having worked in the Square Mile, and having being brought up in areas where crime and drugs were rife, I can honestly say that there was hardly any corruption present. Even though it might seem counterintuitive, people were very honest. It came as a shock to me when I entered the field of education to find the immense level of blatant immorality and exploitation by some administrators who carry on with impunity because of the tenure system. These people would not be able to carry on that way in the real world.

1.3 Road to Research

One morning, I was driving to work and listening to a talk show on the radio. I did not catch the beginning of the transmission but the gist of the conversation was the achievement gap between African-American students and other students. During the radio debate, one of the guests mentioned a speech given by President Lyndon Johnson at a graduation ceremony. When I finished work that day, I searched the internet and found the speech. It was President Lyndon B. Johnson's Commencement Address at Howard University entitled "To Fulfill These Rights" on June 4, 1965. Howard University describes itself as "*Howard University is a federally chartered, private, coeducational, nonsectarian, historically black university located in Washington, D.C., United States*".

The speech was fuelled with an emotional and heartfelt desire to bring about change to enfranchise African-Americans and, considering that this took place in 1965, it must have been very controversial for a white incumbent President to visit a

black university to give such a speech. The 1960s in America were a time of great unrest for African-Americans. In 1964, Muhammad Ali, the heavyweight boxing champion of the world, was stripped of his title and eventually arrested for not wanting to fight in Vietnam. At the same time, the former President George W. Bush did not serve in Vietnam and was not incarcerated because he was in the National Guard and apparently did not even fulfil his obligation to that. Dr Martin Luther King Jr. who, according to his Wiki page, was an American pastor, activist, humanitarian, and leader in the African-American Civil Rights Movement, was incarcerated several times in Birmingham, Alabama, for his leadership of a non-violent protest to stop segregation throughout the United States. Eventually he was assassinated in 1968. Malcom X was a Muslim minister and human rights activist. On February 21, 1965, just three months before President Lyndon Johnson's speech at Howard University, Malcolm X was assassinated. This was a time when lynchings were still taking place in America and when people were strung up and hung by their neck from trees until they were dead. Their crime was that they were African-American. This was a time when the government had to send in the National Guard to allow African-American students to enter desegregated schools, when African-Americans had to drink water from 'colored only' drinking fountains, had to sit only at the back of buses, and were refused service at restaurants. In fact, the USA constitution only recognizes African-Americans as 3/5 of a human being. Under these circumstances, President Johnson had been incredibly brave to give his speech at Howard University. A particularly telling part of the speech was:

But freedom is not enough. You do not wipe away the scars of centuries by saying: Now you are free to go where you want, and do as you desire, and choose the leaders you please.

You do not take a person who, for years, has been hobbled by chains and liberate him, bring him up to the starting line of a race and then say, "you are free to

compete with all the others," and still justly believe that you have been completely fair.

Thus it is not enough just to open the gates of opportunity. All our citizens must have the ability to walk through those gates.

This resonated with me as I remembered as a young boy being given the opportunity to be in the 'O' level English class at school but was not able to take up the opportunity because I was not allowed to train and gain the specific knowledge needed to enter the class as the other students had.

After signing the Education Act of 1965, President Johnson, who was a teacher before he entered politics, said about his experience in teaching Mexican American students during 1928–1929:

I shall never forget the faces of the boys and the girls in that little Welhausen Mexican School, and I remember even yet the pain of realizing and knowing then that college was closed to practically every one of those children because they were too poor. And I think it was then that I made up my mind that this nation could never rest while the door to knowledge remained closed to any American.

It seems to me at that very little progress has been made over the last 90 years. Why are so few African-American students entering higher education? Why are their graduation rates so low? Why do racist stereotypes still exist? President Johnson's bravery and candor added more fuel to the fire that I had burning within to help all underprivileged students to gain an education.

Of the several thousands of students who have passed through my classes, less than 1% have been African-American, but still there have been some. I noticed a peculiar phenomenon with the African-American students. Male students would sit at the very back of the lecture room, as far away from my podium as possible and almost always had no friends in the class and never asked any questions. However, female African-American students would sit as close as possible to my podium

position and would interact with both myself and other students in the lecture room. It appeared to me that African-American male students appeared disenfranchised.

I always encouraged students to come to me whenever they needed assistance, but African-American males would never take me up on the offer. If any student under-performed in an examination, I would intervene and ask him/her to come and see me so that we could work out a remedial plan of action. African-American male students seemed to believe that I was not referring to them. After working on this for a while, they did begin to come for assistance. It was strange and I could tell that initially they felt out of place. At some point, when they realized that I treated everybody fairly and equally, I was understanding, and they had as much right to my time as any other student, I would see a positive change in their attitudes, with them feeling that they too were an integral part of the class. No African-American student has ever failed my classes.

I could actually relate to this phenomenon of feeling the odd one out at school. Apart from not speaking English and not having the knowledge that kindergarten would have given me, there were cultural differences too. We did not eat meat or fish on Wednesdays or Fridays, we went to church, we had to go to Greek school and we had to learn Greek dance. I always remember the other kids would come in each day with fresh clothes and looking pristine. I am not sure if I had five outfits at the point in time, one for each day of the week, but I do remember that all my clothes were my brothers' hand-downs. Also I remember never having more than one pair of footwear at a time. We were poor but initially it felt normal because this was all I knew. At school, however, I could feel a difference because I then had other children with whom to compare myself.

During any semester, other issues were rather more difficult to deal with. Some students were single parents, some were older students returning to school, others were sleeping in their cars because they could not afford rent, some had psychological issues, several students' parents passed away during the semester, some students were sick and undergoing aggressive treatments, one attempted to commit suicide and a couple of students even passed away. Virtually all students also had gainful employment, even including the full-time students. I can identify with the added pressure which working places on students because, during my time as a young adult student, I worked in several jobs including being a waiter, a builder's laborer, a taxi driver and, for good measure, I would buy, repair and sell cars.

I wanted to ensure that the environment that I created would be conducive for learning with enjoyment. I wanted to show students that I was 'normal', or at least as normal as anybody else, and to create an environment where all their issues would be left outside the door and where everybody was equal and treated fairly. To this end, the best advice that I had was from a peasant woman of advanced years with only a few months of formal schooling herself. Despite her lack of formal education, she told me to always remember that the students whom I am teaching are 'somebody': somebody's daughter; somebody's son; somebody's sister; somebody's brother; somebody's mother; or somebody's father. When she told me this, I was not quite sure about what she was referring. Over time, I came to realize that she was telling me to treat people with respect and compassion, and not to hold myself aloof because of my qualifications or position. This lady is my mother, Vasiliki Skordi (nee Panayi) who, despite her lack of formal education, educated herself through reading the bible, and has gone on to author two books. I often use her story as an

example to illustrate that we can achieve so much if we really want to and chasms in our background should not be worn as a badge of honor and act as an excuse to hold us back, but rather they should give us the drive and motivation to succeed.

The unfair treatment that my family received in England from local government officials, some bad school teachers and some racist teachers and students made me passionate about fighting injustice on any and all grounds. Inspirational teachers such as Miss Broom, Mr Usher and Mr Diamond, and the groundbreaking work by President Lyndon Johnson, made me realize that I could fight injustice through the classroom by being the best instructor I could be and helping students, many of whom had problems with which I could identify with. It is strange that, if I had not experienced the terrible teachers and was only exposed to good teachers as many privileged students are, I would not have known that this problem existed. I believe that some instructors who did not experience a negative educational environment when they were students might have difficulty in relating to students' issues.

In order to improve the performance of all disenfranchised students in my statistics classes and re-enfranchise them, I felt a need to learn more about how to create that nurturing and encouraging learning environment for which I was striving, reduce the levels of anxiety, promote healthy attitudes towards statistics, and overturn negative preconceptions in an environment where all students were treated with respect and felt equal opportunity, I decided to undertake this PhD in order to immerse myself in material already written in this area, conduct my own investigation with my own students, and be part of the solution rather than part of the problem. I wanted to stand up and be counted in order to bring about positive change.

1.4 Statement and Importance of Problem

Typically there is an achievement gap separating students by *ethnicity* (Blackburn & Marsh, 1991; Blank & Langesen, 2001; Halsey, Heath, & Ridge, 1980; Jonsson & Mills, 1993; Savage & Egerton, 1997; Shavit & Blossfeld, 1993). A sex achievement gap has also existed and fluctuated over the years (Kafer, 2007), but males have consistently scored higher than females in standardized mathematics tests (Amelink, 2009; CollegeBoard, 2010). Students of different ethnicities and sexes who make it through to university often have deficiencies in their educational background (Bradley, 2004), which can cause many of them to drop out of university and thus perpetuate the problem of underachievement amongst these groups (Hirschman, 2001; Van Hook & Fix, 2000). The experiences of those dropping out can also act as a deterrent to others wishing to enter higher education. Relative to other communities, the communities that are exposed to this phenomenon also tend to suffer from higher crime rates, higher drugs use, higher gang membership and higher mortality rates among their younger members (Lochner & Moretti, 2004, March; Ralph, Colopy, McRae, & Daniel, 1995). Few educators consider that these problems can be repaired through educational reforms. However, if time and effort are afforded to these students so that they can graduate from university, the cycle can be broken and the fabric of their communities can be rewoven, creating a less crime-filled society in which all citizens can feel safer (Lochner & Moretti, 2004, March; Soares, 2004).

Many students are full of trepidation when it comes to taking compulsory, university-level statistics classes (Aldogan & Aseeri, 2003; Baloglu, 2007; Cashin, 1999; Onwuegbuzie, 2004; Sgoutas-Emch & Johnson, 1998; Watts, 1991). This phenomenon is not restricted to any one discipline, but spans a whole multitude of

them, including business (Seipel & Apigian, 2005), biology (Lo & Stevenson, 1991; Mellalieu, 2003), education (Mills, 2004; Onwuegbuzie, 2004), geography (Fenster, 1992), psychology (Kottke, 2000; Piotrowski, Bagui, & Hemasinha, 2002) and sociology (Bessant, 1992; Pan & Tang, 2005). Students often need more than one attempt to pass in these classes. This causes problems for those students not passing (e.g. delays in graduation, waste of time and money when repeating the class, and perhaps having to change degree major if they never pass the compulsory class). Failing students having to repeat a class puts upward pressure on the demand for the limited supply of spaces available in each session, further prolonging graduation. It causes a logistical problem for the university because those not passing create bottlenecks. There is also a financial cost for state-sponsored universities because students repeating classes are partially funded by the government.

A need exists in the workplace for statistical analyses in many jobs, including those in the fields of economics, finance and marketing (Harraway & Barker, 1998). These are the areas where the students in this study will search for work. Harraway and Barker (1998) showed that 89% of respondents in his study reported a need for statistics in their jobs, indicating that statistical analyses are an important component of business activity. Statistics helps in management decisions and allows production of unbiased results and backing-up of otherwise unsubstantiated assertions (Williams, 2014).

1.4.1 Sex, Ethnicity and Age

One of the main aims of my study was the investigation of differences between students differing in sex, ethnicity and age in terms of classroom environment perceptions and outcomes.

Much research has focused on the large achievement gap separating students by sex (CollegeBoard, 2010; Kafer, 2007) and by ethnicity (Blackburn & Marsh, 1991; Blank & Langesen, 2001; Halsey et al., 1980; Jonsson & Mills, 1993; Savage & Egerton, 1997; Shavit & Blossfeld, 1993). Most of this research has not focused specifically on tertiary compulsory business statistics education. I could find no research carried out on the achievement gap between students of different ages taking the same courses and examinations, such as at university, and there is none at the pre-tertiary level which generally has students of the same age.

Despite the apparent importance of business graduates to business and the economy as a whole, there has been no study of the business statistics classroom learning environment in this context. This contrasts with the research at the secondary level that has been carried out over the past 40 years into learning environments in general (Fraser, 1986, 2012), science laboratory classroom environments (Fraser, Giddings, & McRobbie, 1995) and computer laboratory environments (Newby & Fisher, 1997).

Because my study involved sex, ethnic and age differences in perceived learning environment and student outcomes, literature on sex, ethnic and age differences is reviewed in detail in Chapter 2, Section 2.2.2.5.

1.4.2 Learning Environments

The field of classroom learning environments is briefly introduced here, because my study drew on and contributed to it, while a comprehensive literature review is provided in Chapter 2. Much of the learning environment research over the last 40 years has been based on the independent research of Rudolf Moos's and Herbert Walberg. The foundations for Moos' and Walberg's work were laid by

Lewin, Heider, and Heider (1936) and Murray (1938) and this was followed by Pace and Stern (1958). Moos' research led to the development of the Classroom Environment Scale CES (Moos & Trickett, 1974), whilst that of Walberg led to the Learning Environment Inventory LEI (Walberg & Anderson, 1968). This groundbreaking work was the catalyst for much of the research that followed in traditional classroom environments, particularly in the field of science education (McRobbie, Fisher, & Wong, 1998; Tobin & Fraser, 1998) which recognized that students' perceptions are important social and psychological factors in classrooms (Fraser, 1986, 1994). Lewin (1936) recognized that human behavior is determined by the interaction of the environment and the individual's personal characteristics. Often students' interactions that are based on perceptions are assessed using the many questionnaires that have been developed over the last 30 years (Fraser, 2012). The majority of these instruments have been used in primary and secondary schools, but not in higher education.

Even though some research has been carried out at the institutional level in higher education (Halpin & Croft, 1963; Pace & Stern, 1958; Stern, 1970), relatively little has been undertaken at the classroom level in higher education, possibly because a suitable instrument did not exist. However, the College and University Classroom Environment Inventory (CUCEI) was developed for small classes of up to 30 students, but not for lectures or laboratory classes (Fraser & Treagust, 1986; Fraser, Treagust, & Dennis, 1986). No specific instruments have been developed to assess the learning environments for university business statistics, however, which are predominantly taught using a combination of computer laboratories and lectures. Consequently, an important goal in my study was to cross-validate some existing learning environments scales with a sample of university business statistics students.

1.4.3 Aims

A major aim of the study was to investigate student sex, ethnicity and age as determinants of classroom environment and student outcomes. In addition, I investigated associations between the nature of the classroom learning environment and the student outcomes of anxiety, attitudes and achievement. This study involved the validation of three questionnaires, namely, the What Is Happening In this Class? (WIHIC), Revised Statistics Anxiety Rating Inventory (RSARS) and Test of Statistics Related Attitudes (TOStra), for assessing, respectively, university students' perceptions of the learning environment of their business studies classes and their attitudes and anxiety. The sample consisted of several hundred students attending universities in southern California. A practical implication of the study is that it is likely to provide insights into the types of classroom environments that promote more favorable student outcomes. The following three research questions were investigated:

- 1) Are the following questionnaires valid and reliable when used with undergraduate statistics students:
 - a. What Is Happening In this Class? (WIHIC)
 - b. Statistics Anxiety Rating Inventory (RSARS)
 - c. Test of Statistics Related Attitudes (TOStra)?

- 2) Are there (i) sex, (ii) ethnic and (iii) age differences in undergraduate business statistics students?:
 - a. Perceptions of learning environments
 - b. Anxiety
 - c. Attitudes

- d. Achievement?
- 3) Are there associations between the perceived learning environments of business statistics classes and the student outcomes of:
- a. Anxiety
 - b. Attitudes
 - c. Achievement?

1.5 Significance of the Study

This study's significance lies in the fact there has been little research into compulsory, tertiary statistics learning environments and no research for which sex, ethnicity and age were the foci of study. Indeed, at present, no instrument has been validated specifically for measuring perceived statistics classroom learning environments at the university level. Therefore, my study is unique in that it involved the development and validation of such an instrument, based on the modification of existing instruments, and in using it to investigate associations between learning environments and student outcomes.

I also investigated how students of different sexes, ethnicities and ages perceived the statistics classroom learning environment and the student outcomes of anxiety, attitudes and achievement. The analysis of these factors could help to identify how to improve statistics classroom learning environments for different groups of students.

Motivated by findings emerging from my study, instructors and institutions could implement measures to improve the outcomes of anxiety, attitudes and achievement for students of different sexes, ethnicities and ages. For example, student anxiety could be reduced if not eliminated so that students could graduate

more quickly, which would save money and enable students to enter the workforce earlier. Instructors could be provided with guidelines to help them to improve the statistics classroom environment. Because students repeating compulsory business statistics classes can create logistical problems, changes in the curriculum could be implemented after consideration of the results of this study. Finally, the instruments validated in my study might be useful to other researchers wishing to conduct research in other business classes, in statistics classes at the non-tertiary level, or into sex, ethnicity and age differences in student outcomes.

1.6 Overview of Research Methods

Although Chapter 3 is devoted to the research methods of my study, an overview of those methods is provided here. To answer my three research questions, three instruments were utilized to assess the statistics classroom learning environment, anxiety, and attitudes. Also an achievement measure was included. Sections 1.6.1 to 1.6.4 describe the assessment of these four constructs. The subsections below also briefly introduce details of my sample (Section 1.6.5) and data analyses (Section 1.6.6).

1.6.1 Assessing Learning Environment in University Statistics Classrooms

The instrument used for assessing the statistics classroom learning environment was the What Is Happening In this Class? (WIHIC) questionnaire, designed by Fraser, McRobbie and Fisher (1996, April). The WIHIC questionnaire brings together the most salient scales from a wide range of existing questionnaires, eliminating duplicated questions, removing questions that are no longer relevant to

the current classroom learning environment, and introducing new scales to assess equity and constructivism. The WIHIC has two forms: one assesses a student's perceptions of the class as a whole; and the other assesses a student's personal perceptions of his or her role in the classroom. My study used the student personal form. The WIHIC questionnaire has been chosen because of its proven validity and reliability (B.A. Taylor & Fraser, 2012; Zandvliet & Fraser, 2005). The WIHIC is considered in more detail in Chapter 2, Section 2.2.2.9 and Chapter 3, Section 3.2.1. The WIHIC has seven scales each having eight items:

- Student Cohesiveness – Extent to which students know, help, and are supportive of one another
- Teacher Support – Extent to which the teacher helps, befriends, trusts and shows interest in students
- Involvement – Extent to which students have attentive interest, participate in discussions, perform additional work, and enjoy the class
- Investigation – Emphasis on the skills and processes of inquiry and their use in problem solving and investigation
- Task orientation – Extent to which it is important to complete activities planned and to stay on the subject matter
- Cooperation – Extent to which students cooperate with one another rather than compete with one another on learning tasks
- Equity – Extent to which students are treated equitably by the teacher.

Because all scales are relevant to the business statistics classroom, and because of the established validity of the WIHIC internationally in many past studies, I chose it for use in my research.

1.6.2 Anxiety Inventory

The instrument used for assessing learning statistics anxiety and statistics test anxiety was *based* on the Revised Mathematics Anxiety Ratings Scale (RMARS) questionnaire, designed by Plake and Parker (1982), which in turn was based on the Mathematics Anxiety Rating Scale (MARS) of Suinn (1972 July). The questionnaire used in this study is named the Revised Statistics Anxiety Rating Scale (RSARS) and consists of 24 questions in the two areas of statistics learning anxiety and statistics test anxiety. The original design of the RSARS was retained except that the term ‘mathematics’ in the original RMARS was replaced by the word ‘statistics’ in the RSARS.

The RSARS had two scales, the first having 16 items and the second having eight items:

- Statistics Learning Anxiety – Extent to which students feel anxious when absorbing the subject matter
- Statistics Evaluation/Test Anxiety – The level of anxiety felt when answering questions.

The RMARS has not been widely used, but it has exhibited a level of reliability comparable to the original MARS (Capraro, Capraro, & Henson, 2001; Hannafin, 1985; Kazelskis, 1998; Plake & Parker, 1982; B. A. Taylor, 2004). The RMARS is described further in Chapter 3, Section 3.2.2.

1.6.3 Attitudes Inventory

The instrument for assessing statistics classroom attitudes was *based* on the Test of Science Related Attitudes (TOSRA), designed by Fraser (1981). The TOSRA is composed of seven scales measuring student attitudes towards science

and science-related areas. The original TOSRA has 10 questions for each scale. The modified instrument that was used in my study is referred to as the Test of Statistics Related Attitudes (TOSStRA) and it originally measured student attitudes using four scales: Normality of Statisticians, Attitudes Towards Statistics Inquiry, Adoption of Statistics Attitudes and Enjoyment of Statistics Lessons. (But note that only two of these scales survived the validity analyses reported later in Chapter 4.) These modifications were based on those carried out by Taylor and Fraser (2012). The structure and design were kept the same except that the term ‘science’ was replaced by the word ‘statistics’ and the word ‘mathematical’ was replaced by the word ‘statistical’. The TOSStRA had four scales each containing ten items:

- Normality of Statisticians – Students’ perceptions of how ‘normal’ statisticians are
- Attitudes Towards Statistics Inquiry – Extent and manner to which students prefer to investigate statistics issues
- Adoption of Statistics Attitudes – Extent to which students want to challenge and engage statistics concepts
- Enjoyment of Statistics Lessons – Extent to which students enjoy studying statistics.

The TOSRA has been used and validated in the past (Aldridge, Fraser, & Huang, 1999; Ali & Awan, 2013; Bui & Alearo, 2011; Fisher & Waldrip, 1999; Fraser, Aldridge, & Adolphe, 2010). The TOSStRA is described further in Chapter 2 (Section 2.3.2) and Chapter 3 (Section 3.2.3).

1.6.4 Course Achievement

Achievement was measured using standardized weighted aggregated scores achieved on four in-class examinations taken by the students during the course. Achievement scores were converted or standardized to a common mean and standard deviation before aggregation in order to make the total more meaningful and accurate. These achievement tests consisted of three mid-term examinations and a non-cumulative final examination which all used multiple-choice responses. Examinations utilizing multiple-choice responses do have some limitations that are discussed further in Section 1.7.

1.6.5 Sample

In order to have a large enough sample for adequate statistical power, the questionnaire was administered to 375 students from 12 classes at California State University Fullerton Business School and University of California at Santa Barbara Department of Economics. Class sizes varied between 210 students to as few as 30 students. Students were not compensated for their participation, which was during normal class sessions.

In addition to the items that appear on the three questionnaires, students were asked additional questions relating to sex, ethnicity and age, whether they were taking the class for the first time, number of classes currently being taken, estimated GPA and the number of hours of their employment outside the university. In terms of sex, ethnicity and age, my sample was similar to the whole population of business statistics students at these universities, thus permitting generalization of findings. This additional information that was collected was useful for describing the sample and gauging the degree of generalizability of findings, but the exploration of

relationships and differences associated with these demographic variables was outside the scope and stated aims of my study.

A method of identification was used to facilitate the linking of students' questionnaire responses and their final achievement scores for the course. The linking was carried out by a non-vested third party so as to avoid or minimize any possible bias in students' reported responses to the questionnaires.

The questionnaires were administered during the week when 70% of the course had been completed. The sample used in my study is considered in more detail in Chapter 3, Section 3.4.

1.6.6 Analysis of Data

Questionnaire data were analyzed in various ways to answer my three research questions. The validity and reliability were checked for each questionnaire. Factor analysis (Klein, 1994) was carried out on the responses to the three instruments separately to confirm their factor structure. After confirming the factor structure of each instrument, the reliability of the scales was assessed using Cronbach's alpha coefficient (Kupermintz, Zimmerman, & Schunk, 2003).

One research question focused on whether sex, ethnicity and age are determinants of students' perceptions of classroom environment, anxiety, attitudes and achievement in statistics. A three-way MANOVA was conducted in order to answer this research question.

To answer my other research question, correlation and multiple regression analyses were carried out to identify any significant relationships between the learning environment scales (from the WIHIC) and the student outcome variables of anxiety, attitudes and achievement.

1.7 Limitations of the Study

The questionnaires used in this study had forced-choice items. Such questionnaires with well prepared-wording are quick to administer, cheap to produce, non-intimidating to students, prompt to grade, and yield objective responses from many students over a large geographical area without the use of large amounts of manpower (Anderson & Arsenault, 1998). The questionnaires were set up so that the responses could be recorded on the actual questionnaires, thus reducing the time needed and potential errors. The respondents were likely to have given truthful responses as their identities were kept anonymous.

However, there still are a number of limitations to the questionnaire approach. The constructs chosen might not have been appropriate. Even if the factors identified had a relationship with the student outcomes, perhaps another underlying factor actually caused the effect, or the relationship was so weak that I should not have considered that factor. Questionnaire items might have missed aspects important to the research or failed to investigate them in sufficient detail, leading to loss of important information and rendering the research deficient. Also the absence of a pilot study might have been another limitation. To try to mitigate many of these problems, a great deal of time was invested in trying to identify suitable questionnaires.

Some students decided simply not to respond and perhaps the non-respondents' potential answers could have led to a somewhat different set of findings. Fortunately the students who declined to participate were few in number, and approximately 3% of enrolled students did not attend class on the day when the surveys were administered. Most respondents answered all questions, but a few students did not, perhaps because of a lack of understanding of some questions or a

feeling of discomfort about answering certain questions (e.g. questions about sex, ethnicity and age). Non-respondents could have chosen not to participate because the survey took up too much time and effort (Brown, 2003) or because it was not relevant to them (Ray & Tabor, 2003). However, none of these issues had much bearing on this study because close to 100% of the students who were in class on the day when the survey was administered participated and the vast majority answered all questions. Also more than 95.0% of students answered each questionnaire item.

Limitations are discussed further in this thesis in Section 3.6 and 5.4. Some of the other potential limitations in my study that are discussed further in Section 3.6 are: the multiple-choice format of the achievement test restricted the range of important cognitive outcomes that could be assessed; the sample was of somewhat limited size and involved only two universities, therefore limiting the statistical power of data analyses and the generalizability of findings; and the fact that I was the instructor of all classes in the sample could have influenced the results in some ways and limited their generalizability.

1.8 Ethical Issues

There were ethical issues with respect to the collection of data and possibly the reporting of findings. Attention to my own ethical standards together with those of Curtin University, California State University and the laws of the state of California and Federal laws of the USA were adhered to. These were addressed as explained briefly below:

Information. The questionnaires administered to students contained a statement outlining the purposes of the research and how it could be used to improve

the learning environments of future students. All participants had feedback made available to them, both during and at the conclusion of the study.

Permission. Permission was obtained from the lecturers who administered the questionnaires in the first instance. During administration of the questionnaire, students were given the option of not participating.

Privacy and Confidentiality. In order to determine whether achievement was related to the learning environment, it was necessary to be able to identify respondents. This was achieved by use of student numbers. After collection, the data were coded in such a way that, once the achievement data had been incorporated, student anonymity was ensured. A written guarantee was given to this effect.

Consideration. After obtaining permission for classes to participate in the research, arrangements were made to administer the questionnaire on a particular date. This took place at the beginning of the class so as to minimize disruption.

Acknowledgment. The co-operation and contribution of all participants were acknowledged.

Debriefing. Results from the research were made available to the students at their request.

Resources. The resources required for quantitative data analysis were Excel and SPSS running on a PC.

Data Storage. All paper questionnaire responses were kept locked away in my office for the duration of the study. An electronic database of all student responses was stored on password-protected computers at Curtin University and will be kept there for 7 years after the completion of the study. Nobody has had access to the information other than my supervisor and me.

1.9 Overview of Chapters in the Thesis

In Chapter 2, I undertake a thorough review of literature on learning environments. I begin with a review of the historical background of classroom environment research, instruments used to assess classroom environment, and past research on learning environments. I then examine the learning environment instrument used in this study.

A close look is taken at the different definitions and subgroupings of statistics anxiety, and the most salient instruments and research conducted to date are reviewed. Because students' attitudes towards statistics were another important component of this research, I review relevant questionnaires and research which has implications for this study.

In Chapter 3, a detailed explanation of the research methods used for this study is provided. I describe the features of the three instruments used in this study and the modifications made to them for my study. Data sources and collection are discussed, before taking a closer look at the specific data collected for this study. Methods for analysing the data from this investigation are described and, finally, a description of the major strengths and weaknesses of the study is provided.

In Chapter 4, I report the quantitative data analyses that were undertaken in order to answer the research questions posed in this study. First, I begin by examining reliability, validity, and average students' scores for the instruments. Second, sex, ethnic and age differences in learning environment perceptions, statistics anxiety, and attitudes towards statistics are reported. Third, I report associations between classroom learning environment dimensions, statistics anxiety, attitudes towards statistics and achievement.

Chapter 5 begins with a summary of my thesis (Section 5.2). Findings and conclusions are then considered (Section 5.3). Associations between classroom learning environment and student outcomes (statistics anxiety, attitudes and achievement) are then discussed (Section 5.4). An analysis of limitations of the study (Section 5.4) is followed by implications of this study (Section 5.5). Recommendations for further research are considered (Section 5.6) before finally making concluding remarks (Section 5.7).

Chapter 2

LITERATURE REVIEW

2.1 Introduction

The two main foci of my study were some determinants (namely, student sex, ethnicity and age) of classroom environment and its effects on student outcomes (namely, anxiety, attitudes and achievement) among my unique sample of university students undertaking business statistics courses. According to Miller and Cunningham (2011), classroom environment incorporates a broad range of concepts, including:

- physical environment – class composition, class size and class management
- psychological environment – interactions of students and teacher
- classroom climate – interaction of students with each other and with the teacher
- role of the teacher – teacher’s behavior.

In this chapter, I undertake a comprehensive review of the available literature in the main areas that are central to my study: classroom environment; student anxiety; and student attitudes. Although there is a rich vein of literature in the individual areas, little past research has combined the three areas in a single study. Also little past research has focused on the university level for non-science students taking compulsory business statistics classes. For this reason, I reviewed literature

from each of the three areas thoroughly to provide a firm foundation on which to build this study.

The three main areas investigated in this study — learning environments, statistics anxiety and attitudes towards statistics — were brought together to give unique insights into university business statistics classrooms in Southern California and the perceptions of students within them. In this chapter, a review of the literature provides understanding of important factors and issues, as well as identifying areas of consensus and areas of contention using the following structure:

- Learning Environment Research (Section 2.2)
- Statistics Anxiety and Attitudes Towards Statistics (2.3)
- Conclusion (2.4).

2.2 Learning Environment Research

By the time a student graduates from university, he or she has spent nearly 20,000 hours of their lives in educational institutions. Evaluating the educational environment provides the opportunity to identify and correct weaknesses so that the maximum benefit can be achieved by both teachers and students alike. Historically, evaluation in education has been based on achievement outcomes. Whilst this is an invaluable measure, it does not take into account classroom environmental factors that can affect not only achievement, but also classroom experiences and the valuable lessons that can be carried from the classroom to the real world.

A number of instruments have been developed for measuring the actual environment as perceived by both students and teachers. Some questionnaires also assess perceptions of preferred environment. Below I review literature written over a

40-year period that deals with the classroom environment using the following structure:

- Historical background of classroom environment research (Section 2.2.1)
- Instruments used to assess classroom environment (2.2.2)
- Past research on learning environments (2.2.3).

2.2.1 Historical Background of Classroom Environment Research

Much of the past classroom environment research was based on the independent research of Rudolf Moos and Herbert Walberg that was carried out over 40 years ago. Moos' and Walberg's research was influenced by earlier work utilizing low-inference, direct-observational methods (Chávez, 1984). The foundations for Moos' and Walberg's work were laid by Lewin and Heider (1936) and Murray (1938), and then followed by Pace and Stern (1958). Moos' research led to the development of the Classroom Environment Scale CES (Moos & Trickett, 1974), whilst that of Walberg led to the Learning Environment Inventory LEI, (Walberg & Anderson, 1968). This groundbreaking work was the catalyst for much of the research that followed. It was based on traditional teacher-centered classroom environments, particularly in the field of science education (McRobbie et al., 1998; Tobin & Fraser, 1998). Also it recognized that students' perceptions are important social and psychological factors in classrooms (Fraser, 1986, 1994). Lewin's (1936) work documented that human behavior is determined by the interaction of the environment and the individual's personal characteristics. Often students' interactions that are based on perceptions and are assessed using various questionnaires that have been developed and redeveloped over the last 30 years

(Fraser, 2012). The majority of these instruments have been used in primary and secondary schools, but not in higher education.

Even though some research has been carried out at the institutional level in higher education (Halpin & Croft, 1963; Pace & Stern, 1958; Stern, 1970), relatively little research had been undertaken at the classroom level in higher education. One possible explanation is that a suitable instrument did not exist to assist with the research. This gave rise to the College and University Classroom Environment Inventory (CUCEI) that was developed to be used in small classes of up to 30 students, but not for lectures or laboratory classes (Fraser & Treagust, 1986; Fraser et al., 1986). However, no specific instruments have been developed to assess the learning environments for university business statistics, which are predominantly taught using a combination of computer laboratories and lectures.

A scheme for classifying human environments into three dimensions was developed by Moos (1974) as part of his research into a host of environments in which people find themselves. Moos' three dimensions are:

- *Relationship Dimensions* — Identify the nature and intensity of personal relationships within the environment and assess the extent to which people are involved in the environment.
- *Personal Development Dimensions* — Assess the basic direction along which personal growth and self-enhancement tend to occur.
- *System Maintenance and System Change* — The extent to which the environment is orderly, clear in expectations, maintains control and is responsive to change.

It was after this that Moos developed the CES which gave researchers the opportunity to study school classroom environments.

Murray (1938) followed up on Lewin's work and proposed a personal needs–environmental press model (needs–press) that allows for the interaction of person and environment in common terms. Personal needs refer to motivational personality characteristics representing tendencies to move in the direction of certain goals. Pace and Stern (1958) were responsible for popularizing Murray's needs–press model.

Murray (1938) also distinguished between alpha press (the environment as observed by an external observer) and beta press (the environment as observed by milieu inhabitants). This work was extended by Stern, Stein and Bloom (1956) who split the beta press into two categories: private beta press – the idiosyncratic view that each person has of the environment; and consensual beta press – the shared view that members have as a group about the environment. This distinction allows data to be analysed from different viewpoints, as well as allowing different levels of statistical analysis of the data ranging from one student to the whole class.

These early beginnings have led to a plethora of articles and books in the field of classroom learning environment, with considerable international attention been drawn to the area (Fraser, 1986, 1998a; 2012). Fraser (1998a) initiated the journal entitled *Learning Environments Research* and others have assembled books such as Goh and Khine's (2002) *Studies in Educational Learning Environments*.

2.2.2 Instruments for Assessing Classroom Environment

There are many instruments used for assessing classroom learning environment. These instruments most often involve the survey method. Here, I

review nine instruments that are both historically important and those that are still used today. They are all based on the three dimensions for classifying human environments developed by Moos (1974). The dimensions are relationship, personal development and system maintenance and change.

The nine instruments reviewed below are: Learning Environment Inventory (LEI), Classroom Environment Scale (CES), Individualized Classroom Environment Questionnaire (ICEQ), My Class Inventory (MCI), College and University Classroom Environment Inventory (CUCEI), Questionnaire on Teacher Interaction (QTI), Science Laboratory Environment Inventory (SLEI), Constructivist Learning Environment Survey (CLES) and What is Happening in this Class? (WIHIC).

Table 2.1 below shows the name of the instrument, the date when it was developed and its author/s, the level of student education for which it has been developed, the number of items per scale, and the scales classified according to Moos' scheme. Analysis of the development and change in the scales gives us insight into how the field of classroom learning environments has changed over the last 50 years. An overview of the questionnaires is shown in Table 2.1 below.

2.2.2.1 *Learning Environment Inventory (LEI)*

The LEI was developed in the late 1960s as part of research on Harvard Project Physics (Walberg & Anderson, 1968). It contains 105 statements (7 statements for each of its 15 scales) to which a response is solicited. There are four possible responses which are Strongly Disagree, Disagree, Agree and Strongly Agree. The scoring direction is reversed for some of the statements. Typical items are "All students know each other very well" (Cohesiveness) and "The pace of the class is rushed" (Speed).

Table 2.1 — Overview of Scales Contained in Nine Classroom Environment Instruments (LEI, CES, ICEQ, MCI, CUCEI, QTI, SLEI, CLES, and WIHIC)

Instrument	Date Developed and Authors	Level	Items per Scale	Scales Classified According to Moos' Scheme		
				Relationship Dimensions	Personal Development Dimensions	System Maintenance and Change Dimension
Learning Environment Inventory (LEI)	1968 Walberg and Anderson	Secondary	7	Cohesiveness Friction Favouritism Cliqueness Satisfaction Apathy	Speed Difficulty Competitiveness	Diversity Formality Material environment Goal direction Disorganisation Democracy
Classroom Environment Scale (CES)	1974 Moos	Secondary	10	Involvement Affiliation Teacher support	Task orientation Competition	Order and organisation Rule clarity Teacher control Innovation
Individualised Classroom Environment Questionnaire (ICEQ)	1979 Rentoul and Fraser	Secondary	10	Personalisation Participation	Independence Investigation	Differentiation
My Class Inventory (MCI)	1982 Fraser Anderson and Walberg	Elementary	6–9	Cohesiveness Friction Satisfaction	Difficulty Competitiveness	
College and University Classroom Environment Inventory (CUCEI)	1986 Fraser and Treagust	Higher education	7	Personalisation Involvement Student cohesiveness Satisfaction	Task orientation	Innovation Individualization
Questionnaire On Teacher Interaction (QTI)	1990 Creton, Hermans and Wubbels	Secondary/ Primary	8–10	Helpful/friendly Understanding Dissatisfied Admonishing		Leadership Student responsibility and freedom Uncertain Strict
Science Laboratory Environment Inventory (SLEI)	1995 Fraser, Giddings and McRobbie	Upper Secondary/ Higher education	7	Student cohesiveness	Open-endedness Integration	Rule clarity Material environment
Constructivist Learning Environment Survey (CLES)	1995 Taylor, Dawson and Fraser	Secondary	7	Personal relevance Uncertainty	Critical voice Shared control	Student negotiation
What Is Happening In this Class? (WIHIC)	1996 Fraser, McRobbie and Fisher	Secondary	8	Student cohesiveness Teacher support Involvement	Investigation Task orientation Cooperation	Equity

Based on Fraser (2012)

Statistical tests of internal consistency (alpha reliability) and discriminant validity (mean correlation of a scale with another scale) were carried out (Fraser, Anderson, & Walberg, 1982). For the 15 LEI scales, alpha reliability coefficients were 0.70 or higher for a sample of 1048 secondary-school students. The mean correlation with other scales ranged from 0.08 to 0.40, indicating that the 15 scales are fairly independent, for a sample of 149 class means.

The LEI has been translated in to several languages including Hindi. A study in the Hindi language involved 3,000 tenth grade students (Walberg, Singh, & Rasher, 1977).

2.2.2.2 *Classroom Environment Scale (CES)*

The CES was developed in the late 1960s by Rudolf Moos and Edison Trickett at Stanford University (Fisher & Fraser, 1983b; Moos & Trickett, 1987; Trickett & Moos, 1973). It developed out of a comprehensive program of research involving perceptual measures of a variety of human environments including psychiatric hospitals, prisons, university residences, and work milieus (Moos, 1974). After trials, the final version contains 90 statements (10 statements for each of its 9 dimension scales) with the two possible responses of True or False.

Hirata and Sako (1998) used an instrument in the Japanese language that incorporated scales from the CES. For a sample of 635 students, factor analysis suggested a four-factor structure for this questionnaire as opposed to the nine-factor structure. The four factors were Teacher Control, Sense of Isolation, Order and Discipline, and Affiliation. Several studies support the use of the CES, including Moos (1979), Fraser (1982) and Fisher and Fraser (1983a). Typical items are “The

teacher takes a personal interest in the students” (Teacher Support) and “There is a clear set of rules for students to follow” (Rule Clarity).

2.2.2.3 *Individualized Classroom Environment Questionnaire (ICEQ)*

Because the LEI and the CEI were developed for teacher-centered classrooms, they do not distinguish between individualized and conventional classrooms. The ICEQ was the first instrument developed for assessing those dimensions that distinguish individualized from conventional classrooms (Fraser, 1990). The initial development of the ICEQ (Rentoul & Fraser, 1979) occurred after interviewing teachers and secondary school students. The questionnaire was modified after a review by selected experts, teachers and the secondary-school students, and after carrying out statistical tests on the data to determine which items enhanced the scale and which should be removed. The final published version of the ICEQ (Fraser, 1990) contains 50 items (10 items in each of 5 scales). The five possible frequency responses are Almost Never, Seldom, Sometimes, Often and Very Often. The scoring direction is reversed for some of the items.

The ICEQ was evaluated for its internal consistency, discriminant validity and ability to differentiate between classrooms using 1849 students (Fraser, 1990). The alpha reliability for the five scales ranged from 0.68 to 0.79, the mean correlation of a scale with the other scales ranged from 0.07 to 0.28, and ANOVA revealed proportions of variance ranging from 0.20 to 0.43 and statistically significant results for all five of the ICEQ scales. For this group of 1849 students, the ICEQ was valid and reliable. Typical items are “The teacher considers students’ feelings” (Personalization) and “Different students use different books, equipment and materials” (Differentiation). Asghar and Fraser (1995) investigated the

relationship between students' classroom environment perceptions and their attitudes using the ICEQ in Brunei.

2.2.2.4 *My Class Inventory (MCI)*

The MCI is a simplified form of the LEI. It was developed to make it more suitable for children attending elementary school and for students aged 8–12 years (Fisher & Fraser, 1981; Fraser et al., 1982; Fraser & O'Brien, 1985). It has also been used for older children in junior high school who have Limited English Proficiency (LEP).

There are four differences between the LEI and the MCI. The MCI has only five of the LEI's original 15 scales in order to reduce fatigue among younger children. The wording has been simplified to improve readability. The LEI's four-point response format has been reduced to the two alternatives of Yes or No. Answers are recorded directly on the questionnaire to avoid errors when transferring answers. The final form of the MCI has 38 items altogether. Typical items are "Children are always fighting with each other" (Friction) and "Children seem to like the class" (Satisfaction).

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

Even though research has been carried out at the intuitional level in higher education (Halpin & Croft, 1963; Pace & Stern, 1958; Stern, 1970), little had been undertaken at the classroom level in higher education. One possible explanation is that a suitable instrument did not exist to assist with the research. This gave rise to the CUCEI for use in small classes of up to 30 students, but not for lectures or laboratory classes (Fraser & Treagust, 1986; Fraser et al., 1986). The final form of

the CUCEI has 49 items (7 items in each of 7 scales). There are four possible responses: Strongly Agree, Agree, Disagree, Strongly Disagree. Typical items are “Activities in this class are clearly and carefully planned” (Task Orientation) and “Teaching approaches allow students to proceed at their own pace” (Individualization).

The instrument was validated in an Australian study with 536 students in 45 classes (Fraser, Williamson, & Tobin, 1987), resulting in Cronbach alpha coefficient values ranging from 0.72 to 0.92. It was also cross-validated using American and Australian student samples (Fraser & Treagust, 1986). A number of other studies have supported the validity and usefulness of the CUCEI for higher education settings (Fisher & Parkinson, 1998; Yarrow, Millwater, & Fraser, 1997).

Joiner, Malone and Haines (2002) used the CUCEI to determine if reforms in university calculus classes are more inclusive of different genders and personalities. The two reforms were student-centered computer-assisted learning and teacher-centered, teacher-only learning. The outcome was that differences in the actual and preferred classroom environments still existed after the reforms. When Fraser, Williamson and Tobin (1987) evaluated alternative high schools using the CUCEI with a sample of 536 students in 45 classes, they found that these alternative schools were characterized by higher levels of involvement, satisfaction, innovation and individualization. Logan, Crump, and Rennie (2006) used the CUCEI in computing classrooms in New Zealand and found that its psychometric performance was not ideal.

2.2.2.6 *Questionnaire on Teacher Interaction (QTI)*

The QTI originated in the Netherlands and focuses on the nature and quality of interpersonal relationships between students and teachers (Créton, Hermans, & Wubbels, 1990; Wubbels & Brekelmans, 1998, 2005, 2012; Wubbels, Brekelmans, & Hooymayers, 1991; Wubbels & Levy, 1991). Teacher behavior has a proximity dimension (cooperation – opposition) and an influence dimension (dominance – submission) as proposed by Leary (1957). The QTI was later developed to assess student perceptions of eight behavioural aspects exhibited by teachers: Leadership, Helping/Friendly, Understanding, Student Responsibility and Freedom, Uncertain, Dissatisfied, Admonishing, and Strict behavior. The original version of the QTI was developed in the early 1980s and had 77 items (Wubbels, Créton, & Hooymayers, 1987).

The longer Dutch version of the QTI was reduced to an American version containing 64 items (8 statements for each of its 8 dimension scales) (Wubbels & Levy, 1991). There are five possible frequency responses ranging from never to always on a scale from 1 to 5. A shorter Australian version, which contains 48 items, was developed and validated using 1512 Singaporean students (Goh & Fraser, 1996, 1998, 2000).

The QTI has been cross-validated and found to be useful in several countries at various grade levels: the USA (Wubbels & Levy, 1991) where the teacher–student relationship was shown to be associated with teacher instructional strategies, Australia (Fisher, Henderson, & Fraser, 1995) which confirmed the validity of the QTI in senior-secondary biology classes, Singapore (Goh & Fraser, 1996) where satisfactory factorial validity and internal consistency reliability were found for 5th

grade classes, and Brunei (Riah, Fraser, & Rickards, 1997) which verified validity in secondary school chemistry classes.

The main use of the QTI is to assess relationships between students and teachers. When Fisher and Rickards (1998) used the QTI with mathematics teachers to assess teacher–student interpersonal behavior in their classrooms and to use the assessment as a basis for reflecting on their own teaching using students from Grade 8, 9 and 10 mathematics classes in Australia. When Fisher, Rickards, and Newby (2001) administered the actual and preferred versions of the questionnaire to teachers and the actual version to students in 80 lower-secondary school science classes in Australia, they established that teachers’ actual perceptions of their interactions with students affected students’ perceptions, which in turn affected teachers’ perceptions. Lee, Fraser and Fisher (2003) investigated teacher–student interactions in Korean senior high schools science classrooms and found directing teachers with obeying students. Research using the QTI has shown that students’ ideal teachers are strong, friendly leaders who are more understanding and less uncertain, dissatisfied and admonishing than the average teacher (Fisher & Rickards, 1996).

Fraser, Aldridge, and Soerjaningsih (2010) investigated the relationships between students’ outcomes and the quality of student teacher interactions at a private Indonesian university. Apart from the data supporting the validity of the QTI, they also indicated differences between the two departments of computer science and management in terms of the types of instructor–student interactions that are most likely to promote student outcomes, with students preferring teachers who exhibited leadership and understanding behaviors and less uncertain behavior in their classrooms. When attitudes to science were investigated using 497 secondary-school chemistry students in Singapore, the QTI exhibited satisfactory internal consistency

reliability (Quek, Wong, & Fraser, 2005). The interpersonal behavior of teachers had an effect on students' attitudes towards chemistry. Other investigations found that both teachers and students perceptions of teacher influence grew during the first six years of the teaching career and that both teacher and student perceptions of student-teacher proximity remained fairly stable (Wubbels & Brekelmans, 2012).

2.2.2.7 *Science Laboratory Environment Inventory (SLEI)*

The SLEI was created to meet the need for an instrument that can assess the uniqueness of science laboratory classes at the senior-high school or higher-education levels (Fraser & McRobbie, 1995). It contains 35 items (7 items for each of its five scales) to which students respond using Almost Never, Seldom, Sometimes, Often, and Very Often. Typical items are "I use the theory from my regular science class sessions during laboratory activities" (Integration) and "We know the results that we are supposed to get before we commence a laboratory activity" (Open Endedness).

The SLEI has been field tested and simultaneously validated using a sample of over 5,447 students in 269 countries in six different countries, namely, the USA, Canada, England, Israel, Australia and Nigeria, and then cross-validated with a sample of 1,594 students in 92 classes in Australia by Fraser and McRobbie (1995) and again using a sample of 489 senior high school biology students by Fisher et al. (1995).

Previous research that has cross-validated the SLEI has focused on measuring the environment of chemistry laboratory classes in Singapore using a sample of 497 tenth grade students from three independent schools (Quek et al., 2005) and a sample of 1,592 tenth grade students (A. F. L. Wong & Fraser, 1995), in

Tasmania using a sample of 100 students from two secondary colleges and three independent schools (Fisher et al., 1995), and in Korea using a sample of 439 high school students (Fraser & Lee, 2009). The SLEI has been used in biology, chemistry and physics laboratory classes (Fisher & Rickards, 1998; Henderson, Fisher, Fraser, & Youngs, 2000). It has also inspired other instruments such as the Distance and Open Learning Environment Scale – DOLES (Jegade, Fraser, & Fisher, 1995) and Maor and Fraser's (1996) instrument for evaluating computer-assisted learning.

Lightburn and Fraser (2007) evaluated the use of anthropometric activities in terms of achievement, attitudes, and classroom environment using the SLEI with a sample of 761 high-school biology students in Florida. They found that data analysis supported the SLEI's factorial validity, internal consistency reliability and the ability to differentiate between classrooms, and that using anthropometric activities was effective in terms of both classroom learning environment and student attitudes.

Newby and Fisher (1997) developed the Computer Laboratory Environment Inventory (CLEI), based on the Science Laboratory Environment Inventory, for investigating the classroom environment for courses in which the computer is a fundamental tool. Its five scales are Student Cohesiveness, Open Endedness, Integration, Technology Adequacy and Material Environment. These researchers found that all CLEI scales except Material Environment were associated with the attitudinal measures of Anxiety, Enjoyment, and Usefulness of the Course. They also felt that further refinement was required to the Technology Adequacy or Material Environment scales.

Because so little past learning environment research has focused specifically on university statistics classrooms (the focus of my study), it was important for me to review past research thoroughly irrespective of the subject area or educational

level involved. The above review of studies that involved using SLEI contributes to the completeness of my literature review.

2.2.2.8 *Constructivist Learning Environment Survey (CLES)*

Because Section 2.2.2 provides a review of all frequently-used classroom learning environment instruments, this section is devoted to a consideration of a questionnaire suited to constructivist-oriented classrooms. Constructivists believe that learning is based on a thought process by which individuals make sense of the world in relation to the knowledge and experiences that they have built up over their lifetime. This process involves active negotiation and consensus building. The CLES was developed to assist teachers and researchers to assess the degree to which a classroom's environment is consistent with the constructivist view and to assist teachers to reflect on their epistemological assumptions and reshape their teaching practice (P. C. Taylor, Fraser, & Fisher, 1997). It contains 35 items (7 items for each of its 5 dimension scales) with the five possible responses of Almost Never, Seldom, Sometimes, Often and Almost Always. Typical items are "I help the teacher decide what activities I do" (Shared Control) and "other students ask me to explain my ideas" (Student Negotiation). A shortened revised version with 20 items has been validated using a sample of 290 upper elementary, middle and high school science and preservice teachers in the USA (Johnson & McClure, 2004).

When Nix, Fraser, and Ledbetter (2005) gathered data from a diverse sample of 1079 students in 59 science classes in North Texas, they found strong support for the factorial validity and internal consistency of the CLES. It was found that the CLES scales were capable of differentiating significantly between the perceptions of students in different classes.

Aldridge, Fraser, Taylor, and Chen (2000) reported sound validity in a cross-national study of junior high school science classroom learning environments when an English version of the CLES was administered to 1081 students in 50 classes in Australia and a Mandarin version was administered to 1879 students in 50 classes in Taiwan.

Aldridge, Fraser, and Sebela (2004) administered the English version of the CLES to a sample of 1864 grade 4–6 mathematics learners in 43 classes in South Africa. The outcome of the data analysis was to validate the CLES's factorial validity, internal consistency reliability, discriminant validity, and ability to distinguish between classrooms. The main aim of this study was to make teachers more aware of their daily classroom teaching. This resulted in some improvements in the constructivist orientation of their classrooms learning environments during a 12-week intervention.

The CLES was translated into Korean and was cross-validated with a sample of 1083 students in 24 Grade 10 science students by Kim, Fisher, and Fraser (1999). Their data analysis supported the factor structure and reliability of the Korean-language version and also revealed statistically significant relationships between classroom environment and students' attitudes to science.

2.2.2.9 *What Is Happening In this Class? (WIHIC)*

Currently the WIHIC questionnaire (Fraser, 1998a) is the most-frequently used classroom instrument around the world and has achieved almost bandwagon status (Dorman, 2001). It was chosen for my study because of its proven validity and reliability (Koul & Fisher, 2005; Taylor & Fraser, 2012; Zandvliet & Fraser, 2005)

This questionnaire brings together the most salient scales from a wide range of existing questionnaires, eliminating overlapping studies and duplicated questions, removing questions that are no longer relevant to the current classroom learning environment and adding in scales for equity and constructivism that meet contemporary education concerns. It was developed by Fraser et al. (1996, April). The original scale had 90 items and nine scales but was refined after further input from students, teachers and experts and a statistical review (Fraser et al., 1996, April). It has two forms: one assesses a student's perceptions of the classroom as a whole; and the other assesses a student's personal perceptions as to their role within the class. The final form of the WIHIC questionnaire has 56 items, with 8 items in each of 7 scales (Aldridge et al., 1999). There are five possible frequency responses which are Almost Never, Seldom, Sometimes, Often and Very Often, indicating how often a practice is undertaken. The WIHIC's seven scales are:

- Student Cohesiveness – Extent to which students know, help, and are supportive of one another
- Teacher Support – Extent to which the teacher helps, befriends, trusts and shows interest in students
- Involvement – Extent to which students have attentive interest, participate in discussions, perform additional work, and enjoy the class
- Investigation – Emphasis on the skills and processes of inquiry and their use in problem solving and investigation
- Task orientation – Extent to which it is important to complete activities planned and to stay on the subject matter
- Cooperation – Extent to which students cooperate with one another rather than compete with one another on learning tasks

- Equity – Extent to which the teacher treats students equitably.

I judged that all scales were relevant to the business statistics classroom, which was the setting for my study.

Table 2.2 lists many major studies conducted using the WIHIC. Each set of entries in the table shows: reference(s), country(ies) where the studies were conducted, languages, information about samples used, factorial validity, any associations with the environment, and unique contributions.

The entries in Table 2.2 show that the questionnaire has been translated from the original English language version to the five other languages of Arabic, Indonesian, Korean, Mandarin and Spanish.

Other than the countries and languages in which the WIHIC questionnaire was administered, Table 2.2 also provides the size and composition of the sample. The table also indicates that all the studies supported the factorial validity and internal consistency of the WIHIC. Most of the studies also produced evidence supporting the WIHIC's ability to differentiate between the perceptions of students in different classrooms.

The final column of Table 2.2 shows the unique contributions of each study. For example: Zandvliet and Fraser (2004, 2005) simultaneously investigated the physical (ergonomic) and psychosocial environments; Pickett and Fraser (2009) evaluated the success of a mentoring program for beginning teachers in terms of changes in the learning environment of teachers' school classrooms; Peer and Fraser (in press) conducted the first science classroom learning environment research in primary classrooms in Singapore and identified class type, grade-level and sex differences.

Other than the original version of the WIHIC, custom versions have been developed and validated. Many researchers have incorporated into their research scales selected from the WIHIC questionnaire which were most salient for their particular research. See Table 2.3 for an overview of some of these studies. Each set of entries in the table shows: reference(s), country(ies) where the studies were conducted, languages, information about samples used, factorial validity, and unique contributions.

Based on the WIHIC, Aldridge, Laugksch, Seopa and Fraser (2006) developed and validated the Outcomes-Based Learning Environment Questionnaire (OBLEQ) in the Sepedi language, which includes four scales from the WIHIC. The OBLEQ can be used to monitor the implementation of outcomes-based classroom instruction in South Africa.

Giallousi, Gialamas, Spyrellis, and Pavlatou (2010) developed and validated the How Chemistry Class is Working (HCCW) questionnaire using two of the WIHIC scales. When the HCCW was administered in Greece and Cyprus in a Greek language version, more positive classroom environment perceptions were found among Cypriot students than Greek students.

Dorman (2001) developed a questionnaire for investigating associations between student academic efficacy and classroom environment. This research revealed that the classroom environment was related positively with academic efficacy.

Table 2.2 — Major Studies Conducted Using the WIHIC

Reference(s)	Country/ies)	Language(s)	Sample(s)	Factorial Validity and Reliability	Associations with Environment for:	Unique Contributions
Aldridge, Fraser and Huang (1999); Aldridge and Fraser (2000)	Australia Taiwan	English Mandarin	1081 (Australia) and 1879 (Taiwan) junior high science students in 50 classes	✓	Enjoyment	Mandarin translation Combined quantitative and qualitative Methods
Dorman (2003)	Australia UK Canada	English	3980 high school students	✓	NA	Confirmatory factor analysis substantiated invariant structure across countries, grade levels and sexes
Fraser, Aldridge and Adolphe (2010)	Australia Indonesia	English	567 students (Australia) and 594 students (Indonesia) in 18 secondary science classes	✓	Several attitude scales	Differences were found between countries and sexes
Zandvliet and Fraser (2004, 2005)	Australia Canada	English	1404 students in 81 networked classes	✓	Satisfaction	Involved both physical (ergonomic) and psychosocial environments
Chionh and Fraser (2009)	Singapore	English	2310 grade 10 geography mathematics students	✓	Achievement Attitudes Self-esteem	Differences between geography and mathematics classroom environments were smaller than between actual and preferred environments
Khoo and Fraser (2008)	Singapore	English	250 working adults attending computer education courses	✓	Satisfaction	Adult population Males perceived more trainer support and involvement but less equity
Koul and Fisher (2005)	India	English	1021 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

Continued

Aldridge, Fraser and Ntuli (2009)	South Africa	English	1077 grade 4–7 students	✓	NA	Preservice teachers undertaking a distance–education program used environment assessments to improve teaching practices
Kim, Fisher and Fraser (2000)	Korea	Korean	543 grade 8 science students in 12 schools	✓	Attitudes	Korean translation Sex differences in WIHIC scores
Wahyudi and Treagust (2004)	Indonesian	Indonesian	1400 lower–secondary science students in 16 schools	✓	NA	Indonesian translation Urban students perceived greater cooperation and less teacher support than suburban students
MacLeod and Fraser (2010)	UAE	Arabic	763 college students in 82 classes	✓	NA	Arabic translation Students preferred a more positive actual environment
Afari, Aldridge, Fraser, and Khine (2013)	UAE	Arabic	352 college students in 33 classes	✓	Enjoyment Academic efficacy	Arabic translation Use of games promoted a positive classroom environment
den Brok et al. (2006)	California, USA	English	665 middle–school science students in 11 schools	✓	NA	Girls perceived the environment more Favourably
Martin-Dunlop and Fraser (2008)	California, USA	English	525 female university science students in 27 classes	✓	Attitude	Very large increases in learning environment scores for an innovative Course
Ogbuehi and Fraser (2007)	California, USA	English	661 middle–school mathematics students	✓	Two attitude scales	Used 3 WIHIC and 3 CLES scales Innovative teaching strategies promoted task orientation
Reference(s)	Country/ (ies)	Language/(s)	Sample(s)	Factorial Validity and Reliability	Associations with Environment for:	Unique Contributions Continued

Wolf and Fraser (2008)	New York, USA	English	1434 middle-school science students in 71 classes	✓	Attitudes Achievement	Inquiry-based laboratory activities promoted cohesiveness and were differentially effective for males and females
Allen and 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
Robinson and Fraser (2013)	Florida, USA	English Spanish	78 parents and 172 kindergarten science students	✓	Achievement Attitudes	Kindergarten level Involved parents Spanish translation Relative to students, parents perceived a more favourable environment but preferred a less favourable environment
Helding and Fraser (2013)	Florida, USA	English Spanish	924 students in 38 grade 8 and 10 science classes	✓	Attitudes Achievement	Spanish translation Students of NBC teachers had more favourable classroom environment perceptions
Continued						
Reference(s)	Country/ies)	Language(s)	Sample(s)	Factorial Validity and	Associations with Environment for:	Unique Contributions

Reliability						
Taylor and Fraser (2013)	California, USA	English	745 high school students in 34 mathematics classes	✓	Attitudes Anxiety	Mathematics anxiety led to two factorially-distinct dimensions (Learning Mathematics Anxiety and Mathematics Evaluation Anxiety), which yielded different patterns of results for sex differences and for anxiety–environment associations
Velayutham and Aldridge (2013)	Australia	English	1360 students in grades 8, 9 and 10 in five public schools	✓	Motivation Self-regulation	Identified salient psychosocial features of the classroom environment that influence student motivation
Peer and Fraser (in press)	Singapore	English	1081 students in 55 primary school classes	✓	Attitudes	First science classroom learning environment research in primary classrooms in Singapore identifying sex, grade-level and stream differences

–Adapted from Fraser (2012)

2.2.2.10 Other Learning Environment Questionnaires

As the field of educational research attracts more researchers, with them come new ways of thinking. Recently constructivism and critical theory have made a major impact on the field and led to the development of new or improved ways of measuring classroom environment. The use of computers has also had a major impact on all aspects of our lives and has been introduced as a learning aid in classrooms (Maor & Fraser, 1996; P. C. Taylor, Dawson, & Fraser, 1995, April). The unique setting of science laboratories has so far been under-researched but this important area is drawing more attention now (Fraser et al., 1995; A. F. L. Wong & Fraser, 1995).

Table 2.3 — Specific-Purpose Questionnaires Incorporating WIHIC's Salient Scales

Instrument	Reference (s)	Country(ies)	Language(s)	Sample(s)	Factorial Validity and Reliability	Unique Contributions
Outcomes-Based Learning Environment Questionnaire (OBLEQ)	Aldridge, Laugksch, Seopa, and Fraser (2006)	South Africa	Sepedi	2638 grade 8 science students	✓	Monitoring implementation of outcomes-based classroom environment
How Chemistry Class is Working (HCCW)	Giallousi et al. (2010)	Greece and Cyprus	Greek	1394 Greek and 225 Greek Cypriot grade 10 students	✓	Chemistry classroom environment specific questionnaire
No specific name	Dorman (2001)	Australia	English	1035 mathematics students from Australian Secondary schools	✓	Associations between student academic efficacy and classroom environment questionnaire

Table 2.4 — Feedback Instruments for Monitoring New Innovations

Instrument	Date Developed and Authors	Level	Items per Scale	Scales classified according to Moos' scheme		
				Relationship Dimensions	Personal Development Dimensions	System Maintenance and Change Dimension
Technology-Rich Outcomes-Focused Learning Environment (TROFLEI)	Aldridge and Fraser (2003)	Secondary	10	Student cohesiveness Teacher support Involvement Young Adult ethos	Investigation Task orientation Cooperation	Equity Differentiation Computer Usage
Constructivist-Oriented Learning Environment Survey (COLES)	Aldridge, Fraser, Bell and Dorman (2012)	Secondary	11	Student cohesiveness Teacher support Involvement Personal relevance	Task orientation Cooperation	Equity Differentiation Formative assessment Assessment criteria

Distance learning is also developing rapidly, with many high-profile institutions (such as the Institute and Faculty of Actuaries) giving students the option of obtaining qualifications by way of distance learning. These environments are also attracting researchers' attention (Jegade et al., 1995).

The two instruments summarized in Table 2.4 enable educators and researchers to provide feedback regarding the success of new innovations.

The Technology-Rich Outcomes-Focused Learning Environment Inventory (TROFLEI) is a relatively new instrument which incorporates a wide range of dimensions (from several questionnaires) which were important when using ICT program delivery in a new post-secondary school. Specifically, the TROFLEI incorporates all of the WIHIC's seven scales in addition to the three further important scales of Differentiation from the ICEQ, Computer Usage and Young Adult Ethos. The TROFLEI has both the 'actual' and 'preferred' forms and is responded to on a five-point frequency scale (Almost Never, Seldom, Sometimes, Often and Almost Always).

The TROFLEI was validated using a sample of 2,317 students from grade 11 and 12 classes from Western Australia and Tasmania (Aldridge & Fraser, 2008). Aldridge, Dorman, and Fraser (2004) again validated the TROFLEI using multitrait–multimethod modelling with a sample of 1,249 students from Western Australia and Tasmania. When the TROFLEI was used in both its actual and preferred forms in a study conducted in New Zealand using a sample of 1027 high school students from 30 classes (Koul, Fisher, & Shaw, 2011), this study established the validity and reliability of the instrument and revealed significant differences between actual and preferred learning environment. These researchers also found that female students perceived their technology-related learning environment more positively than male students did. Statistically significant associations were found between the scales of the TROFLEI and three affective outcome scales. A cross-cultural study between the USA and Turkey established the validity of the TROFLEI (Welch, Cakir, Peterson, & Ray, 2012) using a sample of 980 students in grades 9–12 in Turkey and 130 students in grades 9–12 in the USA. The researchers concluded that the TROFLEI is valid for use in both Turkey and the USA, but cautioned that the psychometric properties ought to be further examined with populations other than grade 9–12 students.

Even though the TROFLEI is a relatively new instrument, there has been some notable research validating its scales. When Dorman and Fraser (2009) used the TROFLEI with a sample of 4,146 high school students from 286 classes in Western Australia and Tasmania, they concluded that improving classroom environment has the potential to improve student outcomes.

The Constructivist-Oriented Learning Environment Survey (COLES) (Aldridge, Fraser, Bell, & Dorman, 2012) was developed to provide teachers with

feedback from students on their perceptions of their teachers' teaching practices in order to allow teachers to make changes in strategies to improve the learning environment. The COLES includes six scales from the WIHIC and leaves out only the Investigation scale. In addition, the COLES has the scales of Differentiation from the ICEQ, Young Adult Ethos from the TROFLEI and Personal Relevance from the CLES. The most distinctive feature of COLES is the inclusion of two new scales related to assessment which are Formative Assessment (the extent to which students feel that their assessment tasks make a positive contribution to their learning) and Assessment Criteria (extent to which assessment criteria are explicit and known so that the basis for judgments is transparent). The validity and reliability for the COLES were established using a sample of 2043 grade 11 and 12 students from 147 classes in Western Australia (Aldridge et al., 2012).

Evaluation of computer-assisted learning by Maor and Fraser (1996) led to the Computerized Classroom Environment Inventory (CCEI). They developed a five-scale classroom environment instrument to assess Investigation, Open-Endedness, Organization, Material Environment and Satisfaction. They validated it in a study of the perceptions of 120 students and seven teachers in Australia.

Because my study was pioneering in its focus on applying learning environment ideas to university statistics classrooms, it was important that my research built on a comprehensive understanding of all relevant prior learning environment research in all subjects and at all educational levels. Therefore, for the sake of completeness, the review below includes brief consideration of a range of less-frequently used, but still noteworthy, learning environment questionnaires.

Woods and Fraser (1995, April) developed a questionnaire that assesses students' perceptions of specific teacher behaviours. The Classroom Interaction

Patterns Questionnaire (CIPQ) focuses on teaching style. Its six scales are Praise and Encouragement, Open Questioning, Lecture and Direction, Individual Work, Discipline and Management, and Group Work. Successive versions were field tested in Western Australia with a total of 1470 Grade 8–10 students in 62 classes.

Fisher and Waldrip (1997) developed a 40-item questionnaire that assesses culturally-sensitive factors of learning environments. The Cultural Learning Environment Questionnaire (CLEQ) has seven scales that assess Equity, Collaboration, Risk Involvement, Competition, Teacher Authority, Modeling, Congruence and Communication. The questionnaire was found to have satisfactory internal consistency reliability and factorial validity with a sample of 3,031 secondary science students in 135 classes in Australia. Dhindsa and Fraser (2004) successfully cross-validated the CLEQ using a sample of 475 teacher trainees from the University of Brunei Darussalam.

Jegade et al. (1995) developed the Distance and Open Learning Environment Scale (DOLES) for use among university students taking distance learning courses. Its five core scales are Student Cohesiveness, Teacher Support, Personal Involvement and Flexibility, Task Orientation and Material Environment, and Home Environment. It also has the two optional scales of Information Technology Resources and Study Centre Environment. Internal consistency reliability was supported for a sample of 660 university students.

Dorman, Fraser, and McRobbie (1997) developed a 66-item instrument to assess the classroom environment in Catholic schools. The seven scales of Student Application, Interactions, Cooperation, Task Orientation, Order and Organization, Individualization and Teacher Control were validated using a sample of 2,211 students in 104 classes in Queensland.

Sinclair and Fraser (2002) developed a questionnaire suitable for primary school children. Teachers used it to guide improvements in the primary classroom environments. Its four scales of Cooperation, Teacher Empathy/Equity, Task orientation and Involvement were validated with a sample of 745 students in 43 classes in Texas.

Idiris and Fraser (1997) developed a questionnaire for use in agricultural science classes for assessing Negotiation, Autonomy, Student Centeredness, Investigation and Differentiation. It was validated with a sample of 1175 students in Nigeria.

N. Wong (1993) developed a questionnaire in Hong Kong, which assesses differences between actual and preferred environment. Its eight dimensions are Enjoyability, Order, Involvement, Achievement Orientation, Teacher Led, Teacher Involvement, Teacher Support and Collaboration. The instrument was validated using a sample of 1766 Grades 7–13 mathematics students in Hong Kong.

2.2.3 Past Research on Learning Environments

There are many different applications of classroom environment instruments and research has been carried out in 12 areas identified by Fraser (1998a):

- Associations Between Student Outcomes and Environment
- Evaluation of Educational Innovations
- Differences Between Student and Teacher Perceptions of Actual and Preferred Environment
- Do Students Perform Better in their Preferred Environments?
- Teachers' Attempts to Improve Classroom Environment
- Combining Quantitative and Qualitative Methods

- School Psychology
- Links Between Educational Environments
- Cross-National Studies
- Transition from Primary to High School
- Teacher Education
- Teacher Assessment

Below, the five areas of past research that are most relevant to my study are discussed in detail.

2.2.3.1 *Associations Between Student Outcomes and Environment*

Fraser (1994) tabulated 40 past studies showing that associations between student outcome measures and learning environment perceptions have been replicated for a variety of cognitive and affective outcome measures, classroom environment instruments and samples ranging across countries and grade levels. Associations between classroom environment and cognitive and affective outcomes were found for high school chemistry classes in Australia using the SLEI (Fraser & McRobbie, 1995; McRobbie & Fraser, 1993), senior high school biology students in Australia (Fisher, Henderson, & Fraser, 1997) and chemistry students in Singapore (Wong & Fraser, 1996). Teh and Fraser (1995) conducted a study in Singapore using high school geography students from in computer-assisted instruction classrooms and found associations between classroom environment, achievement and attitudes. Associations were found between student outcomes and perceived patterns of teacher–student interaction using the QTI for Australian high school biology students (Fisher, Henderson, & Fraser 1995), high school science and mathematics students in Australia (Fisher, Fraser, & Rickards 1997) and primary school mathematic students

in Singapore (Goh, Young, & Fraser, 1995). Using both the actual and preferred from of the ICEQ, it was shown that class achievement of certain outcomes might be improved by moving the actual classroom environment towards that preferred by the class (Fisher & Fraser, 1983a, 1983b).

Historically, techniques used for analyzing associations between student outcomes and environment have usually been multiple regression rather than multilevel analysis (Bock, 1989; Bryk & Raudenbush, 1992; Goldstein, 1987). When A. F. L. Wong, Young, and Fraser (1997) used the SLEI and Goh, Young, and Fraser (1995) used the MCI to compare results using a multiple regression model against those from a hierarchical linear model, they found that most statistically significant results from the multiple regression analysis were replicated by the hierarchical linear model.

A meta-analysis involving 17,805 students from several disciplines and several countries showed that learning posttest scores and regression-adjusted gains were strongly associated with cognitive and affective learning (Haertel, Walberg, & Haertel, 1981).

Walberg (1981) includes psychosocial learning environment as one of the factors of his model of educational productivity. Secondary analysis of National Assessment of Educational Achievement data revealed that classroom and school environment were strong predictors of both achievement and attitudes when other factors were mutually controlled (Walberg, Fraser, & Welch, 1986).

Table 2.2 identifies studies that used the WIHIC in investigations of associations between learning environment and student outcomes. Each set of entries in the table shows: reference(s), country(ies) where the studies were conducted,

languages, information on samples used, factorial validity, any associations with the environment and unique contributions.

2.2.3.2 Evaluation of Educational Innovations

Classroom environment instruments can be used to evaluate educational innovations. Students involved with the Australian Science Education Project (ASEP) perceived their classrooms as being more satisfying, individualized and having a better environment than a comparison group (Fraser, 1979). Students reported that, after the introduction of a classroom computerized database, their classes became more inquiry oriented (Maor & Fraser, 1996). Classroom environment measures were used in Singapore for evaluating computer-assisted learning innovations (Teh & Fraser, 1994) and computer application courses for adults (Khoo & Fraser, 2008). Disappointing results emerged from the urban systematic reform initiative in the USA when the use of the CLES suggested no success in the constructivist reform of science education (Dryden & Fraser, 1996, April).

An evaluation of a teacher professional development program in Texas involved 445 students in 25 classes using an innovative form of the CLES which had a side-by-side response format so that students could provide their perceptions of THIS classroom and OTHER classroom. Students of teachers who had experienced the professional development (THIS classroom) perceived higher levels of Personal Relevance and Uncertainty relative to the comparison classes (OTHER classroom) (Nix et al., 2005).

Lightburn and Fraser (2007) involved 761 high-school students in southeastern USA in using the SLEI in an evaluation of the effectiveness of using

anthropometric activities. They found that, relative to a comparison group, the anthropology group had significantly higher scores on some SLEI and attitude scales.

An innovative science course for prospective elementary school teachers in Southern California was evaluated by Martin-Dunlop and Fraser (2008). When learning environment scales selected from the WIHIC and SLEI were administered to 525 female student teachers taking this innovative course, very large differences (of over 1.5 standard deviations) were found between students' perceptions of the innovative course and their previous courses.

Afari et al. (2013) involved 352 students taking college-level mathematics classes in the United Arab Emirates to investigate whether the use of games in their mathematics classes was effective in improving their perceptions of the learning environment and their attitudes towards mathematics. They found that students exposed to in-class mathematics games perceived more teacher support, involvement, personal relevance, enjoyment of mathematics lessons and academic efficacy.

2.2.3.3 *Differences between Student and Teacher Perceptions of Actual and Preferred Environment and Teachers' Attempts to Improve Classroom Environments*

Most learning environment questionnaires have two separate forms for 'actual' or experienced perceptions of classroom environment and of 'preferred' or ideal classroom environment. The point of having two forms is so that we can identify weaknesses in the current classroom environments and then make changes to improve them. There are five steps in improving classroom environments (Fisher & Fraser, 1981):

1. Assessment – Assess all students with the preferred environment questionnaire. Sometime later, administer the actual environment questionnaire.
2. Feedback – This allows the major differences between actual and preferred forms to be identified.
3. Reflection and discussion – identify areas that need to be addressed.
4. Intervention – introduce the interventions identified from step 3.
5. Reassessment – re-administer actual form to see if the intervention has had the desired effect.

Several studies have been conducted using information obtained on student or teacher perceptions as feedback to teachers to enable them to improve classroom experiences by focusing their attempts at specific areas, which were identified as having a large difference between preferred and actual environments. These studies have been carried out at the early-childhood level (Fisher, Fraser, & Bassett, 1995), primary-school level (Fraser & Deer, 1983), secondary-school level (Thorpe, Burden, & Fraser, 1994; Woods & Fraser, 1995, April) and higher-education level (Yarrow & Millwater, 1995; Yarrow et al., 1997). Woods and Fraser (1995, April) used the actual and preferred forms of the Classroom Interaction Patterns Questionnaire (CIPQ) to assess student perceptions of teacher behavior (Praise and Encouragement, Open Questioning, Lecture and Direction, Individual Work, Discipline and Management and Group work) and found that teachers receiving feedback were able to achieve larger reductions in the gap between actual and preferred classroom environment than those who did not. Using the CUCEI at the university level and the MCI at the primary-school level, preservice teachers in

training were able to improve the learning environment of both their preservice programs and primary-school classrooms during field experience (Yarrow et al., 1997).

The English version of the CLES was administered by mathematics teachers in South Africa to 1864 grade 4–9 students (Aldridge, Fraser, et al., 2004). During the intervention stage of this study, some teachers were able to increase the constructivist orientation of their classrooms, reinforcing the value of using the CLES to provide feedback to guide change.

Aldridge et al. (2012) used the 11-scale COLES to investigate the feasibility of teachers using feedback from their students' actual and preferred learning environment perceptions in action researched intended to improve their classrooms. They found that the feedback was useful and led to the implementation of classroom changes that resulted in improvements in their classroom learning environments.

2.2.3.4 Other Lines of Past Learning Environment Research

There appears to have been historically two camps of researchers: those using qualitative research methods and those using quantitative. It can be very beneficial to use both types within the same study (Fraser & Tobin, 1991; Tobin & Fraser, 1998). Qualitative methods provide insights into classroom life, whilst quantitative methods have led to the development of widely-used questionnaires. Quantitative methods were the main thrust of this research.

Aldridge et al. (1999) conducted a mixed-methods study of learning environments in Taiwan and Australia in which the WIHIC questionnaire was used in conjunction with classroom observations and interviews with students and

teachers. Overall, the qualitative and quantitative information complemented each other.

Associations between school environment and home environment have been established by simultaneously considering interactions between them (Marjoribanks, 1991). Moos (1991) showed links between school, home and parents' work environments. Dorman et al. (1997) illustrated a weak link between school and classroom environment. Jegede, Fraser, and Okebukola (1994) developed and validated a questionnaire and illustrated that students' socio-cultural environment in non-Western societies interacts with the classroom environment and can create a wedge between what is taught and what is learnt. Fraser and Kahle (2007) administered a questionnaire to a sample of nearly 7,000 students enrolled in middle-school science and mathematics classes and found that class environment accounted for a statistically significant amount of variance in achievement scores beyond that attributable to the home environment.

Cross-national studies help to highlight potential differences between countries, as there can be a greater variation in items of interest such as teaching methods and student attitudes. The status-quo in one country can appear strange to people of a different country (Fraser, 1997). Aldridge et al. (1999) conducted a cross-national study between Australia and Taiwan using the WIHIC with samples of junior high school students from each country and found that Australian students had a more positive perception than Taiwanese students for the two scales of Involvement and Equity. Similar cross-national research involving the use of the WIHIC in Indonesia and Australia was reported by Fraser, Aldridge, and Adolphe (2010).

Midgley, Eccles, and Feldlaufer (1991) reported a deterioration in classroom environment when students moved from generally smaller primary schools to larger lower secondary schools and postulated that this could have been attributable to less positive student–teacher relations and reduced student opportunities for decision making. Classroom environment for these transitioning students was less favorable than at their primary schools, with both student gender and school size being moderating variables (Ferguson & Fraser, 1996).

2.2.3.5 Determinants of Learning Environments

In this study, I considered sex, ethnicity and age as determinants of classroom environment and student outcomes.

2.2.3.5.1 Sex

A sex achievement gap has existed and fluctuated over the years (Kafer, 2007), but males have consistently scored higher than females on standardized mathematics tests (Amelink, 2009; CollegeBoard, 2010). Because of the absence of any noteworthy research into the sex achievement gap in statistics, mathematics achievement was used as a proxy because mathematics self-concept and statistics achievement are related (Benson, 1989). Stereotype threat (Steele & Aronson, 1995), in which the stereotype acts as a self-fulfilling prophecy, has been suggested as a contributing factor in female students achieving less well than male students in mathematics courses (Inzlicht & Ben-Zeev, 2000; Keller & Dauenheimer, 2003; Quinn & Spencer, 2001; Schmader, Johns, & Barquissau, 2004; Spencer, Steele, & Quinn, 1999).

Few studies have been conducted specifically into sex differences in statistics anxiety, with most research findings of sex differences in statistics-induced anxiety having been extracted from studies of mathematics test anxiety.

Ogbuehi and Fraser (2007) conducted a study of 661 middle-school students from four inner city schools in California using modified versions of the CLES, the WIHIC, and some attitude scales. They found sex differences for student Negotiation and Task Orientation from the CLES and that females students perceived the classroom environment more positively than did the male students. When it came to achievement and students' attitudes to mathematics, no statistically significant differences were found. B. A. Taylor and Fraser (2013) found that females perceived a more positive classroom environment and were less anxious about learning, but had greater anxiety regarding evaluation.

Rodarte-Luna and Sherry (2008) undertook a study of sex differences with 323 students using measures of statistics anxiety and learning strategies. Sex differences on these measures were found to be statistically significant, but with small effect sizes. Statistics anxiety and learning strategies were different between men and women. Men were found to procrastinate more than women did and this was positively related to fear of asking for help and poor organization. Peer learning and procrastination were positively related to test and class anxiety and interpretation anxiety. For females, peer learning and procrastination were positively related to aspects of statistics anxiety, with all other learning strategies being negatively related.

Haynes, Mullins, and Stein (2004) concluded that, even though both sexes experienced mathematics anxiety, the experience was not the same. For example, mathematics anxiety in males was found to be related to general test anxiety but, for

women, higher mathematics anxiety was related to lower perceived mathematics ability and a lower opinion of their instructors. In contrast, Bui and Alearo (2011) found no significant ethnic or sex differences in anxiety and attitudes towards science.

Bandalos, Yates, and Thorndike-Christ (1995) suggested that females with higher mathematics self-concept put their success down to their own behavior, while those females with lower mathematics self-concept believed success in statistics was dependent on external causes. Further, it was suggested that men who attribute failure to outside influences are more likely to worry about their statistical abilities. Females generally have more test anxiety (Salamé, 1984), especially when taking mathematics-related courses (Betz, 1978; Brush, 1978). Udo, Ramsey, and Mallow (2004) found that female non-science major students taking statistics classes exhibited higher levels of statistics anxiety than males.

Fenster (1992) found no sex differences in performance for students of statistics in an urban environment. Persistence motivation factors were shown to be different for men and women (Bartlett, 1994). For example, men tend to learn so that they can pass an examination, whereas women learn to increase their knowledge or be better equipped to help their children or grandchildren.

Wolters (1999) noted that, relative to men, women implemented more strategies to succeed. Niemivirta (1997) suggested that men are more likely to employ superficial strategies to learning and passing examinations such as memorization or rote-learning, whereas other research has suggested that men are more likely to employ a deeper level of understanding when learning than women (Rozendaal, Minnaert, & Boekaerts, 2005; Slaats, Lodewijks, & van der Sanden, 1999).

In a study by George (2006), it was concluded that, from an early age, females have more negative attitudes than males to science classes and these sex differences persist and increase as students get older (Desy, Peterson, & Brockman, 2009; P. H. Miller, Slawinski Blessing, & Schwartz, 2006).

2.2.3.5.2 Ethnicity

Very little research has focused on ethnicity in terms of statistics learning environments at the university level for non-science majors. However, Noel and Smith (1996) found that students felt more comfortable with teachers with whom they shared a common ethnicity and would interact more with them. Lundberg and Schreiner (2004) noted that teacher interaction with students was a predictor of student learning and, when marrying their results with those of Noel and Smith (1996), hypothesized that having diverse ethnic teachers who matched the ethnicities of the students would lead to enhanced student learning.

Hurtado (2001) reported that instructors of different ethnicities have distinct teaching styles that influence both content and delivery of knowledge and, if students of different ethnicities experience their learning environments differently, having a diverse teaching staff is likely to enhance students' cognitive and affective development during their schooling.

Levy, Wubbels, den Brok, and Brekelmans (2003) examined differences in students' perceptions of interpersonal teacher behavior among 3023 students in secondary schools. Several factors were significantly related to students' perceptions: student and teacher sex, student and teacher ethnic background – substantiating the results of Noel and Smith (1996) and Hurtado (2001), student age and grade, class size, grade level, subject taught and teacher experience. African-

American students believed that their teachers were more helpful and friendly, exhibited good leadership skills, and were more uncertain. In contrast, Asian-American students perceived that teachers were stricter and provided them with less responsibility. Interaction effects were found between some factors, such as student ethnicity and student sex, as well as student and teacher sex. In contrast, earlier studies had shown no differences between African-American students and their peers and that Asian-American students perceived their teachers to be more submissive (den Brok, Levy, Rodriguez, & Wubbels, 2002; Levy, Wubbels, Brekelmans, & Morganfield, 1997).

In a study by Bui and Alearo (2011), different ethnic groups were not significantly different on statistics anxiety and attitudes towards science. Other studies, not specifically in statistics for non-science majors at the university level, have typically shown a large achievement gap separating students by ethnicity (Bhattacharyya, Ison, & Blair, 2003; Blackburn & Marsh, 1991; Blank & Langesen, 2001; Halsey et al., 1980; Jonsson & Mills, 1993; Kao & Thompson, 2003; Phalet, Deboosere, & Bastiaenssen, 2007; Richardson, 2008; Savage & Egerton, 1997; Shavit & Blossfeld, 1993).

2.2.3.5.3 Age

Very little research has been conducted into the age of university business students as a determinant of learning environment, anxiety, attitudes and achievement for students taking service classes, such as the statistics course under investigation in my study. However, students who are 25 years or older have traditionally been considered to have richer life experiences, higher levels of maturity, more prior knowledge, limited time and different motivations and attitudes

than younger students (Apps, 1981; Cross, 1981; Knowles, 1969). Bean and Metzner (1985) reported that older students aged 25 years or more had academic disadvantages stemming from family background (more likely to be married, having greater family responsibilities, and having lower socioeconomic status and lower parental educational attainment) but still had grade point averages higher than for younger students (Kasworm & Pike, 1994). My investigation considered the overall GPA and not that specific to statistics service classes. Only 38.1% of the students under investigation in my study were business majors. When considering statistics service classes, Bell (2003) found that the mature-age students achieved statistically significant lower test scores than the younger students, with the cause being attributed to the higher level of anxiety exhibited by the older students.

Kasworm and Pike (1994) reported that students aged under 25 years exhibited lower levels of teacher–student interaction and higher levels of peer interaction, whereas the converse was true for older students.

A reduction in cognitive ability with increasing age has been found by Moffat, Zonderman and Resnick (2001), with older subjects taking longer to solve problems and making more errors when asked to solve problems in a spatial environment navigation test. Truluck and Courtney (2002) noted that older adults prefer a more reflective and observational learning environment, whereas younger adults prefer a more hands-on ‘feeling and doing’ environment.

Khoo and Fraser (2008) used the WIHIC to assess students’ perceptions of the learning environment and the TOSRA to investigate satisfaction among 250 working adults attending courses in computer education centers in Singapore. It was found that there was variation in student satisfaction between students of different ages.

Generally older students are more aware of the value of statistics than younger students, but they suffer higher levels of anxiety (Baloğlu, 2003). The higher levels of anxiety associated with increasing age could be attributable to more bad experiences with mathematics through the passage of time (Pajares & Kranzler, 1995).

Increasing age has also been found to be related to more negative attitudes towards statistics (Bell, 2003; Onwuegbuzie & Wilson, 2003). According to Bui and Alearo (2011), younger students have more negative attitudes to the social implications of science and experience less enjoyment. Relative to younger students, older students perceived that their teachers were stricter (Levy et al., 2003) and more dominant (Levy et al., 1997). Conversely, Levy, Wubbels, and Brekelmans (1992) found that student age was unrelated to perceptions of teacher dominance and Levy et al. (2003) concluded that, on occasions, students' age has been found to significantly related to their perceptions of teachers.

2.3 Statistics Anxiety and Attitudes Towards Statistics

In Section 2.2, I discussed aspects of the learning environment which were very important to my study. Two other important constructs that were investigated as part of my study were statistics anxiety and attitudes towards statistics. Literature is reviewed for statistics anxiety in Section 2.3.1 and attitudes towards statistics in Section 2.3.2.

2.3.1 *Statistics Anxiety*

Statistics anxiety refers to the apprehension that occurs as a result of encountering statistics in any form and at any level (Onwuegbuzie, DaRos, & Ryan,

1997). Onwuegbuzie (1998) stated that between two-thirds and four-fifths of graduate-level students experience uncomfortable levels of statistics anxiety.

Early research into anxiety was carried out by Spielberger (1972), who divided anxiety into two basic types: state anxiety and trait anxiety. State anxiety is normally short-lived anxiety that is brought on by a particular situation, whereas trait anxiety is long term and inherent. Statistics anxiety would be associated with state anxiety.

Often business majors take only one or two compulsory statistics classes (Zimmer & Fuller, 1996). Research suggests that statistics anxiety is related to the number of university-level classes completed and the time interval since last taking a mathematics course (Benson, 1989; Dykeman, 2011; Roberts & Saxe, 1982; Tomazic & Katz, 1988; Wilson, 1997), although some students with no mathematics anxiety were found to have statistics anxiety (Onwuegbuzie et al., 1997). Apart from prior mathematics exposure, prior achievement also has a bearing on statistics anxiety (Burton & Russell, 1979; Zeidner, 1991).

Mature-age students showed a higher level of statistics anxiety and lower test scores than their younger counterparts (Bell, 2003). International students also exhibited higher levels of statistics anxiety than home students (Bell, 1998). Williams (2010) found that statistics anxiety is influenced by instructor immediacy (immediacy refers to behaviours that influence the perception of physical and psychological closeness (Andersen, Norton, & Nussbaum, 1981; Gorham, 1988)).

Because mathematics anxiety is related to statistics anxiety according to Onwuegbuzie et al. (1997) and Roberts and Saxe (1982), research and literature on mathematics anxiety can enhance the understanding of statistics anxiety. Mathematics anxiety is negatively related to mathematics performance and

achievement (Hembree, 1990; Liebert & Morris, 1967; F. C. Richardson & Suinn, 1972; Sarason, 1986; Wigfield & Meece, 1988). The correlation between mathematics anxiety and performance ranges between -0.11 and -0.36 , with students with higher mathematics anxiety performing less well (Cooper & Robinson, 1989; Eccles & Jacobs, 1986; Engelhard, 1990; Green, 1990; Hembree, 1990; Morris, Davis, & Hutchings, 1981; Tocci & Engelhard, 1991; Wigfield & Meece, 1988). The effects of this anxiety also manifest themselves in indirect ways other than performance (Engelhard, 1990), including that anxious individuals are more likely to have negative attitudes towards statistics (Adams & Holcomb, 1986).

B.A. Taylor and Fraser (2013) found that mathematics anxiety could be partitioned into two separate factors. These factors were learning mathematics anxiety and mathematics evaluation anxiety, which gave different results for sex differences and anxiety-environment associations. Females perceived a more positive classroom environment and were less anxious about learning but had greater anxiety regarding evaluation. Females generally have more test anxiety (Salamé, 1984) and especially when taking mathematics related courses (Betz, 1978; Brush, 1978). Non-science majors taking science courses, such as the business majors considered in this study, often are highly science anxious, with one of the predictors of science anxiety being sex and with females exhibiting higher levels of science anxiety (Udo et al., 2004).

Low mathematics self-esteem reinforces mathematics test anxiety (Smith, 1981). Benson (1989) found that mathematics self-concept and achievement in statistics were both negatively related to statistical test anxiety, and that students who reported high levels of general test anxiety also reported high levels of statistical test anxiety. Procrastination is sometimes used as a means of avoiding anxiety, yet

Rodarte-Luna and Sherry (2008) found that procrastination was positively related to statistics anxiety.

In general, test anxiety increases when the course content is thought to be difficult (Richardson & Woolfolk, 1980). Specifically, university students tend to have higher levels of test anxiety in quantitative courses (Richardson & Suinn, 1972) and Onwuegbuzie and Wilson (2003) reported that many students have higher levels of anxiety in statistics courses than any other courses. Dykeman (2011) found that university students taking a statistics class showed a higher level of debilitating anxiety than those taking other classes. Those students also showed lower self-efficacy but there was no difference for facilitative anxiety. Highly-anxious students often do not perform as well as their less-anxious counterparts on tests (Osterhouse, 1975). A negative correlation has been found between statistics anxiety and course performance (Elmore, Lewis, & Bay, 1993, April; Lalonde & Gardner, 1993; Onwuegbuzie & Seaman, 1995; Zeidner, 1991), and a reduction in test anxiety can be accompanied by improved test performance and grade point average (Hembree, 1988). Because better achievement leads to greater student interest (George, 2006), this becomes a cycle with statistics anxiety influencing performance, which influences interest in statistics.

Test anxiety was thought of as a one-dimensional construct. Liebert and Morris (1967) were the first to propose a two-factor model of test anxiety by drawing on a distinction between affective and cognitive anxiety. Affective test anxiety accounts for the emotional part of anxiety, such as fear (Morris & Liebert, 1970; Sarason, 1986; Schwarzer, van der Ploeg, & Spielberger, 1982). Cognitive test anxiety encompasses the worry part of anxiety, such as negativity (Morris et al., 1981; Morris & Liebert, 1970; Sarason, 1986; Wigfield & Meece, 1988). Research

that has examined the different associations of affective and cognitive test anxiety with performance has been inconclusive. Some studies have shown that affective test anxiety is not correlated with test performance (Liebert & Morris, 1967; Morris & Liebert, 1970), whilst others have revealed an inverse correlation (Deffenbacher, 1978, 1980; Doctor & Altman, 1969; Sharma & Rao, 1983; Spiegler, Morris, & Liebert, 1968). Cognitive test anxiety has consistently shown a negative correlation with test performance (Deffenbacher, 1978; Wine, 1971).

In 1972, the Mathematics Anxiety Rating Scale (MARS) was developed (Richardson & Suinn, 1972) to measure multiple dimensions of mathematics anxiety. Its purpose was twofold: firstly, to diagnose students who mathematics anxiety; and, secondly, as an aid in the treatment of mathematics anxiety. The original 98-item scale was reduced in size to a 24-item scale, partially to reduce administration time (Alexander & Martray, 1989; Plake & Parker, 1982; Suinn & Winston, 2003) and revised to form the Mathematics Anxiety Questionnaire (Wigfield & Meece, 1988) and Fennema–Sherman Mathematics Attitude Scale (Fennema & Sherman, 1976).

My research used the Revised MARS (RMARS) (Plake & Parker, 1982) with the word ‘mathematics’ replaced by the word ‘statistics’, and this version of the instrument was named the Revised Statistics Anxiety Rating Scale (RSARS). The RMARS has five possible responses to each question which are Not at all Anxious, a Little Anxious, Moderately Anxious, Pretty Much Anxious and Very Anxious. Even though this instrument has not been widely used, it has exhibited a level of reliability comparable to the original MARS (Capraro et al., 2001; Hannafin, 1985; Kazelskis, 1998; Plake & Parker, 1982; B.A. Taylor, 2004). The RMARS shows a relationship between state, trait and test anxiety and mathematics test achievement (Plake & Parker, 1982). Plake and Parker (1982) were able to partition statistics class-related

anxiety into Learning Statistics Anxiety and Statistics Evaluation, the same distinction which B.A. Taylor and Fraser (2013) found for mathematics.

When Lester and Hand (1989) used the RMARS with college-level statistics students, students who were more anxious about their performance on mathematics examinations did not perform as well as the other students. It was further found that learning mathematics anxiety and belief in locus of control were not related to examination performance. Locus of control is an individual's perception about the underlying main cause of events in his/her life (i.e. whether one believes that his/her destiny lies in his/her own hands).

Williamson and Mattiske (2002) used the RMARS and concluded that there are at least two sources of statistics anxiety, namely, lack of self-confidence and uncertainty about own ability.

When Macher, Paechter, Papousek, and Ruggeri (2012) investigated the relationship between statistics anxiety and academic performance using RMARS, statistics anxiety was the strongest direct predictor of performance. Students with higher statistics anxiety achieved less well in the examination and showed higher procrastination scores. Statistics anxiety was related indirectly to putting in less effort and time on learning. Trait anxiety was found to be related positively to statistics anxiety and, counter-intuitively, to academic performance. This result was explained by considering trait anxiety as having two parts, namely, a part that is statistics related and a part which is not statistics related. It is believed that the part of trait anxiety that is unrelated to the specific part of statistics anxiety was correlating positively with performance.

An older instrument that has not been used that often recently is the Statistical Anxiety Rating Scale (STARS) (Cruise & Wilkins, 1980). It is a 51-item,

5-point Likert-format instrument developed to assess anxiety associated with the academic study of statistics. It comprises six components of statistics anxiety namely: Worth of Statistics – refers to a student's perception of the relevance of statistics; Interpretation Anxiety – concerned with the anxiety experienced when a student is faced with making a decision from or interpreting statistical data; Test and Class Anxiety – refers to the anxiety involved when taking a statistics class or test; Computational Self-concept – involves the anxiety experienced when attempting to solve mathematical problems, as well as the student's perception of her/his ability to do mathematics; Fear of Asking for Help – measures the anxiety experienced when asking a fellow student or professor for help with understanding the material covered in class or any type of statistical data, such as an article or a printout; and Fear of Statistics Teachers – concerned with the student's perception of the statistics instructor. Baloglu (2003) found that the scale internal consistency reliability coefficients varied between 0.64 and 0.96 in his study utilising the STARS. In another study utilising the STARS, Onwuegbuzie (1998a) found that the reliability of the six scales for statistics anxiety ranged from 0.80 to 0.84.

2.3.2 Attitudes Towards Statistics

The word 'attitude' refers to inferred rather than observed behavior and is related to predicting individuals' behavior in contexts involving choices based on simple preference (Allport, 1935). There has been no consensus on the meaning of the word. It can be used to mean the positive or negative degree of affect associated with a subject (Haladyna, Shaughnessy & Shaughnessy, 1983) or it can be broken down into several components (e.g. emotional response towards the subject, beliefs regarding the subject and behavior related to the subject) (Hart, 1989). Regarding the

meaning of the word attitude, Kulm (1981) contended that probably it is not possible to offer a definition of attitude towards mathematics (statistics) that would be suitable for all situations and, even if one were agreed on, it would probably be too general to be useful. For my study, attitudes towards statistics are defined as a disposition to respond favorably or unfavorably to objects, situations or people related to statistics (Chiesi & Primi, 2009; Roberts & Bilderback, 1980; Schau, 2003, August; Schau, Stevens, Dauphine, & Del Vecchio, 1995; Wise, 1985).

Finney and Schraw (2003) found that students in the social and behavioral sciences tended to feel intimidated by statistics courses and felt insufficiently competent to gain the necessary conceptual understanding. Shaughnessy (1992), Gal, Ginsburg, and Schau (1997), Leong (2006), Schau et al. (1995) and Waters, Martelli, Zakrajsek, and Popovich (1988) acknowledge that attitudes towards statistics contribute to students' difficulties in learning basic statistics concepts. It is therefore important to look into the relationship between statistics attitudes and examination performance. Dykeman (2011) found that there were no differences in attitudes towards statistics between those students who had prior statistics exposure and those who had no prior statistics exposure. Shultz and Koshino (1998) showed that there is a consistent positive correlation between statistics attitudes and achievement in statistics, which confirmed the earlier findings by Araki and Schultz (1995, May), Elmore and Lewis (1991, April), Elmore et al. (1993, April), Roberts and Saxe (1982), Sutarso (1992) and Wise (1985). The Student Attitudes and Conceptions in Statistics (STACS, Evans, 2005) is an instrument measuring student attitudes towards and conceptions about statistics. It uses a 5-point Likert-style scale with responses ranging from Strong Agreement to Strong Disagreement. When it was administered to university students taking introductory statistics service classes,

Evans (2007) noted that student attitudes and conceptions can be improved with the use of real-world problems.

Assessing students' attitudes towards statistics can provide information to teachers to help them to identify effective teaching approaches. Research has shown that using everyday life examples, to which students can relate, can have a positive impact on students' attitudes towards statistics (Carnell, 2008; Keeler & Steinhorst, 1995; Leong, 2006; Mills, 2004; Shultz & Koshino, 1998; Suanpang, Petocz, & Kalceff, 2004).

In the past, instruments such as the Statistics Attitudes Survey (SAS) (Roberts & Bilderback, 1980) and the Attitudes Towards Statistics (ATS) (Wise, 1985) have been widely used to assess statistics anxiety. Other researchers have also developed some less well-known and less-utilized evaluative instruments (Schau et al., 1995; Shultz & Koshino, 1998; Waters et al., 1988).

Gal and Ginsburg (1994) expressed reservations about the quality of instruments that have been used to assess statistics anxiety. Despite this, the ATS scale was used to investigate attitudes towards statistics, and the relationship of those attitudes with statistics examination results for university students taking statistics courses (Vanhoof, Castro Sotos, Onghena, & Verschaffel, 2006). It was found that a relationship did exist. Schau and Emmioglu (2012) investigated 2,200 students taking statistics service classes across the United States using the ATS instrument. Students' perceptions were measured at the outset of the class and again at the end. They found that students' attitudes remained about the same for most aspects being measured and that there were no improvements in attitudes. However, attitudes did decrease for the students' perceptions of the value of statistics, their interest in statistics and the effort that they put into the class.

The Survey of Attitudes Towards Statistics (SATS) (Schau, Stevens, Dauphine & del Vecchio, 1995) is a 32-item instrument with 4 scales assess attitudes towards statistics. Responses are recorded on a 7-point Likert-style scale ranging from Strongly Disagree to Strongly Agree. The four scales are: Affect (7-items) – positive or negative feelings concerning statistics; Cognitive Competence (7-items) – attitudes about intellectual knowledge and skills when applied to statistics; Value (10-items) – attitudes about the usefulness, relevance, and worth of statistics; and Difficulty (8-items) – attitudes about the difficulty of statistics as a subject. The structure of SATS was validated (Schau, Stevens, Dauphine & del Vecchio, 1995) and then cross-validated using the Attitudes Towards Statistics (ATS) (Wise, 1985). Using SATS, it has been shown that students see less value in statistics after taking a course than before (Pierce, 2006; Schau, 2003, August), even though other studies have shown no such pattern (Schield & Schield, 2008).

In my research, I used a modified version on the Test of Science Related Attitudes (TOSRA) (Fraser, 1981) to evaluate student attitudes towards statistics. The TOSRA was designed to measure attitudes towards science among secondary school students. The original version had 10 items for each of seven scales based on Klopfer's (1971) classification. Each of the seven scales measures a distinct attitude: Social implications of Science, Normality of Scientists, Attitude to scientific Inquiry, Adoption of Scientific Attitudes, Enjoyment of Science lessons, Leisure Interest in Science, and Career Interest in Science. The responses involve Likert's (1932) possible alternatives of Strongly Agree, Agree, Not Sure, Disagree and Strongly Disagree.

The TOSRA has been used to establish a relationship between student attitudes and student achievement (Ferreira, 2001; Osborne, Simon, & Collins, 2003;

White & Richardson, 1993, November). A relationship between sex and attitude has also been established (Joyce & Farenga, 1999; Smist & Owen, 1994, April). Females generally have more negative attitudes than males to science classes from an early age (George, 2006). These sex differences persist and become greater as students get older (P. H. Miller et al., 2006) and persist into the collegiate years (Desy et al., 2009). It is noteworthy that the TOSRA has been adapted and validated for other subjects, including mathematics (Ogbuehi & Fraser, 2007), geography (Walker, 2006), English (Liu & Fraser, 2013), and Spanish (Adamski, Fraser & Peiro, 2013).

Whilst the TOSRA has been used and validated in the past (Aldridge et al., 1999; Ali & Awan, 2013; Bui & Alearo, 2011; Fisher & Waldrip, 1999; Fraser, Aldridge, & Adolphe, 2010), it has not been used specifically in the context of assessing statistics attitudes.

The TOSRA was used in my research because it has the advantage of giving a score for each conceptually-distinct attitudinal scale rather than a single overall score. This allows a more detailed analysis of differences and relationships. My version replaces the word 'science' with the word 'statistics' and the word 'scientist' with the word 'statistician' and utilizes the four scales of Normality of Statisticians, Attitude to Statistical Inquiry, Adoption of Statistical Attitudes and Enjoyment of Statistics Lessons. Social Implications of Statistics, Leisure Interest in Statistics, and Career Interest in Statistics were not considered of high salience in my study. However, not all of these scales were retained during the validation analysis reported in Chapter 4.

2.4 Conclusion

This chapter was devoted to reviewing literature pertinent to my study. Because my study drew on and contributed to the field of learning environments, a major part of this review focused on learning environments literature.

A historical perspective on the field of learning environments reveals that its foundations were laid in the 1930s in non-educational settings by Lewin, Heider and Heider, and Murray. In educational, pioneering work was carried out in the 1950s by Pace and Stern and in the 1960s by Walberg and Moos. Considerable advancement in the field has occurred over the past 40 years by leaders including Fraser.

A distinguishing feature of the field of learning environments is the availability of the wide range of versatile and validated questionnaires that were reviewed in Section 2.2. The most-frequently used questionnaire currently is the What Is Happening In this Class? (WIHIC) which, according to Dorman (2001), has achieved almost bandwagon status. Past studies involving the WIHIC were summarized in Table 2.2. The WIHIC was selected for my study.

Many of the learning environment questionnaires have been translated from English into several other languages and validated in non-English speaking countries, including Singapore, Brunei, China, Indonesia, Korea, Malaysia, India, Japan, Brunei, Thailand, Greece and Cyprus. Fraser and Tobin (1991) identified a potential issue with questionnaires in that a person could be answering a questionnaire either from the perspective of an individual or as a proxy for the whole class, and the different perspective could yield different results.

Because two main student outcomes in my study were statistics anxiety and attitudes to statistics, literature in these two areas was reviewed in Section 2.3. In particular, I reviewed literature related to the two questionnaires that was adopted for

use in my research – the Revised Mathematics Anxiety Rating Scale (RMARS) and the Test of Science Related Attitudes (TOSRA).

The major goal of my study was to investigate sex, ethnic and age differences in students' classroom environment perceptions, anxiety, attitudes and achievement. Therefore, I reviewed past research into differences in environment perceptions and outcomes according to student sex (Section 2.2.3.5.1), ethnicity (Section 2.2.3.5.2) and age (Section 2.2.3.5.3). Although hardly any past research has specifically involved university statistics classes, it still was important to review past studies of sex, ethnic and age differences conducted for other subjects and educational levels.

Several types of past research on classroom learning environments were reviewed, such as associations between student outcomes and classroom environment, using learning environment as a criterion of effectiveness in the evaluation of educational innovations, and teachers' attempts to improve their classroom environments. Because I investigated relationships between student outcomes and the learning environment in my study, I reviewed past studies in this area in Section 2.2.2.1 to establish a consistent pattern of associations over many studies in different countries.

It can be seen, there are many areas of agreement, such as students of different ethnic groups having different levels of achievement, and a few areas of contention, such as male students outperforming female students on achievement outcomes. The contentious areas could be the result of the dynamic of the passage of time as well as certain results not being robust enough to cross different types of classroom environments. Despite any areas of contention, learning environments research has had an impact in schools in many countries where it has been used to

improve that huge part of our lives that is spent in classrooms. It even extends beyond the classroom in that a good education is often an important determinant of how life after schooling is finished. Our income, social standing and perhaps even ethical viewpoints are often related to our school experiences during our formative years.

Chapter 3

RESEARCH METHODOLOGY

3.1 Introduction

In this study, I attempted to answer the following research questions:

2) Are the following questionnaires valid and reliable when used with undergraduate statistics students:

- a. What Is Happening In this Class? (WIHIC)
- b. Revised Statistics Anxiety Rating Scales (RSARS)
- c. Test of Statistics Related Attitudes (TOSrA)?

3) Are there sex, ethnic and age differences in undergraduate business statistics students':

- a. Perceptions of learning environments
- b. Anxiety
- c. Attitudes
- d. Achievement?

4) Are there associations between the perceived learning environments of business education classes and the student outcomes of :

- a. Anxiety
- b. Attitudes
- c. Achievement?

To answer my three research questions, three questionnaires (WIHIC, TOSrA and RSARS) and an achievement measure were utilized. In Section 3.2, I describe the features of the three questionnaires, any modifications made to them for

my study, and my achievement measure. Data sources and collection are discussed (Section 3.3). A closer look at the sample for this study is taken (Section 3.4). Methods for analysing data are described (Section 3.5). A description of the major strengths and weaknesses of the study are then discussed (Section 3.6).

3.2 Assessment of Classroom Environment, Anxiety, Attitudes and Achievement

Because the WIHIC, RSARS and TOSTRA questionnaires were used to collect quantitative data for answering my research questions, the following sections provide a more in-depth discussion of the three instruments and any modifications that were made to them for the purpose of my study. Section 3.2.1 discusses the What Is Happening In this Class? (WIHIC) learning environment questionnaire. Section 3.2.2 focuses on an anxiety inventory known as the Revised Statistics Anxiety Rating Scale (RSARS). The attitudinal questionnaire known as the Test of Statistics Related Attitudes (TOSTRA) is considered in Section 3.2.3. Finally, my measure of statistics achievement is discussed in Section 3.2.4.

3.2.1 Statistics Classroom Learning Environment

The instrument that was used without modification for assessing statistics classroom learning environment was the What Is Happening In this Class? (WIHIC) questionnaire designed by Fraser, McRobbie and Fisher (1996, April). The WIHIC brings together the most salient scales from a wide range of existing questionnaires, eliminating duplicated questions, removing questions that are no longer relevant to the current classroom learning environment and introducing new scales relevant to equity and constructivism. The WIHIC has two forms: one assesses a student's

perceptions of the class as a whole; and the other assesses a student's personal perceptions of his or her role in the classroom. This study used the students' personal perceptions. The WIHIC questionnaire has been chosen because of its proven validity and reliability (Aldridge et al., 1999; Koul & Fisher, 2005; B. A. Taylor & Fraser, 2012; B. A. Taylor & Fraser, 2012; Zandvliet & Fraser, 2005) as reviewed in Chapter 2, Section 2.2.2.9.

The WIHIC has seven scales each having eight items:

- Student Cohesiveness – Extent to which students know, help, and are supportive of one another
- Teacher Support – Extent to which the teacher helps, befriends, trusts and shows interest in students
- Involvement – Extent to which students have attentive interest, participate in discussions, perform additional work, and enjoy the class
- Investigation – Emphasis on the skills and processes of inquiry and their use in problem solving and investigation
- Task orientation – Extent to which it is important to complete activities planned and to stay on the subject matter
- Cooperation – Extent to which students cooperate with one another rather than compete with one another on learning tasks
- Equity – Extent to which students are treated equitably by the teacher.

Because all scales were judged to be relevant to the business statistics classroom, and because of the WIHIC's established validity in many past studies, I chose it for use in my research. The WIHIC is discussed in detail in Chapter 2, Section 2.2.2.9 and a full listing of the WIHIC's items are located in Appendix A.

3.2.2 *Anxiety Inventory*

The instrument for assessing statistics classroom anxiety, learning statistics anxiety and statistics test anxiety was *based* on the Revised Mathematics Anxiety Ratings Scale (RMARS) questionnaire, designed by Plake and Parker (1982), which in turn was based on the Mathematics Anxiety Rating Scale (MARS) of Suinn et al. (1972, July). The questionnaire used in this study was named the Revised Statistics Anxiety Rating Scales (RSARS) and consists of 24 questions in the two areas of statistics learning anxiety and statistics test anxiety. The structure and design of the RSARS was kept the same as for the RMARS except that, wherever the term ‘mathematics’ appeared in RMARS, it was replaced by the word ‘statistics’ in the RSARS.

The RSARS has two dimensions, the first having 16 items and the second having eight items:

- Statistics Learning Anxiety – Extent to which students feel anxious when absorbing the subject matter
- Statistics Evaluation/Test Anxiety – The level of anxiety felt when answering questions.

The anxiety scales were reviewed in Chapter 2, Section 2.3.1. A full listing of RSARS items is located in Appendix B.

3.2.3 *Attitudes Inventory*

The instrument used for assessing statistics classroom attitudes was based on the Test of Science related Attitudes (TOSRA), designed by Fraser (1981). The TOSRA is composed of seven scales measuring student attitudes towards science and science-related areas. The original TOSRA has 10 questions for each scale. The

modified instrument that was administered in this study is referred to as the Test of Statistics Related Attitudes (TOStra) and measured student attitudes using four scales: Normality of Statisticians, Attitudes Towards Statistics Inquiry, Adoption of Statistics Attitudes and Enjoyment of Statistics Lessons. This modification was based on that carried out by Taylor and Fraser (2012). The structure and design was kept the same except that the term ‘science’ was replaced by the word ‘statistics’. This version of TOStra had four 10-item scales (but two scales were lost during the validation analyses described in Chapter 4). The four scales are:

- Normality of Statisticians – Students’ perceptions of how ‘normal’ statisticians are
- Attitudes Towards Statistics Inquiry – Extent and manner to which students prefer to investigate statistics issues
- Adoption of Statistics Attitudes – Extent to which students want to challenge and engage statistics concepts
- Enjoyment of Statistics Lessons – Extent to which students enjoy studying statistics

The attitude inventory was discussed in Chapter 2, Section 2.3.2. A full listing of TOStra items is located in Appendix C.

3.2.4 *Statistics Achievement*

Course achievement was measured using the weighted percentage scores on three mid-term examinations and a non-cumulative final examination, which all involved multiple-choice responses. Multiple-choice responses were used to eliminate any possible grader bias that exists when answers are open-ended and are graded subjectively. All students took the same examinations – another step taken to

reduce bias in results related to the difficulty of different examination papers. These examinations were developed by several instructors, rigorously tested over a number of years, and found to be a satisfactory measure of achievement. The number of items contained in the four achievement tests were 14, 16, 15 and 30, respectively.

A method of identification was used to facilitate linking students' responses to their final percentage achievement scores for the course. The identification was carried out by a non-vested third party, and then the completed questionnaires were given to an impartial third party who entered the data into an Excel spreadsheet. Data entry was independently checked by three further graduate assistants for accuracy. Missing data for any items were left blank and scored by allowing 3 on the 5-point scale.

3.3 Data Sources and Collection

In order to have a sample whose size was large enough to provide adequate statistical power, the questionnaires were administered during normal class sessions to several hundred students at two universities in Southern California: a non-PhD-awarding Business School and a PhD-awarding university Department of Economics. Class sizes varied between as many as 210 students and as few as 30 students. Students were not compensated for their participation. The questionnaires were administered during the week when 70% of the course had been completed. They were administered in hard-copy form by instructors who did not teach those students in an attempt to avoid any potential bias that might have occurred if instructors administered the surveys to their own students.

Students were also asked to indicate their sex, ethnicity and age, whether they were taking the class for the first time, the number of classes currently being taken,

estimated Grade Point Average (GPA) and the number of hours employed. My sample was relatively representative of the student population in terms of sex, ethnicity and age.

Some students decided simply not to respond and perhaps the non-respondents' potential answers could have led to somewhat different findings. Fortunately, very few students declined to participate, but approximately one-fifth of the enrolled students did not attend class on the day when the survey was administered. Most respondents answered all questions but a few students did not. This might have been because of a lack of understanding of the questions or a feeling of discomfort in answering certain questions (e.g. questions about age, gender and ethnicity.) Non-respondents could have chosen not to participate because the survey took up too much time and effort (Brown, 2003) or because it was not perceived to be relevant to them (Ray & Tabor, 2003).

Table 3.1 — Percentage of Students Responding to Demographic Questions

Demographic Question Regarding	Percentage of Students Responding
Gender	98.4%
Ethnicity	94.5%
Age	97.4%
First Time Taking Course	99.0%

None of these issues had a major bearing on this study because close to 100% of the students who were in class on the day of the survey participated and the vast majority answered all questions. Table 3.1 shows the proportion of students who responded to the demographics questions and Figure 3.1 shows the number of students not answering each non-demographic question. There was one question that 20 students did not answer, but the remaining 94.8% of students did answer it. For all remaining non-demographic questions, more than 95.0% of the students answered. The effect of time (Brown, 2003), is visible in Figure 3.1 because the frequency of non-responses increases as time passed.

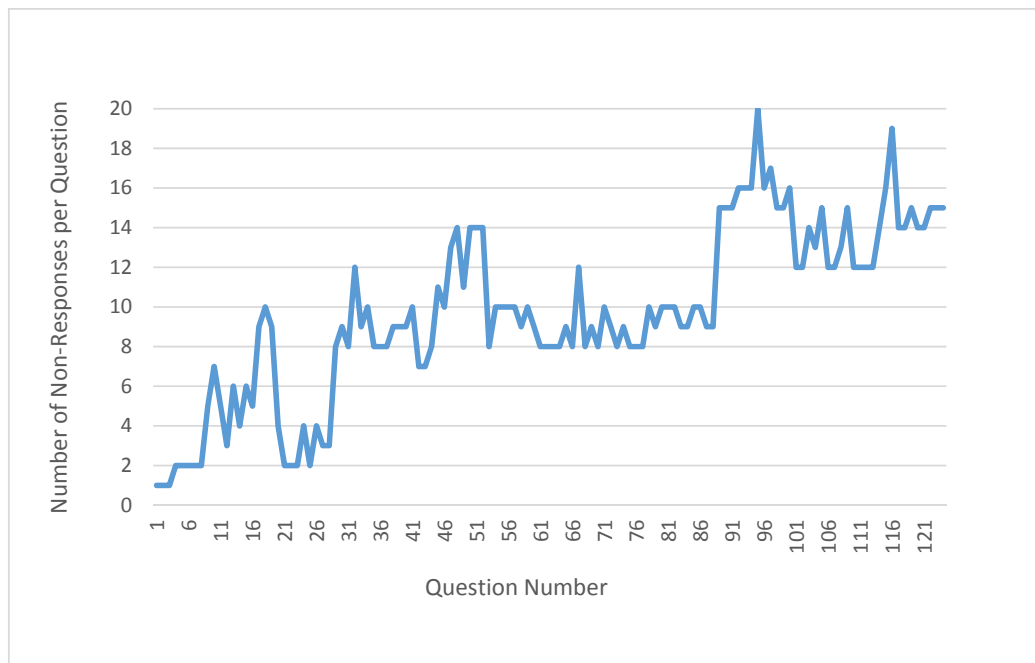


Figure 3.1 – Frequencies of Non-Respondents to Demographic Questions

Other students might have misunderstood a question and therefore answered a different question from the one intended by the researcher (Bourhis et al., 1989; Hadlow & Pitts, 1991) and some students could have deliberately distorted their answers because they felt uncomfortable about divulging certain information (Bradburn et al., 1978). The response alternatives possibly could be interpreted

differently by respondents, and research suggests that ethnicity and sex are key factors leading to differences in interpretation (Bolt & Johnson, 2009; Hui & Triandis, 1989; Watkins & Cheung, 1995), which could have introduced errors and bias into the data. It is impossible to know if students misunderstood the questions, distorted their answers or misunderstood the response alternatives, and whether any of these issues led to untraceable errors and distortions. Research has been conducted on correcting for bias in data caused by non-respondents (Armstrong & Overton, 1977; Hendricks, 1949), but little research has been carried out into correcting respondents' data.

Instructors, who did not teach the students, collected data by handing out hard copies of the questionnaires during a regular class meeting after 70% of the course had been completed. The data were then entered into an Excel spreadsheet by a graduate assistant and then independently checked by three further graduate assistants. Student identification, class meeting details and demographic data were also recorded. The demographic data consisted of sex, ethnicity and age, number of previous attempts at this class, number of other classes being currently taken, hours per week in gainful employment and estimated GPA.

3.3.1 *Ethical Issues*

It was recognized that there are ethical issues with respect to the collection of the data and possibly the reporting of the findings (Berg & Lune, 2004; Neuman, 2006). Attention was paid to my own ethical standards, together with those of Curtin University, the non-PhD-awarding university, the PhD-awarding university, and the laws of the state of California and Federal laws of the USA. This study has been approved by the Curtin University Human Research Ethics Committee.

After obtaining permission from the universities for classes to participate in the research, arrangements were made to administer the questionnaire on particular dates. This took place at the beginning of the class to minimize disruption. The questionnaires were administered by consenting instructors. Respondents were not compensated for their participation.

Students were provided with a statement outlining the purpose of the research and how it could be used to improve the learning environments of future students. During the administration of the questionnaire, students were given the opportunity of not participating. All participants had feedback made available to them, both during and at the conclusion of the study.

In order to answer my research questions concerning classroom environment, anxiety, attitudes and achievement, it was necessary to be able to identify and link respondents to their achievement scores. This was achieved by the use of student identification numbers. After collection, the data were coded in such a way that, once the achievement data were incorporated, student anonymity was ensured. A written guarantee was given to this effect.

The co-operation and contribution of all participants were acknowledged. Results from the research were made available to the students at their request. The resources required for quantitative data analysis were Excel and SPSS.

All paper questionnaire responses were kept locked away in my office for the duration of the study. An electronic database of all student responses was stored on password-protected computers at Curtin University and will be kept there for seven years after the completion of the study. Nobody will have access to the information other than my supervisor and me.

3.4 Sample

All students in the sample were taking a business statistics course for non-business majors in one of two universities in Southern California. The universities both receive state funding and one of them awards PhDs but the other is not mandated to do so. The PhD-awarding university had courses that run over a ten-week quarter, that are held in a lecture theatre which is not a laboratory, and have three meetings per week each lasting 50 minutes. The non-PhD-awarding university from which data were collected had regular 15-week semesters and two 75-minute class meetings a week. Data were also collected from the summer classes at this university, which ran over 5 weeks with 130-minute class sessions on 4 days of the week. All classes were held in laboratories in which students had access to computers.

Table 3.2 provides details about the classes from which data were collected. In particular, it reports the nominal identification numbers that were given to each student, whether the students correctly identified the number of classes that they were taking compared with the university's records, the number of meetings per week, the days of the week when the meetings were held, the meeting times, the duration of the course, the university at which the study was conducted, the class size, and the semester/quarter when the classes were taken.

The questionnaires were administered in Southern California to 12 university classes whose sizes ranged from 30 to 210 students. A sample of 375 students from the total group of 638 registered students completed every questionnaire and had an achievement score. Some students chose not to take part, but the majority of non-participants were not in class on the day when the survey was administered.

The demographic question on the surveys regarding ethnicity was not restricted to a set of ethnicities, but was left to the respondent to enter whatever they wanted. This approach was taken because, during a trial run of questionnaire administration, some students reported that the ethnicity with which they identified was not an option and they ended up inserting ‘other’, which rendered them ineligible for inclusion in analyses for ethnic differences. Ethnicities which accounted for 1% or more of the survey’s respondents are shown in Figure 3.2, and other ethnicities were grouped together under the ‘other’ category. In this study, 364 of the 375 respondents could be categorized into one of the main groups of Hispanic (86), White (117) and Asian (161) students.

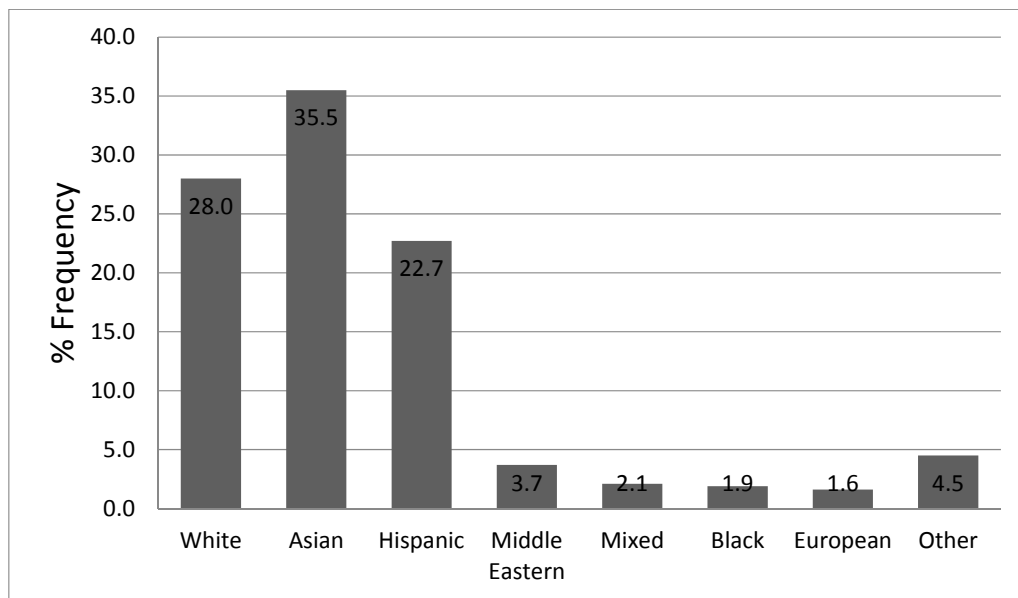


Figure 3.2 – Ethnicity of Students in Sample

The proportion of male and female respondents was similar with 52% female students and 48% male students as shown in Figure 3.3. Of the 379 respondents who disclosed their sex, there were 181 males and 194 females.

Table 3.2 — Descriptive Information for Classes Involved in the Study

ID	Correct # Classes	Meetings Per Week	Days	Meeting Times	Teaching Duration	School	Class Size	Session
200-217	Yes	1	Thurs	7:00-9:45 p.m.	15 weeks	Non-PhD	44	Spring
250-262	No							
300-317	Yes	2	Tues/Thurs	8:30-9:45 a.m.	15 weeks	Non-PhD	44	Spring
350-361	No							
400-424	Yes	2	Tues/Thurs	2:30-3:45 p.m.	15 weeks	Non-PhD	42	Spring
450-465	No							
500-523	Yes	2	Tues/Thurs	5:30-6:45 p.m.	15 weeks	Non-PhD	44	Spring
550-550	No							
600-615	Yes	1	Thurs	7:00-9:45 p.m.	15 weeks	Non-PhD	44	Spring
650-653	No							
700-720	Yes	3	Mon/Tues/Wed	10:00-10:50 a.m.	10 weeks	PhD- Awarding	210	Spring
800-886	No							
900-914	Yes	4	Mon/Tues/Wed/Thurs	8:00-10:50 a.m.	5 weeks	Non-PhD	30	Summer Session A
915-920	No							
1001-1012	Yes	4	Mon/Tues/Wed/Thurs	8:00-10:50 a.m.	5 weeks	Non-PhD	31	Summer Session B
1013-1017	No							
1101-1110	Yes	4	Mon/Tues/Wed/Thurs	10:30-12:45 p.m.	5 weeks	Non-PhD	31	Summer Session B
1111-1124	No							
1200-1224	Yes	2	Mon/Wed	1:00-2:15 p.m.	15 weeks	Non-PhD	44	Fall
1225-1227	No							
1300-1319	Yes	2	Mon/Wed	2:30-3:45 p.m.	15 weeks	Non-PhD	40	Fall
1320-1321	No							
1400-1417	Yes	2	Mon/Wed	4:00-5:15 p.m.	15 weeks	Non-PhD	44	Fall
900-914	Yes	4	Mon/Tues/Wed/Thurs	8:00-10:50 a.m.	5 weeks	Non-PhD	30	Summer Session A
915-920	No							
1001-1012	Yes	4	Mon/Tues/Wed/Thurs	8:00-10:50 a.m.	5 weeks	Non-PhD	31	Summer Session B
1013-1017	No							
1101-1110	Yes	4	Mon/Tues/Wed/Thurs	10:30-12:45 p.m.	5 weeks	Non-PhD	31	Summer Session B
1111-1124	No							
1200-1224	Yes	2	Mon/Wed	1:00-2:15 p.m.	15 weeks	Non-PhD	44	Fall
1225-1227	No							
1300-1319	Yes	2	Mon/Wed	2:30-3:45 p.m.	15 weeks	Non-PhD	40	Fall
1320-1321	No							
1400-1417	Yes	2	Mon/Wed	4:00-5:15 p.m.	15 weeks	Non-PhD	44	Fall
1418-1419	No							

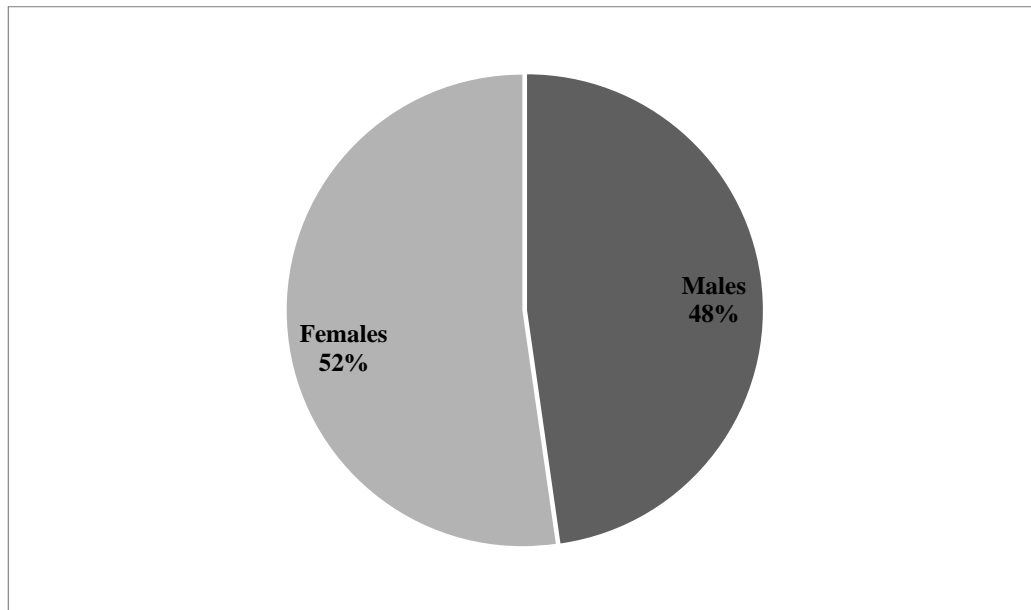


Figure 3.3 – Gender Composition of Sample

In California, students typically graduate from high school at the age of around 18 years. Those entering higher education have two main choices: going directly to university and undertaking a degree program that typically takes four years; or going to a community college for two years before enrolling at a university for a further two years. Whichever route is taken, typically graduation takes place approximately at age 22 years. In my classrooms, students who are older than 22 years often reveal to me that they feel old. There are many reasons why students graduate after the age of 22 years, such as, from my experience, students taking time away from education to pursue other interests before returning, failing specific courses, or studying part-time. Age 22 years appeared to be a convenient age for splitting the sample into two age groups.

Figure 3.4 reports the percentage of students taking the class for the first time. The majority of students – 81% – were taking the class for the first time and only 19% were repeating the class.

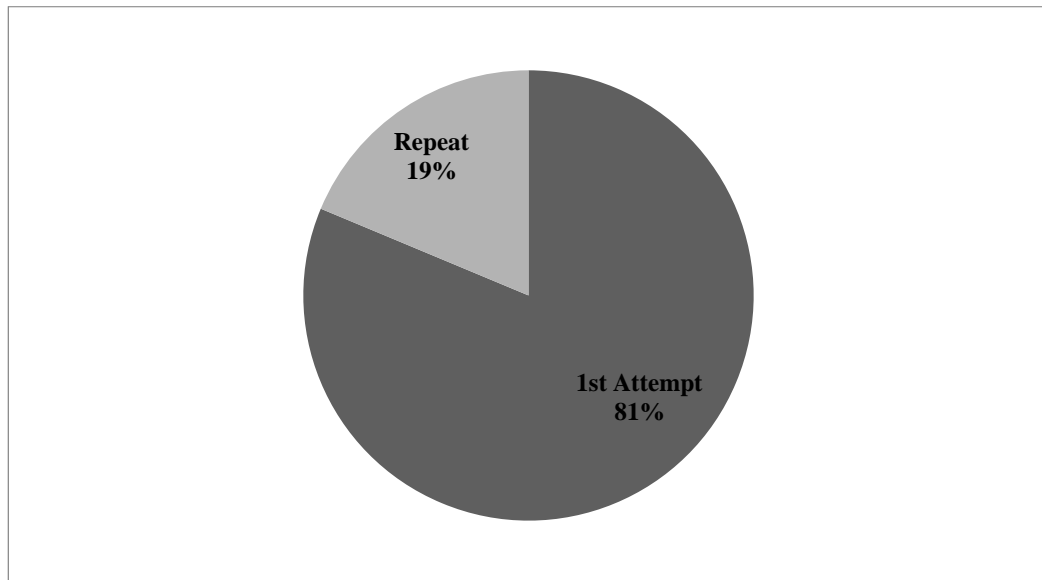


Figure 3.4 – Percentage of Students Repeating Class and Attempting it for First Time

3.5 Data Analyses

The first step in the data analyses was to generate information about the validity and reliability and of questionnaires for assessing learning environment, statistics anxiety, and attitudes towards statistics among university students who are not statistics majors but who are undertaking statistics classes in Southern California. Validity involves how accurately the scales of a survey measure the constructs intended to be measured. Reliability measures the degree to which questions used in the survey elicit the same type of information each time an experiment is repeated under similar conditions. Factor analyses (Klein, 1994) were carried out for each of the three instruments separately to confirm their factor structure. Also, internal consistency reliability and discriminant validity were checked.

3.5.1 *Factor Analyses*

Factor analysis establishes whether the correlations between a set of observed variables emerge from their relationships to a latent variable. The factor analysis was carried out using SPSS using principal axis factoring with two alternative methods of rotation (Varimax and Direct Oblimin) and Kaiser normalization. Principal axis factoring is a multivariate technique which groups questions together into potential factors. Rotation is a procedure in which factor axes are rotated in order to obtain simple and more interpretable factors (Yaremko, Harari, Harrison & Lynn (1986). Kaiser normalization takes the output of a non-normalized solution and reports the normalized solution.

Essentially there are two factor rotation methods: orthogonal rotation assumes that the factors are uncorrelated, whereas oblique rotation assumes that factors are correlated (Gorsuch, 1983). In my study, based on prior research, it could be assumed that WIHIC scales would be largely uncorrelated, but it was unclear whether RSARS and TOSTRA scales would be correlated or uncorrelated. Therefore, for the factor analysis of WIHIC data, a method of orthogonal rotation was used (namely, Varimax Rotation). However, for RSARS and TOSTRA data, two rotation methods were conducted and compared in terms of the results obtained: a methods of orthogonal rotation (namely, Varimax Rotation) and a method of oblique rotation (namely, Direct Oblimin Rotation).

As a general rule, a factor loading can be considered high if it is above 0.60 (Hair, Anderson, Tatham, & Black, 1998). In my study, items were retained if factor loadings were 0.35 or above on their own scale and less than 0.35 on all other scales.

Eigenvalues refer to the amount of variation in the entire instrument explained by a single factor, and the percentage of variance expresses the eigenvalue as a

percentage of the total variation by dividing it by the number of variables (Horel, 1984; Kaiser, 1958).

3.5.2 *Internal Consistency Reliability and Discriminant Validity*

After confirming the factor structure of each instrument, the internal consistency reliability of the scales was assessed using Cronbach's (1951) alpha coefficient. Cronbach's alpha describes the strength of the relationship among items in the same scale, with a value of 0 indicating no correlation and a value of 1 indicating a perfectly aligned linear relationship. According to de Vellis (1991), an alpha value of at least 0.6 typically reflects satisfactory reliability.

Discriminant validity is a measure of the correlation between the different scales of each instrument (Lewis-Beck, Bryman & Liao, 2003). Ideally, scales in the same questionnaire would have low inter-correlations, indicating that each scale is measuring a different latent variable. The convenient statistic used to indicate discriminant validity in my study was the mean correlation of a scale with each of the other scales of the instrument.

3.5.3 *Sex, Ethnic and Age Differences in Learning Environment Perceptions, Statistics Anxiety, and Attitudes towards Statistics*

After verifying the factorial validity, internal consistency reliability, and discriminant validity of the WIHIC, RSARS and TOSrA, I proceeded to investigate and answer my second research question concerning sex, ethnic and age differences in students' perception of classroom environment and the student outcomes of statistics anxiety, attitudes and achievement.

In deciding upon a rigorous approach to analysing data to investigate sex, ethnic and age differences, three potential threats to rigor were identified and accommodated. First, in order to reduce the Type I error rate associated with performing any univariate tests for individual dependent variables (7 WIHIC scales, 2 RSARS scales, 2 TOSTRA scales, and 1 achievement scale), MANOVA (Hair, Black, Babin & Anderson, 2010) was performed for the 12 dependent variables as a set prior to conducting or interpreting any univariate ANOVA analyses. That is, the univariate test of sex, ethnic or age differences in any dependent variable was interpreted only after MANOVA first revealed statistically significant differences for that determinant for the set of 12 dependent variables as a whole.

Second, because it is not meaningful to interpret results for the main effects of sex, ethnicity and age if statistically significant interactions exist between any of the independent variable, conducting MANOVA was also used to detect the presence or absence of significant interactions. If significant interactions were found, then no attempt would be made to interpret sex, ethnic or age differences independently of each other.

Third, in order to consider the multivariate influence of sex, ethnicity and age simultaneously on the dependent variables, a three-way analysis was conducted (rather than three separate one-way analyses). That is, a three-way MANOVA was conducted in order to estimate the influence of each independent variable while the other two independent variables were mutually controlled.

In summary, in the light of the considerations described above, I conducted a three-way MANOVA with 12 dependent variables (consisting of WIHIC, RSARS, TOSTRA and achievement scales) and the 3 independent variables of sex, ethnicity and age. As discussed above, my data were divided into the three ethnic groups of

Hispanics, Whites and Asians and the two age groups of at least 22 years and over 22 years. My measure of achievement, as described in Section 3.2.4, consisted of the standardized and weighted mean of four multiple-choice tests administered throughout the course. The number of items in the four achievement tests were 14, 16, 15 and 30, respectively.

Effect size is an objective standardized measure of the strength or magnitude of an observed difference between two variables. Effect sizes quantify differences between samples but do not provide any conclusions about differences in the underlying populations. Effect size is a useful measure of the practical significance of a difference under consideration (Thompson, 1998). Measures include Cohen's d and Glass's g . Cohen's d expresses a difference between two groups in standard deviation units by dividing the difference between group means by the pooled standard deviation (Cohen, 1988). In my analysis, Cohen's d was used to indicate the effect size associated with a difference between two sex groups, ethnic groups or age groups for a specific scale.

In interpreting any statistically significant differences between the three ethnic groups revealed via ANOVA for any scale, I conducted pairwise comparisons of ethnic groups using Tukey's HSD multiple comparisons procedure. A well, Cohen's d was employed to estimate the magnitude of differences between the scores of pairs of ethnic groups (i.e., Hispanics vs Whites, Hispanics vs. Asians, and Whites vs Asians).

3.5.4 Associations between Learning Environment Perceptions and the Student Outcomes of Statistics Anxiety, Attitudes towards Statistics, and Achievement

Associations of classroom learning environment dimensions with statistics anxiety, attitudes towards statistics, and achievement were analyzed using Pearson's correlation and multiple regression analyses. The simple correlations described the bivariate associations between each learning environment scale and each outcome scale of the RSARS, TOSTRA and achievement.

A multiple regression analysis was conducted with the independent variables being the scales of the learning environment instrument and each RSARS, TOSTRA and achievement scale used in turn as the dependent variables. Beta coefficients were used to indicate the unique contribution made by each of the learning environment scales to a dependent variable when all other learning environment scales were simultaneously controlled.

3.6 Strengths and Weaknesses of the Study

In this section, consideration is given to the questionnaire method (Section 3.6.1), the multiple-choice answer format of the achievement examinations (Section 3.6.2), and the sample (Section 3.6.4).

3.6.1 Questionnaire Method

A well-prepared questionnaire is quick to administer, cheap to produce, non-intimidating to students, clear and economically yields objective responses from many students over a large geographical area without the use of large amounts of manpower (Anderson & Arsenault, 1998). The questionnaire is set up so that the responses can be recorded on the actual questionnaire utilizing the multiple-choice style. The

respondents usually give truthful responses if their identities are kept anonymous. The information gathered from questionnaires can be tabulated and show scores for variables such as classroom environment, attitudes and anxiety in my study.

There are some potential limitations to the questionnaire approach. The constructs chosen might not be appropriate. Even if the constructs identified have an apparent relationship with the dependent variable, perhaps other underlying factors could actually be causing the effect, or the relationship could be so weak that a chosen construct shouldn't be considered. The items in a questionnaire might exclude aspects important to the investigation or fail to investigate in sufficient detail, leading to loss of important information and reducing the value of the research. To try to mitigate many of these problems, I devoted a lot of time to identifying and developing the right questionnaires.

Some students decided not to respond and perhaps the non-respondents' potential answers could have led to somewhat different research results. Some students might have not understood the questions and not answered. Other students might have misunderstood the questions and answered different questions from the ones that the researcher intended. The scales' anchors might have been interpreted differently by different respondents, which could have introduced errors and bias in the data.

3.6.2 Multiple-Choice Achievement Tests

Students' achievement in statistics was measured by standardized and weighted scores on a series of multiple-choice examinations. Multiple-choice items have some appealing characteristics. They are useful for assessing knowledge and mastery of concepts because students must answer the question being asked and they

cannot use a compelling writing style to gain credit for areas where they have weak or no knowledge at all. With the removal of the writing element, a large number of concepts can be tested economically in a short period. The difficulty of the examination can be adjusted by manipulating the degree of similarity between the responses. Even though there is a 20% chance of guessing the correct answer to a five-choice multiple-choice question, the probability of guessing enough correct answers and passing an examination which has 20 questions is around 1 in 542,004 as calculated using the binomial distribution. So passing by merely guessing is highly unlikely. Multiple-choice items are quick to administer, and prompt to grade using electronic equipment (which also removes the human error element), and they yield objective responses from many students over a large geographical area without the use of large amounts of manpower (Anderson & Arsenault, 1998). There is no bias in scoring, as there is no subjective element (DePalma, 1990, November).

However, purely guessing at an answer can sometimes be possible with multiple-choice items as is using a process of elimination of the possible incorrect answers. It might be difficult to ask in-depth questions using the multiple-choice format and poor question wording could make the results of a multiple-choice test unreliable. There is limited scope to assess the student's ability to organise and usually express ideas and there is no partial credit available (Kubiszyn & Borich, 2003).

3.6.3 Limitations in the Sample

The sample of 375 students was taken from two universities in Southern California. Initially 638 students enrolled in the classes, but some withdrew because of lack of funds or personal reasons. Approximately 3% of enrolled students did not

attend class on the day of the survey and a very small number of students who were present opted not to participate. Had the 3% of students who did not participate in the survey chosen to participate, it is possible that somewhat different results might have emerged, although the effect would be limited because of the very small number of non-participants. A bigger sample both in terms of the number of universities included in the study and the number of student respondents might have led to analyses being carried out at a deeper and more-focused level. Also using more than two universities in Southern California or located in areas beyond Southern California would have allowed greater generalizability of findings and the comparison of universities. Class size, time of day at which classes were run, duration of each class session, number of meetings per week, number of weeks per semester/quarter, and time of the year could have had a minor influence on the findings.

3.7 Conclusion

In this chapter, I described the methods used in my study, beginning with how I assessed classroom environment with the WIHIC, anxiety with the RSARS, attitudes with the TOSTRA, and achievement using examination scores. There were no modifications made to the WIHIC, but the RMARS became the RSARS by replacing the term ‘mathematics’ with the word ‘statistics’, and the TOSRA became the TOSTRA by replacing the word ‘science’ with the word ‘statistics’.

Data were collected from two universities in Southern California over a one-year period. Each survey was run when 70% of the course had been completed. There were a total of 375 respondents. In addition to the questionnaires, students were asked questions regarding their sex, ethnicity and age. Course achievement was based on the weighted total score obtained from four examinations taken during the course. In

addition, for each class, I recorded the number of meetings per week, the days of the week, meeting times, length of course, class size and the semester when the class was held.

The initial analysis of data was aimed at establishing whether the three questionnaires (WIHIC, RSARS and TOSTRA) exhibited satisfactory factorial validity, internal consistency reliability, discriminant validity. Correlation and regression analyses were carried out to identify any statistically significant relationships between the learning environment scales (from the WIHIC) and the student outcome variables of anxiety, attitudes and achievement. Regression coefficients were used to identify which individual environment scales were related to an outcome when the other environment scales were mutually controlled.

In order to investigate the influence of three determinants (namely, sex, ethnicity and age) of a set of 12 dependent variables (namely, 7 WIHIC scales, 2 RSARS scales, 2 attitude scales, and 1 achievement measure), a three-way MANOVA was conducted. ANOVA results were interpreted for an individual dependent variable for a specific determinant only if MANOVA first revealed the absence of any significant interaction effects and the presence of a significant multivariate association for the set of 12 dependent variables as a whole.

Acknowledgement was given to the major strengths and weaknesses of this study, with particular attention being given to the questionnaire method, the use of multiple-choice achievement tests, instructor influences, and limitations of the sample used.

Chapter 4

DATA ANALYSES AND RESULTS

4.1 Introduction

In this study, three instruments were used to investigate possible associations between the perceived learning environment and three student outcomes (level of statistics anxiety, attitudes towards statistics, and statistics achievement) among students taking statistics as non-statistics majors in two Southern California universities. Also I investigated sex, ethnicity and age as determinants of students' perceived learning environment and outcomes. A group of 375 students from 12 classes formed the sample for this study.

The assessment of the learning environment involved using the What Is Happening In this Class? (WIHIC) instrument to elicit a student's personal perceptions as to his/her role within the class. The WIHIC questionnaire has 56 items in total, with 8 items in each of 7 scales and the five possible frequency responses of Almost Never Happens, Seldom Happens, Sometimes Happens, Often Happens and Very Often Happens for indicating how often a practice takes place. The seven scales are Student Cohesiveness, Teacher Support, Investigation, Involvement, Task Orientation, Cooperation, and Equity. The WIHIC is considered in more detail in Chapter 2, Section 2.2.2.9 and Chapter 3, Section 3.2.1.

Learning Statistics Anxiety and Statistics Evaluation Anxiety were measured using the Revised Statistics Anxiety Rating Scale (RSARS), which is based on the Revised Mathematics Anxiety Rating Scale (RMARS). The RSARS has 24 items with the five possible responses of Not at all Anxious, a Little Anxious, Moderately

Anxious, Pretty Much Anxious and Very Anxious. More details about statistics anxiety and the RMARS are provided in Chapter 2, Section 2.3.1 and the RMARS is described further in Chapter 3, Section 3.2.2.

A modified version of the Test of Science Related Attitudes (TOSRA), called the Test of Statistics Related Attitudes (TOSStRA), was used to measure attitudes towards statistics. It comprised 40 items in the four ten-item scales of Normality of Statisticians, Attitude to Statistical Inquiry, Adoption of Statistical Attitudes, and Enjoyment of Statistics Lessons (although some of these scales were lost during the statistical analyses described later in Section 4.2). Each question has five possible responses that are Strongly Agree, Agree, Not Sure, Disagree, and Strongly Disagree. More details about attitudes towards statistics are located in Chapter 2, Section 2.3.2 and TOSStRA is described further in Chapter 3, Section 3.2.3.

In this chapter, I report the analyses of the data that were undertaken in order to answer the research questions posed in this study using the following structure:

4.2 Validity of Instruments

4.2.1 Factorial Validity of WIHIC, RSARS and TOSStRA

4.2.1.1 Factorial Validity of WIHIC

4.2.1.2 Factorial Validity of RSARS

4.2.1.3 Factorial Validity of TOSStRA

4.2.2 Internal Consistency Reliability, Discriminant Validity and Mean Scores for WIHIC, RSARS and TOSStRA

4.2.2.1 Internal Consistency Reliability of WIHIC, RSARS and TOSStRA

4.2.2.2 Discriminant Validity of WIHIC, RSARS and TOSStRA

4.2.2.3 Average Students' Scores for WIHIC, RSARS and TOSStRA

- 4.2.3 Summary of Validity and Reliability Analyses
- 4.3 Sex, Ethnic and Age Differences in Learning Environment Perceptions, Statistics Anxiety, Attitudes towards Statistics, and Statistics Achievement
 - 4.3.1 Sex Differences in Learning Environment Perceptions, Statistics Anxiety, Attitudes towards Statistics and Achievement
 - 4.3.2 Ethnic Differences in Learning Environment Perceptions, Statistics Anxiety, Attitudes towards Statistics and Statistics Achievement
 - 4.3.3 Age Differences in Learning Environment Perceptions, Statistics Anxiety, Statistics Attitudes and Statistics Achievement
 - 4.3.4 Summary of Sex, Ethnic and Age Differences
- 4.4 Associations between Classroom Learning Environment and Student Outcomes (Statistics Anxiety, Attitudes and Achievement)
 - 4.4.1 Associations Between Anxiety and Learning Environment
 - 4.4.2 Associations Between Attitudes and Learning Environment
 - 4.4.3 Associations Between Achievement and Learning Environment
 - 4.4.4 Summary of Outcome–Environment Associations
- 4.5 Chapter Summary.

4.2 Validity of Instruments

The first step in the data analyses was to generate evidence to support the validity and reliability of the questionnaires assessing learning environment, statistics anxiety, and attitudes towards statistics when used with university students who are not statistics majors but who are taking statistics classes in Southern California.

In this study, factor analysis was used to identify groups of questions which appeared to be assessing the same construct by describing variability among observed,

correlated questions, in terms of a potentially lower number of unobserved scales which are called factors. As noted in Section 3.5.1, factor analysis also helps with the identification of unnecessary questions (Harman, 1970; Klein, 1994).

As noted in Section 3.5.2, internal consistency reliability refers to how closely a related set of items form a group in terms of their intercorrelations and measure the same dimension. Internal consistency reliability was measured using Cronbach's alpha coefficient (Kupermintz et al., 2003). The degree to which each scale can be considered to be independent and measures a unique dimension not covered by the other scales, known as discriminant validity, was assessed by using the mean correlation of a scale with the other scales in that instrument. For small values of this measure, it is likely that the scale in question is measuring different concepts from the other scales.

Even though the instruments used in my study have been validated in the past, they have never been used to assess learning environment, statistics anxiety and attitudes towards statistics for university students who are not statistics majors but who are taking statistics classes in Southern California. In this section, I report:

- Factorial Validity of WIHIC, RSARS and TOSTRA (Section 4.2.1)
- Reliability, Discriminant Validity and Average Students' Scores for WIHIC, RSARS and TOSTRA (Section 4.2.2).

4.2.1 Factorial Validity of WIHIC, RSARS and TOSTRA

As noted in Section 3.5.1, for each of these three questionnaires, I conducted a separate principal axis factor analysis with one or two methods of rotation and Kaiser normalization. The two criteria used for the retention of any item were that it must

have a factor loading of at least 0.35 with its own scale and less than 0.35 with all other scales in the same questionnaire.

4.2.1.1 Factorial Validity of WIHIC

The factor analysis results for the 56-item seven-scale WIHIC instrument for my sample of 375 students in 12 classes at two universities in Southern California are shown in Table 4.1. Because much past research (see Section 2.2.2.9) has revealed that WIHIC scales are relatively independent, Varimax Rotation was considered appropriate and used. Only factor loadings of 0.35 and above are shown in the table. A full listing of WIHIC items is provided in Appendix A. At the bottom of Table 4.1, the eigenvalue and percentage variance for each scale of the instrument are shown.

Factor analysis of the 56-item WIHIC replicated the clear factor structure found in previous research (Aldridge et al., 1999; Pickett & Fraser, 2009; Zandvliet & Fraser, 2004, 2005). All 56 items were retained because each item had a factor loading of at least 0.35 with its own scale and less than 0.35 with the other six WIHIC scales.

The weakest factor was Student Cohesiveness, whose items had factor loadings of 0.35–0.69, with the question “I work well with other class members” having a factor loading of 0.38 and the question “I help other class members who are having trouble with their work” having a factor loading of 0.35. Removing these two items would result in factor loadings for the Student Cohesiveness scale of 0.40–0.69. The Teacher Support scale had factor loadings between 0.48 and 0.78. The question in that scale with the lowest factor loading of 0.48 was “The teacher’s questions help me to understand” and removing this question would result in factor loadings between 0.62 and 0.78.

Table 4.1 Factor Analysis Results for WIHIC

Item No	Factor Loadings						
	Student Cohesiveness	Teacher Support	Involvement	Investigation	Task Orientation	Cooperation	Equity
Stu Coh 1	0.56						
Stu Coh 2	0.69						
Stu Coh 3	0.43						
Stu Coh 4	0.75						
Stu Coh 5	0.38						
Stu Coh 6	0.35						
Stu Coh 7	0.53						
Stu Coh 8	0.40						
Tea Sup 1		0.65					
Tea Sup 2		0.78					
Tea Sup 3		0.66					
Tea Sup 4		0.62					
Tea Sup 5		0.74					
Tea Sup 6		0.75					
Tea Sup 7		0.62					
Tea Sup 8		0.48					
Invol 1			0.71				
Invol 2			0.81				
Invol 3			0.65				
Invol 4			0.73				
Invol 5			0.68				
Invol 6			0.57				
Invol 7			0.48				
Invol 8			0.55				
Inves 1				0.69			
Inves 2				0.62			
Inves 3				0.84			
Inves 4				0.64			
Inves 5				0.79			
Inves 6				0.80			
Inves 7				0.82			
Inves 8				0.72			
Tas Orn 1					0.64		
Tas Orn 2					0.62		
Tas Orn 3					0.65		
Tas Orn 4					0.59		
Tas Orn 5					0.76		
Tas Orn 6					0.59		
Tas Orn 7					0.68		
Tas Orn 8					0.64		
Coop 1						0.71	
Coop 2						0.78	
Coop 3						0.76	
Coop 4						0.71	
Coop 5						0.77	
Coop 6						0.84	
Coop 7						0.81	
Coop 8						0.79	
Equ 1							0.65
Equ 2							0.72
Equ 3							0.60
Equ 4							0.84
Equ 5							0.83
Equ 6							0.84
Equ 7							0.75
Equ 8							0.81
% Variance	3.19	6.15	5.04	7.98	3.63	28.71	9.54
Eigenvalue	1.79	3.44	2.82	4.47	2.03	16.07	5.34

N= 375

Factor loadings less than 0.35 have been omitted from the table.

Principal axis factoring with varimax rotation and Kaiser normalization.

The Involvement scale had factor loadings between 0.48 and 0.81 and removing the question “Students discuss with me how to go about solving problems” would result in factor loadings of between 0.55 and 0.81. The Investigation scale had factor loadings between 0.62–0.84, the Task Orientation scale had factor loadings between 0.59 and 0.76, the Cooperation scale had factor loadings between 0.71 and 0.84, and the Equity scale had factor loadings between 0.65 and 0.84.

The bottom of Table 4.1 shows that the proportion of variance accounted for ranged from 3.19% to 28.71% for different WIHIC scales. Together, the seven scales of the WIHIC accounted for a total of 64.24% of the variation for the instrument. Scale eigenvalues ranged between 1.79 and 16.07, which is noteworthy given that the instrument has only 56 items.

4.2.1.2 Factorial Validity of RSARS

The Revised Mathematics Anxiety Rating Scale RMARS is a 24-item instrument with two *a priori* scales called Learning Statistics Anxiety (LSA) and Statistics Evaluation Anxiety (SEA). It is based on a revised version of the 98-item RMARS (F. C. Richardson & Suinn, 1972). In the instrument which was used for this study, the Revised Statistics Anxiety Rating Scale (RSARS), the word ‘statistics’ replaced the word ‘mathematics’. The RSARS instrument in its entirety is provided in Appendix B and was discussed previously in Section 2.3.1 and 3.2.2.

As for the WIHIC, factor analysis of RSARS data was carried out with SPSS using principal axis factoring with Kaiser normalization. But, as explained in Section 3.5.1, two alternative methods of rotation, Varimax and Direct Oblimin, were each used and their results compared. Varimax Rotation is suitable when factors are uncorrelated, whereas Direct Oblimin Rotation is suitable when factors are correlated.

Items were retained if factor loadings were 0.35 and above on their own scale and less than 0.35 on all other scales. Factor loadings, eigenvalues and the percentage of total variation for each factor from the RSARS are reported in Table 4.2 separately for each rotation method (Varimax and Direct Oblimin).

The results in Table 4.2 reveal a clear factor structure as in previous research (Capraro et al., 2001; Hannafin, 1985; Kazelskis, 1998; Plake & Parker, 1982; B. A. Taylor, 2004). The LSA scale had factor loadings ranging between 0.35 and 0.81 when Varimax Rotation was used and from 0.35 to 0.78 when Direct Oblimin Rotation was used. The eight-item SEA scale had factor loadings ranging from 0.38 to 0.86 when Varimax Rotation was used and from 0.35 to 0.90 when Direct Oblimin Rotation was used. All items in my original version of the RSARS were retained because they had factor loadings of at least 0.35 with their own scale and below 0.35 for the other RSARS scale.

The eigenvalue for the LSA was 10.97 when Varimax Rotation was used and was 10.17 when Direct Oblimin Rotation was used, and the related variance was 45.48% when Varimax Rotation was used and 42.30% when Direct Oblimin Rotation was used. The eigenvalue for the SEA scale was 3.10 when Varimax Rotation was used and was 2.90 when Direct Oblimin Rotation was used. The associated variance was 12.91% when Varimax Rotation was used and 12.31% when Direct Oblimin Rotation was used. Overall, 58.39% of the variation in the RSARS instrument could be explained by those 24 items in the LSA and SEA scales when Varimax Rotation was used, and 54.61% was explained when Direct Oblimin Rotation was used.

An important conclusion from the factor analysis results reported in Table 4.2 is that the use of Varimax Rotation and the use of Direct Oblimin Rotation led to identical factor structures and the retention of the same set of items.

Table 4.2 Factor Analysis Results for the RSARS for Two Rotation Methods (Varimax and Direct Oblimin)

Item	Factor Loadings			
	Learning Statistics Anxiety (LSA)		Statistics Evaluation Anxiety (SEA)	
	Varimax	Direct Oblimin	Varimax	Direct Oblimin
LSA1	0.72	0.76		
LSA2	0.64	0.63		
LSA3	0.65	0.71		
LSA 4	0.61	0.63		
LSA5	0.75	0.77		
LSA6	0.72	0.74		
LSA7	0.81	0.84		
LSA8	0.62	0.58		
LSA9	0.71	0.69		
LSA10	0.73	0.72		
LSA11	0.65	0.64		
LSA12	0.35	0.35		
LSA13	0.38	0.35		
LSA14	0.72	0.75		
LSA15	0.73	0.78		
LSA16	0.59	0.58		
SEA1			0.58	0.56
SEA2			0.72	0.72
SEA3			0.38	0.35
SEA4			0.80	0.79
SEA5			0.85	0.90
SEA6			0.67	0.61
SEA7			0.86	0.93
SEA8			0.61	0.59
% Variance	45.48	42.30	12.91	12.31
Eigenvalue	10.97	10.17	3.10	2.90

N = 375

Factor loadings less than 0.35 have been omitted from the table.

Principal axis factoring with Kaiser normalization and two rotation methods (Varimax and Direct Oblimin)

4.2.1.3 Factorial Validity of TOSTRA

The Test of Statistical Related Attitudes (TOSTRA) utilized in my study was derived from the Test of Science Related Attitudes (TOSRA) developed by Fraser (1981). My original version of the TOSTRA for this study had four of the seven original scales of the TOSRA and replaced the word ‘science’ with the word ‘statistics’ and the word ‘scientist’ with the word ‘statistician’. The initially chosen four scales for my study were: Attitude to Statistical Inquiry; Adoption of Statistical Attitudes; Normality of Statistics Instructors; and Enjoyment of Statistics Lessons. There are 10 items in each of the four scales. The 40-item TOSTRA was administered

to my sample of 375 students in 12 classes at two universities in Southern California. A full listing of the TOSTRA items is provided in Appendix C and TOSTRA was discussed previously in Sections 2.3.2 and 3.2.3.

As for the RSARS, factor analysis using principal axis factoring with and Kaiser normalization and two alternative methods of rotation (Varimax and Direct Oblimin) was used with TOSTRA items. As noted in Section 3.5.1, Varimax rotation is more suitable when factors are uncorrelated and Direct Oblimin Rotation is more suitable when factors are correlated. Questions were retained if factor loadings were 0.35 and above on their own scale and less than 0.35 on all other scales. Factor loadings above 0.35, eigenvalues and the percentage of variance for each factor are shown for the TOSTRA in Table 4.3 separately for Varimax Rotation and Oblimin Rotation.

The factor analysis revealed that (for both methods of rotation) two of the four *a priori* factors, namely, Attitude to Statistical Inquiry and Adoption of Statistical Attitudes, had items which did not satisfy the criteria of having factor loadings of 0.35 and above on their own scale and less than 0.35 on all other scales, and did not form separate factors. Therefore, those two scales were completely eliminated from the investigation.

Table 4.3 Factor Analysis Results for the TOSTRA for Two Rotation Methods (Varimax and Direct Oblimin)

Item	Factor Loadings			
	Normality of Statisticians		Enjoyment of Statistics Lessons	
	Varimax	Direct Oblimin	Varimax	Direct Oblimin
NORM9	0.44	0.51		
NORM13	0.44	0.36		
NORM17	0.57	0.63		
NORM21	0.59	0.57		
NORM25	0.54	0.65		
NORM29	0.46	0.38		
NORM33	0.48	0.54		
NORM37	0.38	0.35		
ENJ4			0.80	0.81
ENJ8			0.75	0.72
ENJ12			0.51	0.57
ENJ16			0.81	0.78
ENJ20			0.75	0.77
ENJ28			0.88	0.89
ENJ32			0.67	0.66
ENJ36			0.84	0.85
ENJ40			0.68	0.66
% Variance	9.51	13.93	28.52	31.28
Eigenvalue	3.80	2.78	7.41	6.25

N=375

Factor loadings less than 0.35 have been omitted from the table.

Principal axis factoring with Kaiser normalization and two rotation methods (Varimax and Direct Oblimin)

Items NORM 1, NORM 5, ENJ 24 and all items from Attitude to Statistics and Adoption of Statistical Attitudes were omitted.

Sequence of question numbers is in increments of 4, reflecting the order in questionnaire. Full listing appears in Appendix C.

Also two of the 10 items in the Normality scale – “Statisticians usually like to solve equations when they have a day off” (NORM 1) and “Statisticians are about as fit and healthy as other people” (NORM 5) – had factor loadings of less than 0.35 with their own scale and therefore were omitted. The remaining eight items had factor loadings ranging from 0.38 to 0.59 when Varimax Rotation was used and from 0.35 to 0.63 for Direct Oblimin Rotation. The Normality scale had an eigenvalue of 3.80 (Varimax Rotation) or 2.78 (Direct Oblimin Rotation) and 9.51% (Varimax Rotation) or 13.93% (Direct Oblimin Rotation) of the variation in the TOSTRA was explained.

One of the 10 items in the Enjoyment scale – “Statistics lessons are a waste of time” (ENJ 24) – had a factor loading below 0.35 and therefore was omitted. The remaining nine Enjoyment items had factor loadings of between 0.51 and 0.88

(Varimax Rotation) or from 0.57 to 0.89 (Direct Oblimin Rotation). The eigenvalue for Enjoyment was 7.41 (Varimax Rotation) or 6.25 (Direct Oblimin Rotation) and the associated proportion of variance was 28.52% (Varimax Rotation) or 31.28% (Direct Oblimin Rotation). The Normality scale together with the Enjoyment scale contributed 38.03% (varimax Rotation) or 45.21% (Direct Oblimin Rotation) to the variation in the two-factor TOSTRA. All of these remaining items had factor loadings of below 0.35 for the scale other than their own.

It is noteworthy that the use of Varimax Rotation yielded a virtually identical optimal factor solution as the use of Direct Oblimin Rotation (see Table 4.3).

4.2.2 Internal Consistency Reliability, Discriminant Validity and Mean Scores for WIHIC, RSARS and TOSTRA

In this section, further information is provided to support the validity of each instrument, namely, internal consistency reliability (Section 4.2.2.1) and discriminant validity (Section 4.2.2.2). As well, the average item mean (the scale mean divided by the number of items in that scale) is provided as a descriptive statistic for each scale of each instrument. Table 4.4 reports results for the internal consistency reliability, discriminant validity and mean score for each WIHIC, RSARS and TOSTRA scale.

4.2.2.1 Internal Consistency Reliability of WIHIC, RSARS and TOSTRA

As noted above, internal consistency reliability refers to how closely items within a scale intercorrelate and therefore measure a common construct. In my study, I used Cronbach's alpha coefficient as a measure of internal consistency.

Table 4.4 contains results for the internal consistency reliability (alpha coefficient) for each scale of the WIHIC, RSARS and TOSRA. Alpha coefficients for

different scales ranged from 0.87 to 0.95 for the seven WIHIC scales. For the RSARS, the alpha coefficient was 0.93 for the LSA scale and 0.90 for the SEA scale. For the TOSTRA, the alpha coefficient was 0.74 for the Normality scale and 0.83 for the Enjoyment scale. Overall, Table 4.4 supports the strong internal consistency reliability of all WIHIC, RSARS and TOSTRA scales for my sample of university students in California.

Table 4.4 Scale Mean, Scale Standard Deviation, Internal Consistency Reliability (Cronbach Alpha Coefficient), Discriminant Validity (Correlation with Other Scales) for WIHIC, RSARS and TOSTRA

Instrument	Scale	No of Items	Mean	SD	Alpha Reliability	Mean Correlation
WIHIC	Student Cohesiveness	8	3.53	0.79	0.87	0.39
	Teacher Support	8	3.59	0.91	0.91	0.39
	Involvement	8	2.62	0.92	0.91	0.42
	Investigation	8	2.96	0.90	0.92	0.29
	Task Orientation	8	4.35	0.58	0.87	0.26
	Cooperation	8	3.15	1.04	0.95	0.41
	Equity	8	4.36	0.76	0.93	0.31
Revised Statistics Anxiety Rating Scale	Learning Statistics Anxiety (LSA)	16	2.06	0.80	0.93	0.62
	Statistics Evaluation Anxiety (SEA)	8	3.31	0.95	0.90	0.62
TOSTRA	Normality of Statisticians	8	3.76	0.52	0.74	0.27
	Enjoyment of Statistics	10	3.32	0.66	0.83	0.27

N=375

WIHIC responses: 1 = Almost Never Happens, 5 = Almost Always Happens

TOSTRA responses: 5 = I strongly agree, 1 = I strongly disagree

RSARS responses: 1 = You are not at all anxious..... 5 = You are very anxious

4.2.2.2 Discriminant Validity of WIHIC, RSARS and TOSTRA

Above it was noted that the discriminant validity of a questionnaire refers to the extent to which the scales of the same instrument are independent of each other. The mean correlation of each scale with the other scales was used as an index of the discriminant validity of the WIHIC. For both the RSARS and TOSTRA, which have only two scales, the correlation between the two scales was used as the indicator of discriminant validity.

As reported in Table 4.4, the mean correlation with other scales ranged between 0.26 and 0.42 for different WIHIC scales. Involvement and Cooperation had a moderate level of correlation with all other scales, and the remaining scales had a relatively low correlation with the other scales. These results show that raw scores on the scales were independent, perhaps with a small overlap between raw scores on Involvement and Cooperation with the other scales. However, the factor analysis results reported previously in Table 4.1 attest to the independence of factor scores.

The correlation between the two RSARS scales of LSA and SEA was 0.62, suggesting that the two anxiety scales were fairly highly related (see Table 4.4). This indicates possible multicollinearity for raw scores. Nevertheless, the factor analysis attests to the independence of factor scores.

Table 4.4 shows that the intercorrelation between the two TOSTRA scales of Normality and Enjoyment was 0.27, indicating little overlap between raw scores on the two scales.

4.2.2.3 Average Students' Scores for WIHIC, RSARS and TOSTRA

In Table 4.4, the average item mean and average item standard deviation of students' responses are reported for each of the WIHIC, RSARS and TOSTRA scales. Responses were assigned an integer value ranging from 1 to 5, with a midpoint of 3 indicating a moderate level of the construct. If the distribution of results adheres to a symmetrical distribution (e.g. normal or uniform distribution) the midpoint of 3 would correspond to the average response.

For the WIHIC, the scales of Involvement and Investigation had an average score below 3, indicating activities that were perceived to happen Sometimes or Seldom. The scales of Student Cohesiveness, Teacher Support, Task Orientation,

Cooperation and Equity all had average scores above 3, indicating that these activities were perceived to occur more often than Sometimes. Task Orientation and Equity had the highest average scores and also the smallest standard deviations.

From Table 4.4, we see that the average item mean score for the LSA scale from the RSARS was 2.06, a value considerably below the average 3, indicating a lower than moderate level of statistics anxiety was experienced during class. But the SEA scale from the RSARS had a mean score of 3.31, indicating higher than moderate level of anxiety during examinations.

For the TOSTRA, Table 4.4 shows that both the scales of Normality of Statisticians and Enjoyment of Statistics had average scores above 3, indicating that students generally agreed that statisticians are normal and that students enjoy statistics classes.

4.2.3 *Summary of Validity and Reliability Analyses*

The results reported above in Sections 4.2.1 and 4.2.2 supported the *a priori* factor structure and internal consistency reliability of both the WIHIC and the RSARS instruments when used with my Californian sample. The results for discriminant validity showed low correlations between raw scores on the scales on the WIHIC instrument, but a higher correlation between raw scores on the two scales of the RSARS. However, the factor analyses attested to the independence of factor scores for the WIHIC and RSARS.

Analysis of the TOSTRA data revealed that the *a priori* structure held up for only two of the four scales originally used in this study. The remaining two scales of Normality of Statisticians and Enjoyment of Statistics exhibited strong factorial

validity and internal consistency reliability. Discriminant validity data indicated a low level of correlation between the scales.

These results add more credibility to these instruments for assessing learning environment, anxiety and attitudes, not only in the settings studied before, but also now for an extended range of usefulness that includes university statistics classrooms for non-statistics majors in Southern California. The validity of the questionnaires provided justification for me to proceed to use them with confidence in further analyses to answer my other research questions.

Although two alternative methods of rotation (Varimax and Direct Oblimin) were tried out for the factor analysis of the RSARS and TOStra, almost identical factor structures were obtained.

4.3 Sex, Ethnic and Age Differences in Learning Environment Perceptions, Statistics Anxiety, Attitudes towards Statistics and Statistics Achievement

Because the data analyses reported in Section 4.2 supported the factorial validity, internal consistency reliability and discriminant validity of the seven-factor WIHIC, two-factor RSARS and two-factor TOStra, I used scores from these three instruments when undertaking further data analyses to answer my second research question concerning three determinants (sex, ethnicity and age) of students' scores on WIHIC, RSARS, TOStra and achievement scales.

As described in Section 3.5.3, three potential threats to rigor were identified and accommodated. First, in order to reduce the Type I error rate associated with performing any univariate tests for individual dependent variables (7 WIHIC scales, 2 RSARS scales, 2 TOStra scales, and 1 achievement scale), MANOVA was

performed for the 12 dependent variables as a set prior to conducting or interpreting any univariate ANOVA analyses. Second, because it would not be meaningful to interpret results for the main effects of sex, ethnicity and age if statistically significant interactions exist between any of the independent variables, conducting MANOVA also enabled detection of the presence or absence of significant interactions. Third, in order to consider the multivariate influence of sex, ethnicity and age simultaneously on the dependent variables, a three-way analysis was used to estimate the influence of each independent variable while the other two independent variables were mutually controlled.

In summary, I conducted a three-way MANOVA with 12 dependent variables (consisting of WIHIC, RSARS, TOSTRA and achievement scales) and the 3 independent variables of sex, ethnicity and age. As discussed in Chapter 3, Section 3.4, my data were divided into the three ethnic groups of Hispanics, Whites and Asians and the two age groups of at least 22 years and over 22 years. My measure of achievement, as described in Chapter 2, Section 3.2.4, consisted of the standardized weighted mean of four multiple-choice tests administered throughout the course. The number of items in the four tests were 14, 15, 16 and 30, respectively.

Using Wilks' lambda criterion, this MANOVA revealed the following key results for the set of 12 dependent variables as a whole:

- All two-way interactions (sex-by-ethnicity, sex-by-age and ethnicity-by-age) and the three-way interaction (sex-by-ethnicity-by-age) were all statistically nonsignificant. Therefore, consideration of sex effects, ethnicity effects, and age effects independently below was justified, and no further consideration of interaction effects was needed when discussing results below.

- Sex differences, ethnicity differences and age differences were all statistically significant.

Because MANOVA results revealed both the absence of significant interactions and the presence of sex, ethnicity, and age differences for the whole set of 12 dependent variables, the univariate ANOVA results for sex, ethnic and age differences were interpreted separately for each WIHIC, RSARS, TOSTRA and achievement scale.

As discussed in Section 3.5.3, an effect size was also calculated for each scale as an objective standardized measure of the strength or magnitude of the difference between groups (i.e. sex groups, ethnic groups, or age groups). In my analysis, Cohen's d was used as the effect size for the difference between two samples (e.g. males and females) for each scale. Cohen (1988) defined d as the difference between two means divided by the pooled standard deviation. Cohen hesitantly categorized effect sizes as small ($d = 0.2$), medium ($d = 0.5$), and large ($d = 0.8$), and stated that "there is a certain risk inherent in offering conventional operational definitions for those terms for use in power analysis in as diverse a field of inquiry as behavioral science" (p. 44). The effect size is a useful measure because it helps understanding of the practical significance of a difference. Effect sizes also are reported below.

In the subsections below, I report ANOVA results and effect sizes for:

- sex differences in learning environment perceptions, anxiety, attitudes and achievement (Section 4.3.1)
- ethnicity differences in learning environment perceptions, anxiety, attitudes and achievement (Section 4.3.2)
- age differences in learning environment perceptions, anxiety, attitudes and achievement (Section 4.3.3).

4.3.1 Sex Differences in Learning Environment Perceptions, Statistics Anxiety, Attitudes towards Statistics and Achievement

As described in Section 4.3 above, potential sex differences for each scale of the WIHIC, RSARS and TOSTRA, together with a measure of achievement, were investigated by using a three-way MANOVA to identify whether statistically significant differences existed between the scores of groups differing in sex, ethnicity or age. Because MANOVA revealed significant main effects but no statistically significant interactions for the whole set of dependent variables, the univariate ANOVA for sex differences was interpreted separately for each of the 12 individual dependent variables (i.e. scales from the WIHIC, RSARS and TOSTRA and achievement). These ANOVA results are reported in Table 4.5 in conjunction with effect sizes.

Table 4.5 Item Mean and Standard Deviation and Sex Difference (ANOVA Result and Effect Size) for WIHIC, RSARS, TOSTRA and Achievement Scales

Scale	Item Mean		Item SD		Difference	
	Male	Female	Male	Female	<i>F</i>	Effect Size
WIHIC (1=Almost Never Happens ... 5=Almost Always Happens)						
Student Cohesiveness	3.42	3.62	0.79	0.78	5.90*	0.25
Teacher Support	3.58	3.61	0.84	0.97	0.29	0.03
Involvement	2.56	2.68	0.90	0.94	1.32	0.13
Investigation	3.03	2.90	0.88	0.92	1.44	-0.14
Task Orientation	4.22	4.47	0.61	0.53	17.98**	0.45
Cooperation	3.02	3.28	1.13	1.13	2.22	0.23
Equity	4.31	4.43	0.71	0.76	1.51	0.16
RSARS (1=You Are Not At All Anxious ... 5=You Are Very Anxious)						
Learning Statistics Anxiety (LSA)	1.95	2.15	0.76	0.81	5.57*	0.25
Statistics Evaluation Anxiety (SEA)	3.19	3.42	0.91	0.98	5.66*	0.24
TOSTRA (1=I Strongly Disagree ... 5=I Strongly Agree)						
Normality of Statisticians	3.70	3.82	0.50	0.53	4.80*	0.25
Enjoyment of Statistics	3.29	3.34	0.61	0.71	0.62	0.07
Achievement ^a	7.79	7.63	0.95	1.16	2.02	-0.15

* $p < 0.05$

Males ($n = 181$); Females ($n = 194$).

^aPercentage scores have been divided by 10.

An overview of the results in Table 4.5 reveals three general patterns. First, sex differences were statistically significant for the two WIHIC scales of Student Cohesiveness and Task Orientation, both RSARS scales, and one TOSTRA scale (Normality of Statisticians). Second, the magnitude of significant sex differences was medium for Task Orientation (0.45 standard deviations) but fairly small for Student Cohesiveness, the two RSARS scales, and Normality of Statisticians (around 0.25 standard deviations) according to Cohen's (1988) criteria. Third, whereas males' scores were slightly higher than females' scores for the two scales of Investigation and achievement, females' scores were higher than males' scores for all other WIHIC, RSARS and TOSTRA scales.

For the WIHIC, a scale score above 3 indicates a response leaning towards Almost Always Happens and a scale score below 3 indicates a response leaning towards Almost Never Happens. Student Cohesiveness, Teacher Support, Task Orientation, Cooperation and Equity all had mean scores above 3 for both males and females, with female scores being somewhat higher than those of males. Females exhibited statistically significantly higher scores only for the scales of Student Cohesiveness and Task Orientation. For the Involvement scale, both males and females had scale scores below 3, but females had slightly higher scores than males. Of the seven WIHIC scales, Investigation was the only one for which the males had higher scores than the females, with males having a score slightly above 3 and the females' score being slightly below 3. Perhaps females viewed the environment more positively than did males (except for Investigation), because females typically are more sociable, enjoy interaction more, and are more motivated than males (Ogbuehi & Fraser, 2007; B. A. Taylor & Fraser, 2013). This is an area in which a future

longitudinal study could illuminate changes in perceptions of classroom environment over time.

Having a mean greater than 3 for RSARS scales indicates that students are more anxious, whereas responses below 3 indicate feelings more consistent with being less anxious. From Table 4.5, Learning Statistics Anxiety scores were below 3 for both males and females, indicating that both sexes were not particularly anxious about learning statistics, but with females still reporting higher levels than males. Statistics Evaluation Anxiety had a mean above 3 for both sexes, indicating more anxious feelings, and again with women reporting higher levels of anxiety than males. The effect size for differences in scores between males and female students was 0.25 standard deviations for LSA and 0.24 standard deviations for SEA, which are considered to be fairly small effects according to Cohen's (1988) classification. Sex differences in anxiety were statistically significant for both scales, which is consistent with earlier research in STEM classes which revealed that females typically are more anxious than males (Betz, 1978; Brush, 1978; Salamé, 1984; Udo et al., 2004).

For the two TOSTRA scales, the data suggest that both male and female students generally perceived statisticians to be normal and enjoyed statistics, but females' scores were somewhat higher than males' scores on both attitude scales. Sex differences in attitudes were statistically significant only for the Normality scale. The effect size for differences in scores between males and female students was 0.25 standard deviations for Normality of Statisticians, which is considered to be relatively small according to Cohen's (1988) classification (see Table 4.5).

4.3.2 *Ethnic Differences in Learning Environment Perceptions, Statistics Anxiety, Attitudes towards Statistics and Statistics Achievement*

Because the majority of students (97%) identified themselves as Asian, White or Hispanic, these were the only ethnicities considered in this study. Because other ethnicities accounted for less than 3% of the respondents, they were not used as part of my analysis of the ethnic differences. The total number of students (out of my total sample of 375) available for analysis of ethnic differences was 364 (86 Hispanic, 117 White and 161 Asian). There were 11 students who did not belong to one of these three ethnicities. The mean and standard deviation are shown separately for each of the three ethnic groups in Table 4.6 for each WIHIC, RSARS, TOSStRA and achievement scale.

As noted in Section 4.3, a preliminary three way-MANOVA justified the interpretation of the univariate one-way ANOVA results for ethnic differences separately for each of the 12 dependent variables. Table 4.6 provides the ANOVA results for ethnic differences for each scale. This table shows that, for the 12 learning environment, anxiety, attitude and achievement scales, ethnic differences were statistically significant only for the three scales of Task Orientation and Equity from the WIHIC and for achievement.

In order to identify which of the three pairwise comparisons between ethnic groups (i.e. Hispanics vs. Whites, Hispanics vs. Asians, and Whites vs. Asians) were statistically significant for the Task Orientation, Equity, and achievement scales, Tukey's HSD multiple comparison procedure was performed. Also the effect size (Cohen's *d*) was calculated for each pairwise comparison of ethnicities for these three scales. Table 4.7 reports these effect sizes and the results of Tukey's tests.

Table 4.6 *Item Mean and Item Standard Deviation and Ethnic Difference (ANOVA Result) for WIHIC, RSARS, TOSTRA and Achievement Scales*

Scale	Mean			SD			F
	Hispanic	White	Asian	Hispanic	White	Asian	
WIHIC (1=Almost Never Happens ... 5=Almost Always Happens)							
Student Cohesiveness	3.57	3.49	3.51	0.81	0.76	0.83	0.26
Teacher Support	3.71	3.62	3.50	0.91	0.88	0.95	1.54
Involvement	2.72	2.58	2.58	0.86	0.89	0.98	0.71
Investigation	3.03	2.93	2.96	0.92	0.91	0.89	0.34
Task Orientation	4.39	4.43	4.26	0.57	0.52	0.63	3.23*
Cooperation	3.24	3.10	3.13	1.18	1.11	1.15	0.41
Equity	4.42	4.56	4.21	0.66	0.61	0.86	7.70**
RSARS (1=You Are Not At All Anxious ... 5=You Are Very Anxious)							
Learning Statistics							
Anxiety (LSA)	2.05	1.95	2.14	0.78	0.68	0.88	1.82
Statistics Evaluation							
Anxiety (SEA)	3.34	3.39	3.23	0.94	0.92	0.99	0.91
TOSTRA (1=I Strongly Disagree ... 5=I Strongly Agree)							
Normality of							
Statisticians	3.78	3.79	3.74	0.50	0.51	0.53	0.46
Enjoyment of Statistics							
	3.42	3.22	3.34	0.71	0.64	0.64	2.38
Achievement ^a	7.50	7.86	7.80	1.19	0.92	1.09	3.22*

N: Hispanic=86, White=117, Asian=161.

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

^a Percentage achievement scores have been divided by 10.

Table 4.7 *Effect Size and Tukey's HSD Multiple Comparison for Statistical Significance of Difference Between Pairs of Ethnicities for Task Orientation, Equity and Achievement*

Scale	Effect Size & Tukey's HSD		
	Hispanic vs. White	Hispanic vs Asian	White vs Asian
Task Orientation	-0.07	0.22**	0.29**
Equity	-0.22**	0.27**	0.47**
Achievement	-0.34	0.26**	0.06

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

N: Hispanic=86, White=117, Asian=161.

For Task Orientation, Tukey's test revealed that Asians' scores were significantly lower than scores for either Hispanics or Whites, which were not significantly different from each other. For Equity, Whites' scores were significantly higher than both Hispanics' and Asians' scores. Also Hispanics' Equity scores were significantly higher than Asians' scores. For achievement, Hispanic students' scores

were significantly lower than those of either Whites or Asians, which were not significantly different from each other.

However, the magnitudes of the statistically significant ethnic differences in Table 4.7 are relatively small (around a quarter of a standard deviation) according to Cohen (1988), except for one case. For Equity, the magnitude of the difference between Whites and Asians was medium (around half a standard deviation).

My finding that Hispanics' achievement was lower than for Whites or Asians is consistent with past research and has been consistent over time (Blank & Langesen, 2001). Reasons put forward for this phenomenon include larger family sizes among Hispanics and lower levels of parental education (Cameron & Hackman, 2001). Fry (2009) reported that, because of family financial responsibilities, Hispanics must work more than other ethnicities and therefore have less time to study. When Hispanic students were asked why on average they did not perform as well as other students, they blamed poor parenting and poor English skills as the main factors (Lopez, 2009).

My finding that Asians perceived the learning environment less favorably than Whites and Hispanics in terms of Task Orientation and Equity is consistent with cross-national studies in which Taiwanese students perceived the learning environment less favorably than Australian students (Aldridge, Fraser & Huang, 1999) and Hong Kong students perceived the learning environment less favorably than American students (Hanke & Fraser, 2013). Because Asian students' command of the oral English language might not be as good as for other students, they might miss oral instructions because the pace is too fast for them to understand and then they are too embarrassed to ask questions.

For the WIHIC, a score of 5 indicates an average response moving towards Almost Always Happens and an average score below 3 and moving towards 1

indicates a response moving towards Almost Never Happens. Table 4.6 shows that each ethnic group perceived an average level of Cohesiveness above 3. For the Teacher Support scale, all ethnicities reported a mean score above 3, with Hispanic students having the highest mean value, followed by Whites and then Asians, but the differences were not statistically significant. The average mean score for the Involvement scale was lower than 3, with Hispanic students perceiving somewhat higher levels than Whites or Asians, but again the differences were not statistically significant. All three ethnic groups had an average score close to 3 for the Investigation and Cooperation scales.

For the RSARS, ethnic differences were nonsignificant for both Learning Statistics Anxiety and Statistics Evaluation Anxiety (Table 4.6). LSA had average scores around 2 for all ethnicities, indicating that students were not particularly anxious about learning statistics. White students reported the lowest LSA score. This could be an indication of the level of engagement during lectures and also it could be a result of the level of English proficiency of the different ethnic groups. The SEA mean was somewhat above 3 for all ethnicities.

The results in Table 4.6 for the TOSTRA attitude scale of Normality of Statisticians shows that mean scores were highly similar for all ethnic groups with means approaching 4 (Agree). Ethnic differences in Normality and Enjoyment scores were statistically nonsignificant. Hispanics enjoyed statistics the most and White students enjoyed statistics the least.

4.3.3 *Age Differences in Learning Environment Perceptions, Statistics Anxiety, Statistics Attitudes and Statistics Achievement*

As discussed in Section 4.3 above, potential age differences for each of WIHIC, RSARS, TOSTRA and achievement scale were investigated by using a three-way MANOVA to identify whether statistically significant differences existed between the scores of groups differing in sex, ethnicity or age. Because MANOVA revealed significant main effects but no statistically significant interactions for the whole set of dependent variables, the univariate ANOVA for age differences are interpreted separately for each of the 12 individual dependent variables (i.e. WIHIC, RSARS, TOSTRA and achievement scales) in Table 4.8. As well, effect sizes (Cohen's *d*) are reported in Table 4.8.

As described in Chapter 3, Section 3.4, I decided to divide student ages into a group of students aged 22 years or less and another group aged 23 years or more. The reason for choosing this split in ages is that the expected age of college graduation typically is 22 years or less for undergraduate degrees in the USA.

Table 4.8 shows that, with the exception of the learning environments scales of Student Cohesiveness and Task Orientation and achievement, older students (≥ 23 years) had higher scores than younger students (≤ 22 years) on all other learning environment, anxiety and attitudes scales. These age differences, however, were statistically significant only for the learning environment scales of Teacher Support and Involvement, Learning Statistics Anxiety and achievement. For these four scales, effect sizes were medium for Teacher Support (0.43 standard deviations) and Learning Statistics Anxiety (0.51 standard deviations) and were relatively small for Involvement (0.25 standard deviations) and achievement (0.23 standard deviations). The interpretation of these significant differences was that, relative to younger students, older students perceived the classroom environment more favorably in terms

of more Teacher Support and Involvement, experienced more Learning Statistics Anxiety, and had lower achievement.

Table 4.8 Item Mean and Standard Deviation and Age Difference (ANOVA Result and Effect Size) for WIHIC, RSARS, TOSStRA and Achievement Scales

Scale	Item Mean		Item SD		Difference	
	≤ 22 yrs	≥ 23 yrs	≤ 22 yrs	≥ 23 yrs	<i>F</i>	Effect Size
WIHIC (1=Almost Never Happens ... 5=Almost Always Happens)						
Student Cohesiveness	3.53	3.51	0.82	0.76	0.05	-0.03
Teacher Support	3.44	3.82	0.91	0.87	16.32**	0.43
Involvement	2.52	2.75	0.91	0.91	6.45*	0.25
Investigation	2.92	3.02	0.89	0.90	0.98	0.11
Task Orientation	4.36	4.33	0.60	0.56	0.28	-0.05
Cooperation	3.09	3.25	1.13	1.15	1.66	0.14
Equity	4.36	4.41	0.75	0.76	0.32	0.07
RSARS (1=You Are Not At All Anxious ... 5=You Are Very Anxious)						
Learning Statistics	1.90	2.31	0.67	0.91	25.20**	0.51
Anxiety (LSA)						
Statistics Evaluation	3.30	3.37	0.93	0.99	0.45	0.07
Anxiety (SEA)						
TOSStRA (1=I Strongly Disagree ... 5=I Strongly Agree)						
Normality of Statisticians	3.73	3.74	0.50	0.53	0.48	0.02
Enjoyment of Statistics	3.28	3.37	0.61	0.71	1.69	0.14
Achievement ^a	7.85	7.61	1.01	1.15	4.48*	-0.23

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

≤ 22 yrs ($n = 227$); ≥ 23 yrs ($n = 148$).

^aPercentage achievement scores have been divided by 10.

Previous research revealed that older students experienced more anxiety (Baloğlu, 2003). My research indicated that Learning Statistics Anxiety was significantly higher for older students, whereas Statistics Evaluation Anxiety was comparable for the two age groups. Khoo and Fraser (2008) found that student satisfaction varied by age, whereas my research indicates that Teacher Support and Involvement were perceived more favorably by older students. It could be that older students' age is closer to that of the instructor and therefore they could feel more comfortable interacting with the instructor. My results showed that older students did not achieve as well as the younger students on examinations.

4.3.4 Summary of Sex, Ethnic and Age Differences

Although a three-way MANOVA revealed no statistically significant interactions, the following statistically significant differences emerged for sex, ethnic and age differences in learning environment, anxiety, attitudes and achievement:

- Relative to males, females perceived more classroom Task Orientation and that statisticians were more normal, but reported higher learning Statistics Anxiety and Statistics Evaluation Anxiety (with effect sizes ranging from 0.24 to 0.45 standard deviations for these scales).
- Hispanics had lower achievement scores than Whites or Asians, and Asians perceived lower levels of classroom Task Orientation and Equity than Hispanics or Whites (with effect sizes ranging from 0.22 to 0.47 standard deviations).
- Relative to younger students, older students perceived higher classroom Teacher Support and Involvement, but were more anxious about learning statistics and had lower achievement (with effect sizes ranging from 0.23 to 0.51 standard deviations).

4.4 Associations Between Classroom Learning Environment and Student Outcomes (Statistics Anxiety, Attitudes and Achievement)

To answer my third research question, associations between classroom learning environment dimensions and three types of student outcomes (statistics anxiety, attitudes towards statistics, and statistics achievement) were investigated using simple correlation and multiple regression analyses. The learning environment scales were used as the independent variables and then each of the five RSARS, TOSTRA and achievement scale was used in turn as the dependent variable. Beta

coefficients were used to indicate the unique contribution made by each individual environment scale to an outcome variable when all other learning environment scales were mutually controlled. It is noteworthy that any associations between classroom learning environment and student outcomes (statistics anxiety, attitudes and achievement) could be the result of the classroom environment that I created and could in part be the result of pre-conceived notions which students brought into the classroom. Table 4.9 reports the results of these simple correlation and multiple regression analyses, which are discussed below separately for anxiety (Section 4.4.1), attitudes (Section 4.4.2) and achievement (Section 4.4.3).

4.4.1 Associations Between Anxiety and Learning Environment

The results of the simple correlation analysis in Table 4.9 show that only the Equity scale from the learning environment instrument exhibited a statistically significant correlation with Learning Statistics Anxiety. The multiple regression analysis for LSA reported in Table 4.9 reveals a statistically significant multiple correlation between LSA and the set of seven WIHIC scales. Inspection of the regression coefficients shows that Equity was the only learning environment scale that was significantly related to LSA scores when scores on the other six WIHIC scales were mutually controlled. Relationships were negative, indicating that a higher level of Equity in the classroom was associated with a lower level of learning anxiety.

For Statistics Evaluation Anxiety, the simple correlation was nonsignificant for every learning environment scale except Teacher Support. However, the multiple correlation for the set of all WIHIC scales was statistically significant, with Teacher Support being a significant independent predictor of SEA. The negative relationship

between Teacher Support and Statistics Evaluation Anxiety suggests that higher levels of teacher support lead to less examination anxiety.

Table 4.9 Simple Correlation and Multiple Regression Analyses of Associations Between Learning Environment Scales and Student Outcomes (Statistics Anxiety, Attitudes and Achievement)

Scale	Learning Statistics Anxiety (LSA)		Statistics Evaluation Anxiety (SEA)		Normality of Statisticians		Enjoyment of Statistics		Statistics Achievement	
	<i>r</i>	β	<i>r</i>	β	<i>r</i>	β	<i>r</i>	β	<i>r</i>	β
Student Cohesiveness	0.02	-0.11	0.03	0.08	0.12*	0.06	0.15**	0.09	0.14**	0.19**
Teacher Support	-0.09	-0.23	-0.13	-0.14*	0.17**	0.06	0.16**	0.12	0.03	0.10
Involvement	0.02	0.03	0.03	0.07	0.08	0.07	0.13*	0.01	0.15**	0.15*
Investigation	0.00	0.03	0.02	0.03	0.08	0.02	0.07	0.01	0.11*	0.06
Task Orientation	0.03	0.03	0.06	0.05	0.12*	0.00	0.17**	0.12*	0.09	0.05
Cooperation	-0.06	-0.13	0.01	0.05	0.12*	0.01	0.12*	0.01	0.13*	0.23**
Equity	-0.16**	-0.26**	0.02	0.03	0.29**	0.26**	0.11*	0.02	0.11*	0.09
Multiple Correlation <i>R</i>		0.26**		0.18**		0.30**		0.22**		0.26**

* $p < 0.05$, ** $p < 0.01$
N=375

Other than for the Equity and Teacher Support scales, overall relationships between the learning environment scales and the two anxiety scales were relatively weak. Perhaps this suggests that students can be enfranchised and buy into the classroom environment because of the teacher's actions in terms of treating the students fairly (Equity) and giving them encouragement, assistance and understanding and showing that they care (Teacher Support).

4.4.2 Associations Between Attitudes and Learning Environment

Results in Table 4.9 for the TOStra attitude scales show that statistically significant positive correlations existed between the Normality of Statisticians scale and the WIHIC learning environment scales of Student Cohesiveness, Teacher Support, Task Orientation, Cooperation and Equity. The WIHIC scales of Involvement and Investigation were not statistically significantly correlated with the Normality of Statisticians scale. Teacher Support and Equity were the two learning environment scales which correlated most strongly with the Normality scale. Perhaps the reason for this is that, because most interaction with the instructor is picked up by the Teacher Support and Equity scales, students associate higher levels of Teacher Support and Equity with instructors being more normal. The multiple correlation between Normality scores and WIHIC scales was statistically significant, with Equity being the only significant independent predictor of Normality.

For the Enjoyment of Statistics scale, all the scales of the WIHIC with the exception of Investigation correlated positively and statistically significantly with Enjoyment. It would appear that students enjoy the class more when they have direction and the class is well planned (Task Orientation), when they feel that the teacher helps them (Teacher Support), when there is more cooperative learning (Cooperation), when the class is interesting and students are allowed to participate (Involvement), when there is a friendly atmosphere (Student Cohesiveness), and when students are treated equally by the teacher (Equity).

The multiple correlation between WIHIC scales and the Enjoyment of Statistics scale was statistically significant. Task Orientation was the only independent determinant of Enjoyment. Perhaps students' enjoyment of statistics

classes for non-statistics majors at university level is influenced by the way in which a teacher controls and conducts the class.

4.4.3 Associations Between Achievement and Learning Environment

For achievement, Table 4.9 reveals a statistically significant simple correlation for Student Cohesiveness, Involvement, Investigation, Cooperation and Equity. As well, the multiple correlation between achievement and the set of seven WIHIC scales was statistically significant. Inspection of regression coefficients shows that Student Cohesiveness, Involvement and Cooperation were statistically significant independent predictors of achievement when the other classroom environment scales were mutually controlled. In particular, statistics achievement was higher in classes with more cohesiveness, involvement and cooperative learning.

4.4.4 Summary of Outcome–Environment Associations

It is noteworthy that all bivariate and multivariate associations between classroom environment and anxiety were negative, and that the associations between classroom environment and the two student outcomes of attitudes and achievement were positive, suggesting the importance of a positive learning environment for promoting student outcomes and reducing anxiety. This replicates considerable past research in many countries reviewed by Fraser (2012) and in this thesis in Chapter 2, Section 2.2.2.9. However, it is noteworthy that generally the magnitudes of the relationships between classroom environment and student outcomes (anxiety, attitudes and achievement) in Table 4.9 are relatively small compared with magnitudes reported in past research reviewed by Fraser (2012). A possible

explanation for this pattern is that other factors (e.g. students' prior educational experiences, the instructor, the peer group) are more influential than the learning environment in influencing those student outcomes in university statistics classrooms.

4.5 Chapter Summary

In order to answer my study's first research question, statistical analyses were undertaken to establish if the questionnaires assessing learning environment (WIHIC), statistics anxiety (RSARS), and attitudes towards statistics (TOStra) were valid and reliable for my sample of university students. Factorial validity was clearly established for the WIHIC and RSARS and, although two of the original TOStra scales were lost, the Normality and Enjoyment scales exhibited a clear factor structure. Internal consistency reliability for all three instruments was supported using alpha coefficients. Discriminant validity analysis for the WIHIC and TOStra, and especially the RSARS, indicated a degree of overlap between raw scores on scales, but factor analyses confirmed the independence of factor scores on each instrument.

A three-way MANOVA was used to answer my second research question concerning sex, ethnic and age differences in classroom environment, anxiety, attitude and achievement scores. Females' scores were significantly higher than males' scores for Task Orientation, Normality of Statisticians, Learning Statistics Anxiety and Statistics Evaluation Anxiety. Hispanics had lower achievement scores than Whites or Asians, but Asians had lower Task Orientation and Equity scores than the other two ethnic groups. Older students perceived higher levels of Teacher Support and Involvement, were more anxious about learning statistics, and had lower achievement relative to younger students. All effect sizes for significant differences ranged

between approximately a quarter and a half of a standard deviation (i.e. in the small to medium range).

To answer my third research question concerning outcome–environment associations, simple correlation and multiple regression analyses were conducted to reveal that two anxiety scales, two attitude scales and achievement each were significantly related to some of the WIHIC’s learning environment scales. In particular, Equity was a significant independent predictor of Learning Statistics Anxiety and Normality of Statisticians. Teacher Support was a significant independent predictor of Statistics Evaluation Anxiety. Task Orientation was a significant independent predictor of Enjoyment of Statistics. For achievement, the statistically significant independent predictors were Student Cohesiveness, Involvement and Cooperation.

Chapter 5

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

5.1 Introduction

In this study, I investigated the learning environment of university business statistics classrooms and its effect on the three student outcomes of anxiety, attitudes and achievement. Also I investigated three determinants (namely student sex, ethnicity and age) of students' classroom environment perceptions, anxiety, attitudes and achievement. In this chapter, I provide a summary of Chapters 1–3 of my thesis (Section 5.2) and the main findings related to my three research questions (Section 5.3), limitations of the research (Section 5.4), and discuss recommendations for further research (Section 5.5) and the significance and implications of this study (Section 5.6).

5.2 Summary of Chapters 1–3

My study provides the first research into compulsory, tertiary statistics learning environments for which sex, ethnicity and age were considered. Because no instrument existed specifically for measuring perceived statistics classroom learning environments at the university level, I validated a questionnaire as part of my study. Associations between the nature of the classroom learning environment and the student outcomes of anxiety, attitudes and achievement were investigated.

I validated the What Is Happening In this Class? (WIHIC), Revised Statistics Anxiety Rating Inventory (RSARS), and Test of Statistics Related Attitudes

(TOSStRA) for assessing, respectively, university students' perceptions of the learning environment of their business studies classes, statistics anxiety, and attitudes to statistics. The following three research questions were formulated for undergraduate business statistics students:

1. Are the following questionnaires valid: WIHIC, RSARS and TOSStRA?
2. Are there sex, ethnic and age differences in perceptions of learning environments, anxiety, attitudes and achievement?
3. Are there associations between the perceived learning environment of business statistics classes and the student outcomes of anxiety, attitudes and achievement?

Chapter 1 established my motivation for undertaking this study and delineated its research questions. Also covered were some methodological and ethical issues, as well as an introduction to some limitations and possible implications of this study.

In Chapter 2, I undertook a thorough review of the literature on learning environments, including the historical background of the field, instruments frequently used to assess classroom environment, and various types of past research on learning environments. The specific learning environment instrument (the WIHIC) used for this study was considered in some detail.

Chapter 2 also provided separate sections devoted to reviewing literature related to the conceptualization, assessment and investigation of two other constructs that were central to my study: statistics anxiety and attitudes to statistics.

A detailed explanation of the research methods used for this study was the focus of Chapter 3. Specific features of the three instruments used in this study, together with any modifications made, were described. Data sources and collection were discussed, before taking a closer look at the specific data collected for this study. Methods for analyzing the data for each research question were described. Finally, the major strengths and weaknesses of the study were considered.

Quantitative data were collected by administering three questionnaires (WIHIC, RSARS and TOSTRA) in Southern California to 12 university classes whose sizes ranged from 30 to 210 students. A sample of 375 students completed questionnaire items and provided an achievement score. Demographic questions regarding student sex, ethnicity and age were included.

The instrument used for assessing the statistics classroom learning environment was the What Is Happening In this Class? (WIHIC) questionnaire, designed by Fraser, McRobbie and Fisher (1996, April). The WIHIC has seven scales each with eight items: Student Cohesiveness, Teacher Support, Involvement, Investigation, Task Orientation, Cooperation, and Equity.

The instrument used for assessing learning statistics anxiety and statistics evaluation anxiety was based on the Revised Mathematics Anxiety Ratings Scale (RMARS) questionnaire, designed by Plake and Parker (1982), which in turn was based on the Mathematics Anxiety Rating Scale (MARS) of Suinn (1972, July). The questionnaire used in my study was named the Revised Statistics Anxiety Rating Scale (RSARS). The RSARS has two dimensions, the first with 16 items and the second with eight items: Statistics Learning Anxiety – the extent to which students feel anxious when learning the subject matter – and Statistics Evaluation/Test Anxiety – the level of anxiety felt when answering questions.

The instrument for assessing attitudes to statistics was based on the Test of Science Related Attitudes (TOSRA), designed by Fraser (1981). The TOSRA is composed of seven scales measuring student attitudes towards science and science-related areas. The original TOSRA has 10 questions for each scale. The modified instrument that was used in my study is referred to as the Test of Statistics Related Attitudes (TOS_tRA). Initially it contained items measuring four scales (Normality of Statisticians, Attitudes Towards Statistics Inquiry, Adoption of Statistics Attitudes and Enjoyment of Statistics Lessons), but two of the scales subsequently were lost during validation analyses.

Achievement was measured using the standardized and weighted aggregated scores achieved in four in-class examinations taken by the students during the course. They consisted of three mid-term examinations and a non-cumulative final examination, which all used multiple-choice responses.

To answer my first research question, an initial analysis of data was aimed at establishing whether the three questionnaires (WIHIC, RSARS and TOS_tRA) exhibited satisfactory factorial validity, internal consistency reliability, and discriminant validity.

In order to investigate the influence of three determinants (namely, sex, ethnicity and age) of a set of 12 dependent variables (namely, 7 WIHIC scales, 2 RSARS scales, 2 attitude scales, and 1 achievement measure), a three-way MANOVA was conducted. ANOVA results were interpreted for an individual dependent variable for a specific determinant and a specific dependent variable only if MANOVA first revealed the absence of any significant interaction effects and the presence of a significant multivariate association for the set of 12 dependent variables as a whole.

For my second research question, simple correlation and multiple regression analyses were conducted to identify any statistically significant relationships between the learning environment scales (from the WIHIC) and the student outcome variables of anxiety, attitudes and achievement. Regression coefficients were used to identify which individual environment scales were related to an outcome when the other environment scales were mutually controlled.

5.3 Findings and Conclusions

This section summarizes analyses and results for each of my research questions. It begins with validation analyses for the three instruments (Section 5.3.1). Sex, ethnic and age differences in learning environment perceptions, statistics anxiety, attitudes towards statistics and statistics achievement are then summarized (Section 5.3.2). Finally, the focus of Section 5.3.3 is my investigation of associations between classroom environment and student outcomes.

5.3.1 *Validity and Reliability of Instruments*

To check the factor structure of each questionnaire, principal axis factor analysis with one or more rotation methods and Kaiser normalization was conducted. The two criteria used for the retention of any item were that it must have a factor loading of at least 0.35 with its own scale and less than 0.35 with all other scales in the same questionnaire.

Factor analysis of the 56-item WIHIC involving Varimax Rotation replicated the clear factor structure found in previous research (Aldridge, Fraser, & Huang, 1999; Pickett & Fraser, 2009; Zandvliet & Fraser, 2004, 2005). All 56 items were retained because each item had a factor loading of at least 0.35 with its own scale and

less than 0.35 with the other six WIHIC scales. The total proportion of variance accounted for by WIHIC scales was 64.24%.

For the factor analysis for the RSARS and TOSTRA, two methods of rotation (Varimax and Direct Oblimin) were compared. The results for the RSARS revealed a clear two-factor structure as in previous research (Capraro, Capraro, & Henson, 2001; Hannafin, 1985; Kazelskis, 1998; Plake & Parker, 1982; Taylor, 2004). All items in my original version of the RSARS were retained because they had factor loadings of at least 0.35 with their own scale and below 0.35 for the other RSARS scale. The total proportion of variance accounted for was 58.39% (Varimax Rotation) and 54.61% (Direct Oblimin Rotation).

The factor analysis for the TOSTRA revealed that two of the four *a priori* factors, namely, Attitude to Statistical Inquiry and Adoption of Statistical Attitudes, had numerous items which did not satisfy the criteria of having factor loadings of 0.35 and above on their own scale and less than 0.35 on all other scales. Therefore, those two scales were completely eliminated from the investigation. Also two of the 10 items in the Normality scale had factor loadings of less than 0.35 with their own scale and therefore were omitted. As well, one of the 10 items in the Enjoyment scale had a factor loading below 0.35 and therefore was omitted. All of these remaining items had factor loadings of below 0.35 on all scales other than their own. The total proportion of variance accounted for was 38.03% (Varimax Rotation) and 45.21% (Direct Oblimin Rotation).

Almost identical factor analysis results were obtained whether Varimax or Direct Oblimin Rotation was used with RSARS and TOSTRA data.

Cronbach's alpha coefficients supported the strong internal consistency reliability of all WIHIC, RSARS and TOSTRA scales for my sample of university students in California.

The mean correlation of a scale with other scales (a measure of scale independence or discriminant validity) ranged between 0.26 and 0.42 for different WIHIC scales. These results suggest that raw scores on WIHIC scales were independent, perhaps with a small degree of overlap. However, the factor analysis results attested to the independence of factor scores. The correlation between the two RSARS scales was higher, suggesting that the two anxiety scales were somewhat related. Nevertheless, the factor analysis attested to the independence of factor scores. The intercorrelation between the two TOSTRA scales of Normality and Enjoyment was only 0.27, indicating little overlap between raw scores on these two scales.

5.3.2 Sex, Ethnic and Age Differences in Learning Environment Perceptions, Statistics Anxiety, Attitudes towards Statistics and Statistics Achievement

Because the data analyses supported the factorial validity, internal consistency reliability and discriminant validity of the seven-factor WIHIC, two-factor RSARS and two-factor TOSTRA, I used scores from these three instruments when undertaking further data analyses to answer my second research question concerning three determinants (sex, ethnicity and age) of student outcomes. For each WIHIC, RSARS, TOSTRA and achievement scale, a three-way MANOVA was used to identify whether statistically significant differences existed between the scores of groups differing in sex, ethnicity or age. Because MANOVA revealed significant main effects but no statistically significant interactions for the whole set of dependent variables, the univariate ANOVA for sex, ethnicity and age differences was interpreted separately

for each of the 12 individual dependent variables (i.e. scales from the WIHIC, RSARS and TOSTRA and achievement). Also, effect sizes (Cohen's d) were used to indicate the magnitude of differences. Section 5.2.3.1 summarizes sex differences, followed by Section 5.2.3.2 which summarizes ethnic differences, and Section 5.2.3.3 which summarizes the results for age differences.

5.3.2.1 Sex Differences in Learning Environment Perceptions, Statistics Anxiety, Attitudes towards Statistics and Achievement

An overview of the results revealed three general patterns. First, sex differences were statistically significant for the two WIHIC scales of Student Cohesiveness and Task Orientation, both RSARS scales, and one TOSTRA scale (Normality of Statisticians). Second, the magnitude of significant sex differences was medium for Task Orientation (0.45 standard deviations) but fairly small for Student Cohesiveness, the two RSARS scales, and Normality of Statisticians (around 0.25 standard deviations) according to Cohen's (1988) criteria. Third, whereas males' scores were slightly higher than females' scores for the two scales of Investigation and achievement, females' scores were higher than males' scores for all other WIHIC, RSARS and TOSTRA scales.

5.3.2.2 Ethnic Differences in Learning Environment Perceptions, Statistics Anxiety, Attitudes towards Statistics and Statistics Achievement

For the 12 learning environment, anxiety, attitude and achievement scales, ethnic differences were statistically significant only for the three scales of Task Orientation and Equity from the WIHIC and for achievement. For Task Orientation, Tukey's post hoc test revealed that Asians' scores were significantly lower than

scores for either Hispanics or Whites, which were not significantly different from each other. For Equity, Whites' scores were significantly higher than both Hispanics' and Asians' scores. Also Hispanics' Equity scores were significantly higher than Asians' scores. For achievement, Hispanic students' scores were significantly lower than those of either Whites or Asians, which were not significantly different from each other. Effect sizes for significant differences ranged from 0.22 to 0.47 standard deviations (small to medium range).

5.3.2.3 Age Differences in Learning Environment Perceptions, Statistics Anxiety, Statistics Attitudes and Statistics Achievement

As described in Chapter 3, Section 3.4, I decided to divide student ages into a group of students aged 22 years or less and another group aged 23 years or more because the expected age of college graduation is 22 years or less in the USA. Older students perceived significantly more Teacher Support and Involvement, but also experienced significantly greater Learning Statistics Anxiety and achieved significantly less relative to younger students. Khoo and Fraser (2008) found that student satisfaction varied with age and my research indicates that Teacher Support and Involvement were perceived more favorably by older students. Perhaps, because older students' age is closer to that of the instructor, they might feel more comfortable interacting with the instructor.

5.3.3 Associations Between Classroom Learning Environment and Student Outcomes (Statistics Anxiety, Attitudes and Achievement)

To answer my third research question, associations between classroom learning environment dimensions and three types of student outcomes (statistics anxiety, attitudes towards statistics, and statistics achievement) were investigated

using correlation and multiple regression analyses. Sections 5.3.3.1 to 5.3.3.3 summarizes these results for different outcomes.

5.3.3.1 Associations Between Anxiety and Learning Environment

The simple correlation analysis showed that Equity was the only learning environment scale with a statistically significant correlation with Learning Statistics Anxiety. The multiple regression analysis for LSA revealed a statistically significant multiple correlation with the set of seven WIHIC scales, with Equity being the only learning environment scale that was significantly related to LSA scores when scores on the other six WIHIC scales were mutually controlled. Associations were negative, indicating that a higher level of Equity in the classroom was associated with less learning anxiety.

For Statistics Evaluation Anxiety, the simple correlation was nonsignificant for every learning environment scale except Teacher Support, but the multiple correlation for the set of all WIHIC scales was statistically significant. Teacher Support was a significant, independent and negative predictor of SEA, suggesting that higher levels of teacher support led to less examination anxiety.

5.3.3.2 Associations Between Attitudes and Learning Environment

Statistically significant positive correlations emerged between the Normality of Statisticians scale and the WIHIC learning environment scales of Student Cohesiveness, Teacher Support, Task Orientation, Cooperation and Equity. The multiple correlation between Normality scores and WIHIC scales was statistically significant, with Equity being the only significant independent predictor of Normality.

For the Enjoyment of Statistics scale, all WIHIC scales with the exception of Investigation correlated positively and statistically significantly with Enjoyment. It would appear that students enjoy the class more when they have direction and the class is well planned (Task Orientation), when they feel that the teacher helps them (Teacher Support), when there is more cooperative learning (Cooperation), when the class is interesting and students are allowed to participate (Involvement), when there is a friendly atmosphere (Student Cohesiveness), and when students are treated equally by the teacher (Equity). The multiple correlation was statistically significant and Task Orientation was a significant independent predictor of Enjoyment.

5.3.3.3 Associations Between Achievement and Learning Environment

For achievement, a statistically significant simple correlation was found for Student Cohesiveness, Involvement, Investigation, Cooperation and Equity. As well, the multiple correlation between achievement and the set of seven WIHIC scales was statistically significant. Inspection of regression coefficients showed that Student Cohesiveness, Involvement and Cooperation were statistically significant independent predictors of achievement when the other classroom environment scales were mutually controlled.

5.4 Limitations of the Study

A great deal of planning went into attempting to ensure that the data collected were free from bias and errors, but it is acknowledged that limitations could still exist. The questionnaires used in this study had fixed-choice items. Questionnaires with well-prepared wording are quick to administer, cheap to produce, non-intimidating to students, and easy to score, and they yield objective responses from many students

over a large geographical area without the use of large amounts of manpower (Anderson & Arsenault, 1998). The questionnaires were set up so that the responses could be recorded on the actual questionnaire utilizing forced responses. The respondents usually gave truthful responses because their identities were kept anonymous.

However, there still were a number of limitations to the questionnaire approach. The constructs chosen might not have been appropriate. Even if the factors identified had a relationship with the student outcomes, perhaps another underlying factor actually caused the effect, or the relationship was so weak that this factor should not have been considered. Questionnaire items might have missed aspects important to the research or failed to probe them in sufficient detail, leading to loss of important information and rendering the research deficient. To try to mitigate against many of these problems, a great deal of time was invested in trying to identify suitable questionnaires.

Some students might have misunderstood some items and therefore answered different questions from the ones intended by the researcher (Bourhis, Roth, & MacQueen, 1989; Hadlow & Pitts, 1991) and other students might have deliberately distorted their answers because they felt uncomfortable about divulging certain information (Bradburn, Sudman, Blair, & Stocking, 1978). The response alternatives could have been interpreted differently by different respondents, and research suggests that ethnicity and gender are key factors leading to interpretation differences in responses (Bolt & Johnson, 2009; Hui & Triandis, 1989; Watkins & Cheung, 1995), which could have introduced errors and bias into the data. It is impossible to know if students misunderstood any questions, distorted their answers or misunderstood the response alternatives.

Despite the responses being anonymous, students might not have believed this and possibly they modified their answers to what they believed was expected rather than giving their true perceptions.

Another potential limitation was that multiple-choice examinations were used to generate the student achievement measure for my study. There are some appealing attributes of multiple-choice tests, such as their being able to quickly assess students without introducing student style bias or grader bias. A disadvantage, however, is the inability to give partial credit (Kubiszyn & Borich, 2003), which could mean that achievement scores do not correctly reflect the true level of mastery. As well, there is a possibility of students correctly guessing an answer even though they have no idea about how to correctly answer it. Importantly, there are likely to be salient course objectives that cannot be measured validly using only multiple-choice format.

The fact that all students taking part in this research were taught by me personally had the benefit of controlling for instructor's accent (Nisbett & Wilson, 1977), subject knowledge (Buchmann, 1984), delivery (Ball, 1988; Post, Behr, Hamel, & Lesh, 1988), and demeanor (Medley, 1979). However, a potential limitation is that my being the instructor might have influenced the results in some ways (internal validity) and might make it difficult to generalize my findings to the students of other instructors.

Several limitations inevitably are related to any sample. The somewhat limited size of my sample (375 students), relative to a larger sample, would be associated with lower statistical power for statistical significance testing and would lead to less accurate estimates of the underlying population. Relative to a broader and more representative sample, the results from my sample from two universities would be less generalizable.

Not all students in my classes responded to the survey for a variety of reasons, including not wanting to devote the time and effort (Brown, 2003) and being absent from class on the day when the survey was administered, or because the survey appeared to lack of relevance to them (Ray & Tabor, 2003). Although non-respondents gave rise to a potential limitation, this was not a particular issue with my research results because over 95% of students responded to any questionnaire item.

Although the types of statistical analysis chosen for my research were quite adequate for my somewhat pioneering and exploratory study, perhaps more sophisticated analyses might have been chosen. For example, because the correlation and multiple regression analyses used to investigate relationships between the student outcomes and learning environment can only detect linear relationships, any existing non-linear relationships would be missed. The somewhat limited sample size made it difficult to conduct analyses using the class mean as the unit of analysis or to use multilevel analysis.

Human error in respondents' coding of answers and in the transfer of answers from the response sheets to an Excel data-base possibly could have resulted in erroneous recording of answers. These issues could give rise to limitations.

The somewhat arbitrary use of 22 years as a convenient cut-off for splitting the student sample by age might not have been the most appropriate partition. Perhaps another choice of cut-off age might have led to somewhat different results.

Another limitation is that using qualitative methods was beyond the scope and resources of my study. The merits of combining qualitative and quantitative methods in learning environment research have been discussed by Tobin and Fraser (1998). The absence of qualitative information potentially could have led to some loss of

insights which could have illuminated and explained the findings from my use of questionnaires.

Another potential limitation regarding my questionnaires was that time constraints and the timing of the university calendar did not permit a pilot study to be conducted. This was unlikely to be a problem with the WIHIC because it has proved to be robust and valid in so many past studies reviewed in Section 2.2.9. However, because the TOSTRA was originally developed for use in science classes (see Sections 2.3.2 and 3.2.3) and the RSARS was originally developed for mathematics classrooms (see Sections 2.3.1 and 3.2.2), a pilot study potentially could have been useful for obtaining feedback from statistics students prior to using these questionnaires in the main study.

5.5 Recommendations for Future Research

The Statistics Classroom Learning Environment Inventory validated in my study could be used in the future in university statistics classrooms in some of the lines of research identified by Fraser (2012) and discussed in Section 2.2.3. These include investigation of differences between students' and teachers' perceptions, a longitudinal study of change in perceptions, whether students achieve better in their preferred environment, links between environments (e.g. home, peer-group and university environments), and instructors' attempts to improve their classroom environments.

The limitations discussed in Section 5.4 lead to numerous suggestions for desirable future research. Because my study was limited to the use of quantitative methods based on questionnaires and achievement tests, the inclusion of qualitative

methods in future research could lead to new insights and help to explain findings from questionnaires, as advocated by Tobin and Fraser (1998).

As with any study, inevitably, my sample had limitations that lead to suggestions for future research. A larger sample of more than 375 students in future research would provide greater statistical power and lead to more accurate estimates of population parameters. Therefore, a more diverse and representative sample would improve the generalizability of findings. Also, in future research, the sample used could extend beyond that in my study by including statistics majors as well as statistics non-majors and a range of different instructors (not just one instructor as in my research). With a more diverse sample, additional ethnic groups (e.g. African-Americans) could be investigated. A larger sample would allow more ways of partitioning students by age and more information on age effects.

In future research, it would be desirable that the achievement measure used goes beyond the limited multiple-choice items used in my study to include other extended-response item types. Similarly, because my questionnaire also was limited to items with restricted choices, it would be advantageous in future research to include questionnaires with a range of other formats (e.g. open-ended questions).

In future research with a larger sample, methods of statistical analysis could be more sophisticated than those used in my study. For example, confirmatory factor analysis could be used as well as exploratory factor analysis. The class mean could be used and the unit of analysis in addition to the student. Multilevel analysis could be used in addition to multiple regression analysis. Non-linear relationships could be investigated as well as linear relationships.

In future research, an alternative learning environment questionnaire could be chosen from those reviewed in Section 2.2.2. Similarly, a broader range of outcome measures could be included. For example, achievement testing could go beyond the multiple-choice format used in my study to reduce guessing and to permit the assessment of a broader range of course objectives (e.g. problem-solving).

5.6 Significance and Implications

The main substantive contribution of this study is that, for the first time, ideas from the field of learning environments were applied in university statistics classrooms.

A methodological contribution is that several questionnaires were cross-validated for future use by researchers and practitioners in university statistics education. As a result of my study, statistics education researchers and statistics instructors now have validated and economical questionnaires for assessing university classroom environments and students' statistics anxiety and attitudes to statistics.

Many students take business statistics classes all over the world each year. Apart from the dread that they feel, many fail and end up having to repeat these classes. Many business students to whom I have spoken tell me that the enduring legacy of their business degree was the difficult time that they experienced with compulsory business statistics classes. Implementing the results from this study potentially could help institutions to minimize the negative stigma associated with low pass rates in statistics classes, reduce the backlog of students trying to re-take failed classes, and ease the logistical issues in trying schedule classes.

My study revealed that statistics students of different sexes, ethnicities and ages differed in their perceptions of classroom environment and the outcomes of anxiety, attitudes and achievement. For example, females had higher scores for Task Orientation, Normality of Statisticians and the two anxiety scales, older students perceived significantly more classroom Teacher Support and Involvement but had higher Learning Statistics Anxiety and lower achievement, and Hispanics had lower achievement than Whites or Asians, whereas Asians perceived lower Task Orientation and Equity than Whites or Hispanics. These results could alert statistics instructors to differences between students of different sexes, ethnicities and ages that might be taken into account in planning differentiated statistics instruction. For example, instructors could try to avoid anxiety-provoking practices by returning coursework and examinations promptly, not giving unannounced quizzes, reducing the number of quizzes, and teaching students how to properly use tables and software packages.

My tentative results concerning associations between emphases in the classroom environment and improved student outcomes have potential implications for the improvement of statistics instruction. For example, Learning Statistics Anxiety was lower in classes with more Equity, Statistics Evaluation Anxiety was lower in classes with more Teacher Support, Enjoyment of Statistics was higher in classes with more Task Orientation, Normality of Statisticians scores were higher in classes with more Equity, and statistics achievement was higher in classes with more Student Cohesiveness, Involvement and Cooperation. These findings tentatively suggest directions for changing classroom environments, possibly using the approach followed in past studies and reviewed in Section 2.2.3.3 (e.g. Aldridge et al., 2012), in an attempt to improve different types of student outcomes (e.g. anxiety, attitudes or achievement). For example, attempts could be made to improve task orientation by

using such tactics as motivation, giving clearer instructions about what is expected, and rewarding students throughout the class sessions. Classroom equity might be improved by the instructor taking active strides to show the students that they will all be treated equally in the class.

Perhaps, most importantly, this study has underlined the importance of the classroom learning environment in its own right, as well as being a consistent predictor of student outcomes. That is, the classroom environment is both an end and a means to an end.

5.7 Concluding Remarks

Clearly, research on the learning environment of business statistics classrooms of non-statistics majors is important because of its potential to guide the creation of environments that best work for students. Research on statistics anxiety and attitudes towards statistics are two further important areas that could influence the teaching of business statistics. Hopefully, my research is likely to help other researchers and instructors to pause for thought and to improve students' experiences and outcomes in business statistics classes.

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Appendix A

What Is Happening In this Class? (WIHIC)

Learning Environment Questionnaire

The WIHIC was developed by Fraser, Fisher and McRobbie (1996) and described in detail in this thesis in Sections 2.2.9 and 3.2.1. It was used in this study and included in this thesis with the permission of its authors.

What is Happening In This Class?

Identify how you feel today regarding the following statements using the scale below:

*I **almost never** feel this way in class.*

*I **seldom** feel this way in class.*

*I **sometimes** feel this way in class.*

*I **often** feel this way in class.*

*I **almost** always feel this way in class.*

Please use the answer sheet provided, remembering to supply information at the top of the form.

Describe how you feel today about this class...

1. I make friends among students in this class.
2. I know other students in this class.
3. I am friendly to members of this class.
4. Members of the class are my friends.
5. I work well with other class members.
6. I help other class members who are having trouble with their work.
7. Students in this class like me.
8. In this class, I get help from other students.

9. The teacher takes a personal interest in me.
10. The teacher goes out of his/her way to help me.
11. The teacher considers my feelings.
12. The teacher helps me when I have trouble with the work.
13. The teacher talks with me.
14. The teacher is interested in my problems.
15. The teacher moves about the class to talk with me.
16. The teacher's questions help me to understand.

17. I discuss ideas in this class.
18. I give my opinions during class discussions.
19. The teacher asks me questions.
20. My ideas and suggestions are used in classroom discussions.
21. I ask the teacher questions.
22. I explain my ideas to other students.
23. Students discuss with me how to go about solving problems.
24. I am asked to explain how I solve problems.

25. I carry out investigations to test my ideas.
26. I am asked to think about evidence for my statements.
27. I carry out investigations to answer questions coming from discussions.
28. I explain the meaning of statements, diagrams, and graphs.
29. I carry out investigations to answer questions that puzzle me.
30. I carry out investigations to answer teacher's questions.
31. I find out answers to questions by doing investigations.
32. I solve problems by using information obtained from my own investigations.

33. Getting a certain amount of work done is important to me.
34. I do as much as I set out to do.
35. I know the goals of this class.
36. I am ready to start class on time.
37. I know what I am trying to accomplish in this class.
38. I pay attention during this class.

39. I try to understand the work in this class.
40. I know how much work I have to do.

41. I cooperate with other students when doing assignment work.
42. I share my books and resources with other students when doing assignments.
43. When I work in groups in this class, there is teamwork.
44. I work with other students on projects in this class.
45. I learn from other students in this class.
46. I work with other students in this class.
47. I cooperate with other students on class activities.
48. Students work with me to achieve class goals.

49. The teacher gives as much attention to my questions as to the other students' questions.
50. I get the same amount of help from the teacher as do other students.
51. I have the same amount of say in this class as other students do.
52. I am treated the same as other students in this class.
53. I receive the same encouragement from the teacher as other students do.
54. I get the same opportunity to contribute to class discussions as other students.
55. My work receives as much praise as other students' work.
56. I get the same opportunity to answer questions as other students.

What is Happening In This Class?
Answer Sheet

Page 1						Page 2					
	Almost Never	Seldom	Sometimes	Often	Almost Always		Almost Never	Seldom	Sometimes	Often	Almost Always
1	1	2	3	4	5	25	1	2	3	4	5
2	1	2	3	4	5	26	1	2	3	4	5
3	1	2	3	4	5	27	1	2	3	4	5
4	1	2	3	4	5	28	1	2	3	4	5
5	1	2	3	4	5	29	1	2	3	4	5
6	1	2	3	4	5	30	1	2	3	4	5
7	1	2	3	4	5	31	1	2	3	4	5
8	1	2	3	4	5	32	1	2	3	4	5
9	1	2	3	4	5	33	1	2	3	4	5
10	1	2	3	4	5	34	1	2	3	4	5
11	1	2	3	4	5	35	1	2	3	4	5
12	1	2	3	4	5	36	1	2	3	4	5
13	1	2	3	4	5	37	1	2	3	4	5
14	1	2	3	4	5	38	1	2	3	4	5
15	1	2	3	4	5	39	1	2	3	4	5
16	1	2	3	4	5	40	1	2	3	4	5
17	1	2	3	4	5	41	1	2	3	4	5
18	1	2	3	4	5	42	1	2	3	4	5
19	1	2	3	4	5	43	1	2	3	4	5
20	1	2	3	4	5	44	1	2	3	4	5
21	1	2	3	4	5	45	1	2	3	4	5
22	1	2	3	4	5	46	1	2	3	4	5
23	1	2	3	4	5	47	1	2	3	4	5
24	1	2	3	4	5	48	1	2	3	4	5
						49	1	2	3	4	5
						50	1	2	3	4	5
						51	1	2	3	4	5
						52	1	2	3	4	5
						53	1	2	3	4	5
						54	1	2	3	4	5
						55	1	2	3	4	5
						56	1	2	3	4	5

Scale Allocation and Scoring for Each Item of the WIHIC

	Student Cohesiveness	Teacher Support	Involvement	Investigation	Task Orientation	Cooperation	Equity
1		9	17	25	33	41	49
2		10	18	26	34	42	50
3		11	19	27	35	43	51
4		12	20	28	36	44	52
5		13	21	29	37	45	53
6		14	22	30	38	46	54
7		15	23	31	39	47	55
8		16	24	32	40	48	56

For all items, the five possible frequency responses of Almost Never, Seldom, Sometimes, Often and Very Often are scored 1, ,2, 3, 4 and 5, respectively, because there are no negatively-worded and reverse-scored items. Omitted or invalid responses are scored 3.

Appendix B

Revised Statistics Anxiety Rating Scale

(RSARS)

The questionnaire is based on the Revised Mathematics Anxiety Rating Scale (RMARS) developed by Plake and Parker (1982) and is discussed in this thesis in Sections 2.3.1 and 3.2.2. It was modified, used in this study and included in this thesis with the permission of its authors.

Revised Statistics Anxiety Rating Scales

The items in this question refer to the things and experiences that could cause fear or apprehension in you. Answer each item below to indicate how you feel today by circling:

- 1= you are **not at all** anxious
- 2= you are **a little** anxious
- 3= you are **moderately** anxious
- 4= you are **pretty much** anxious
- 5=you are **very** anxious

Work quickly and be sure to answer each item individually on the answer sheet provided.

How would you feel today if you were.....

1. Watching a teacher work an algebraic equation on the whiteboard.
2. Buying a statistics textbook on the first day of class.
3. Being given a homework assignment of difficult problems which is due the next class meeting.
4. Thinking about an upcoming statistics test the day before you take it.
5. Solving a square root problem.
6. Reading and interpreting graphs and charts.
7. Signing up for a course in statistics.
8. Listening to another student explain a statistics formula to you.
9. Walking into a statistics class.
10. Looking through the pages of a statistics textbook.
11. Starting a new chapter in a statistics book.
12. Walking onto campus thinking about a statistics course.
13. Picking up a statistics textbook to begin working on a homework assignment.
14. Taking an examination (quiz) in a statistics course.
15. Reading a word associated with statistics such as "hypothesis test" or "standard deviation".
16. Working on an abstract statistical problem.
17. Reading a formula in a statistics class.
18. Taking an examination (final) in a statistics course.
19. Getting ready to study for a statistics test.
20. Being given an unannounced quiz in a statistics class.
21. Waiting to receive a statistics test on which you expected to do well.
22. Listening to a lecture in a statistics class.
23. Having to use a calculator or table to solve a problem.
24. Being told how to solve a statistics equation or write a statistics proof.

Revised Statistics Anxiety Rating Scales
Answer Sheet

	Page 1					Page 2					
	Not At All	A Little	Moderately	Pretty Much	Very Much	Not At All	A Little	Moderately	Pretty Much	Very Much	
1	1	2	3	4	5	14	1	2	3	4	5
2	1	2	3	4	5	15	1	2	3	4	5
3	1	2	3	4	5	16	1	2	3	4	5
4	1	2	3	4	5	17	1	2	3	4	5
5	1	2	3	4	5	18	1	2	3	4	5
6	1	2	3	4	5	19	1	2	3	4	5
7	1	2	3	4	5	20	1	2	3	4	5
8	1	2	3	4	5	21	1	2	3	4	5
9	1	2	3	4	5	22	1	2	3	4	5
10	1	2	3	4	5	23	1	2	3	4	5
11	1	2	3	4	5	24	1	2	3	4	5
12	1	2	3	4	5						
13	1	2	3	4	5						

Scale Allocation and Scoring for Each Item of the RSARS

<i>Learning Statistics Anxiety (LSA)</i>	<i>Statistics Evaluation Anxiety (SEA)</i>
<i>1</i>	<i>3</i>
<i>2</i>	<i>4</i>
<i>6</i>	<i>5</i>
<i>7</i>	<i>14</i>
<i>8</i>	<i>18</i>
<i>9</i>	<i>19</i>
<i>10</i>	<i>20</i>
<i>11</i>	<i>21</i>
<i>12</i>	
<i>13</i>	
<i>15</i>	
<i>16</i>	
<i>17</i>	
<i>22</i>	
<i>23</i>	
<i>24</i>	

For all items, responses of Not at All, A Little, Moderately, Pretty Much, Very Much are scored 1, 2, 3, 4, and 5, respectively, because there are no negatively-worded and reverse-worded items. Omitted or invalid responses are scored 3.

Appendix C

Test Of Statistics Related Attitudes

(TOS_tRA)

This questionnaire is based on the Test of Science Related Attitudes developed by Fraser (1981) and is discussed in this thesis in Sections 2.3.2 and 3.2.3. It was modified, used in this study and included in this thesis with the permission of its author.

Test of Statistics Related Attitudes

This survey is used to measure your attitude towards statistics and statistics related activities. By using the following scale, answer how you feel today regarding these items on the answer sheet provided:

- SA: I **strongly agree** with the statement.
 A: I **agree** with the statement.
 N: I am **not sure** about the statement.
 D: I **disagree** with the statement.
 SD: I **strongly disagree** with the statement.

1. Statisticians usually like to solve equations when they have a day off.
2. I would prefer to find out why something is true by doing a problem than by being told.
3. I enjoy reading about things which disagree with my previous ideas.
4. Statistics lessons are fun.
5. Statisticians are about as fit and healthy as other people.
6. Doing problems is not as good as finding out information directly from teachers.
7. I dislike doing similar problems to make sure I am understanding the concept.
8. I dislike statistics lessons.
9. Statisticians do not have enough free time to spend with their families.
10. I would prefer to do problems than read about them.
11. I am curious about the world in which we live.
12. School should have more statistics lessons each week.
13. Statisticians like sports as much as other people do.
14. I would rather agree with people than investigate a problem to find out for myself.
15. Finding out about new things is unimportant.
16. Statistics lessons bore me.
17. Statisticians are less friendly than other people.
18. I would prefer to do my own problems than have a teacher explain them.
19. I like to listen to people whose opinions are different from mine.
20. Statistics is one of the most interesting school subjects.
21. Statisticians can have a normal family life.
22. I would rather find out about things by asking an expert than working on my own.
23. I find it boring to hear about new ideas.
24. Statistics lessons are a waste of time.
25. Statisticians do not care about their working conditions.
26. I would rather solve a problem by experimenting than be told the answer.
27. In statistics problems, I like to use new methods which I have not used before.
28. I really enjoy going to statistics lessons.
29. Statisticians are just as interested in art and music as other people.
30. It is better to ask the teacher the answer than to find out by trying a problem.
31. I am unwilling to change my ideas when evidence shows that the ideas are poor.
32. The material covered in statistics lessons is uninteresting.
33. Few statisticians are happily married.
34. I would prefer to do a problem on a topic than to read about it in a textbook.
35. In statistics problems, I identify unexpected results as well as expected ones.
36. I look forward to statistics lessons.
37. If you met a statistician, he would probably look like anyone else you might meet.
38. It is better to be told statistical facts than to find them out from problem solving.
39. I dislike listening to other people's opinions.
40. I would enjoy school more if there were no statistics lessons.

Test of Statistics Related Attitudes
Answer Sheet

Page 1						Page 2						Page 3					
Strongly Agree	Agree	Not Sure	Disagree	Strongly Disagree		Strongly Agree	Agree	Not Sure	Disagree	Strongly Disagree		Strongly Agree	Agree	Not Sure	Disagree	Strongly Disagree	
1	SA	A	N	D	SD	14	SA	A	N	D	SD	29	SA	A	N	D	SD
2	SA	A	N	D	SD	15	SA	A	N	D	SD	30	SA	A	N	D	SD
3	SA	A	N	D	SD	16	SA	A	N	D	SD	31	SA	A	N	D	SD
4	SA	A	N	D	SD	17	SA	A	N	D	SD	32	SA	A	N	D	SD
5	SA	A	N	D	SD	18	SA	A	N	D	SD	33	SA	A	N	D	SD
6	SA	A	N	D	SD	19	SA	A	N	D	SD	34	SA	A	N	D	SD
7	SA	A	N	D	SD	20	SA	A	N	D	SD	35	SA	A	N	D	SD
8	SA	A	N	D	SD	21	SA	A	N	D	SD	36	SA	A	N	D	SD
9	SA	A	N	D	SD	22	SA	A	N	D	SD	37	SA	A	N	D	SD
10	SA	A	N	D	SD	23	SA	A	N	D	SD	38	SA	A	N	D	SD
11	SA	A	N	D	SD	24	SA	A	N	D	SD	39	SA	A	N	D	SD
12	SA	A	N	D	SD	25	SA	A	N	D	SD	40	SA	A	N	D	SD
13	SA	A	N	D	SD	26	SA	A	N	D	SD						
						27	SA	A	N	D	SD						
						28	SA	A	N	D	SD						

Scale Allocation and Scoring for Each Item of the TOSTrA

<i>(N) Normality of Statisticians</i>	<i>(I) Attitude towards Statistics</i>	<i>(A) Adoption of Statistics Attitudes</i>	<i>(E) Enjoyment of Statistics Lessons</i>
1 (-)	2 (+)	3 (+)	4 (+)
5 (+)	6 (-)	7 (-)	8 (-)
9 (-)	10 (+)	11 (+)	12 (+)
13 (+)	14 (-)	15 (-)	16 (-)
17 (-)	18 (+)	19 (+)	20 (+)
21 (+)	22 (-)	23 (-)	24 (-)
25 (-)	26 (+)	27 (+)	28 (+)
29 (+)	30 (-)	31 (-)	32 (-)
33 (-)	34 (+)	35 (+)	36 (+)
37 (+)	38 (-)	39 (-)	40 (-)

For positive items (+), responses SA, A, N, D, SD are scored 5, 4, 3, 2, 1, respectively. For negative items (-), responses SA, A, N, D, SD, are scored 1, 2, 3, 4, 5, respectively. Omitted or invalid responses are scored 3.

Appendix D

Student Consent Form

Business Research Analysis Survey

Dear student,

As part of my goal to improve the student learning experience, I invite you to participate in my research project designed to measure the relationship between a person's statistics anxiety, his/her attitude towards statistics, and his/her classroom environment that involves factors of student cohesiveness, teacher support, involvement, investigation, task orientation, cooperation, and equity.

If you agree to participate in this study you will be asked to complete three surveys: one that measures current classroom environment; another that measures attitude towards statistics; and a final survey that measures statistics anxiety.

There are no risks involved in this study, and it will not be a detriment to the class or the instruction that will take place.

I am asking you to volunteer to participate in this study and would ask you to note the following points.

1. Your participation WILL NOT have any effect on your overall grade for this class and DOES NOT have any influence on any other classes in your degree program. This protocol contains no foreseeable risks.
2. Your participation in these surveys is entirely voluntary. You may choose not to take part at all or you may withdraw at any stage after you begin or may choose not to answer any question that makes you feel uncomfortable.
3. The data collected will only be used to analyze the effectiveness of teaching methods and classroom environment.
4. Confidentiality will be provided to the extent allowed by law.

I consent to taking part in this study as described above

Name _____

Date _____

Signature _____

Many Thanks

Panayiotis Skordi

Please start with the Demographic Questions.

Gender M/F

Age _____

Ethnicity _____

Is this your first time taking this class? Y/N

How many classes are you taking this semester/quarter? _____

If you work other than studying, please state how the average hours per week _____

What is your current estimated GPA for all classes since starting at this university? _____