Science and Mathematics Education Centre

Changes in Learning Environment and Students' Attitudes and Anxiety Associated with the Transition from Primary to Secondary School Mathematics

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DECLARATION

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

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

Human Ethics (For projects involving human participants/tissue, etc) The research presented and reported in this thesis was conducted in accordance with the National Health and Medical Research Council National Statement on Ethical Conduct in Human Research (2007) – updated March 2014. The proposed research study received human research ethics approval from the Curtin University Human Research Ethics Committee (EC00262), Approval Number #SMEC-22-12.

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ABSTRACT

Past research has demonstrated that, relative to primary schools, high-school environments are often perceived as being less favourable and having less positive teacher–student relations and reduced opportunities for decision-making in classrooms. Research evidence also suggests that students' attitudes concerning mathematics generally deteriorate during the move from primary to secondary school spheres. This study involved the transition experience of 541 students in 47 classes in 15 schools from both primary (year 7) and secondary (year 8) levels in government and Catholic schools in metropolitan and regional areas of South Australia.

Scales were adapted from three established instruments, namely, the What Is Happening In this Class? (WIHIC), Test of Mathematics Related Attitudes (TOMRA) and Revised Mathematics Anxiety Ratings Scale (RMARS), to identify changes across the transition from primary to secondary school in terms of the classroom learning environment and students' attitude/anxiety towards mathematics. I assessed the learning environment with four 8-item scales (Student Cohesiveness, Teacher Support, Involvement and Cooperation) and attitudes with the two 10-item scales of Attitude to Mathematical Inquiry and Enjoyment of Mathematics Lessons and an 8-item mathematics anxiety scale.

Relative to year 7 students, year 8 students perceived less Involvement, less positive Attitude to Mathematical Inquiry, less Enjoyment of Mathematics and greater Mathematics Anxiety. Differences between students in Years 7 and 8 were very similar for male and female students, although the magnitude of sex differences in attitudes was slightly different in Years 7 and 8. Additionally, with South Australian students, my study cross-validated questionnaire scales assessing learning environments, attitudes and anxiety and replicated associations reported in considerable prior research between students' attitudes/anxiety and the nature of the classroom environment.

This research contributed to the field of learning environments in that it was one of the few studies worldwide of the transition between educational levels that employed a learning environments framework. Also the study provided practical implications for educators about how to ease the transition for mathematics students from primary to secondary school.

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Chapter 1

BACKGROUND TO THE STUDY

1.1   Introduction

The notion of transition between primary and secondary schooling, particularly from year 7 to year 8 in South Australia, forms a pivotal point that is fundamental to this study. My interest in this subject of 'transition' began to incubate at the commencement of my teaching career during the late 1970's in South Australia. Having undertaken a secondary teaching training course under the state government bonded scholarship program, employment was guaranteed on successful completion of studies. For a small group of graduates including myself, employment in the secondary school sector was unavailable at the time of graduation, and so we were all deployed to various primary school vacancies across the state. My placement was in a metropolitan primary school where I was in charge of a year 7 class. I remained in this particular school for five years, always teaching at the year 7 level, where I endeavoured to ease and facilitate the transition from primary to high school for students. An area of special focus was mathematics for which I attempted to lay solid foundations for subsequent high school mathematics teachers to build upon. I was familiar with the secondary mathematics curriculum at the time and I was prepared to extend and challenge the students by introducing and exposing them to year 8 mathematics concepts. I also undertook to introduce and extend them in areas such as film-making and script-writing which were not part of the school curriculum, as well as in advanced art work. In a sense, I was incorporating Vygotsky's (1978) zone of proximal development (ZPD) and utilising 'scaffolding' in that, under experienced guidance, students were able to successfully traverse to a higher level.

Another initiative, which I believe was the first of its kind (at least in metropolitan Adelaide), was a reciprocal teaching arrangement between myself and a teacher in a nearby secondary school. This involved a senior master in mathematics (nowadays referred to as coordinators) coming to my class to take a mathematics lesson on a weekly basis for a term. I would also journey across to the high school to take his class of year 8 mathematics students for a lesson on a weekly basis. This

arrangement was well received by students, parents and administrators. Another area of special interest was in computing for which I introduced microcomputers and BASIC programming to my primary-school students; this was met with much interest and enthusiasm by many students and parents. Towards the end of the school year, an orientation visit to the high school would take place so that students could familiarise themselves with the new school and teachers.

After this five-year period in a primary school setting, I was transferred to a high school to teach mathematics. In this type of environment, when teaching and interacting with year 8 students, I was able to acquire first-hand knowledge of their academic ability, as well as their concerns and fears. During these initial years in the secondary school sphere, my interest in this 'transition' phase continued to grow and blossom to the point where, now in the present moment and because of this study, it is finally coming to some type of fruition.

There are four major systemic transitions that cover the Australian educational spectrum—home to kindergarten (pre-school); pre-school to junior primary; primary to secondary school; and, finally, secondary school to university or work. In South Australia, primary school finishes at year 7 and secondary school begins in year 8 whereas, in all other Australian states, year 6 marks the completion of primary schooling and year 7 heralds the commencement of secondary school. It has been reported by Williams (2015a) in the *Advertiser* newspaper (13/11/15, p. 11) and Williams (2015b) in the *Sunday Mail*, SA Speaks supplement (29/11/15, p. 7) that South Australian Catholic schools intend to move year 7 into the secondary school sector in 2019 and 2020. At the present moment, the South Australian government is not in favour of moving year 7 into the secondary sphere, whereas the state opposition has indicated that it will do so if it is elected to government at the next state election. It appears likely that this push to move year 7 into the secondary domain will occur in South Australia in the near future, in order to bring this state into alignment with the rest of the nation, as well as to integrate it into the structure of the Australian Curriculum.

My study focused on this critically-important transition period and explored some reasons why it can be a difficult crossing, especially in the subject area of

mathematics. The contents of this 'excess baggage' or associated mathematics anxiety that accompany student travellers making this passage from one learning environment to another were examined, in an attempt to understand it and to discourage students from importing this entity across borders with them. The study involved a total of 541 students from year 7 (primary) and year 8 (secondary) schools from metropolitan and regional South Australia. Its mission was to trace changes across transition in classroom learning environments and students' attitude/anxiety towards mathematics. This study utilised a shortened form of the What Is Happening In this Class? (WIHIC) instrument to assess the learning environment, an attitude questionnaire derived from a modified Test of Mathematics Related Attitudes (TOMRA), and an anxiety measure which I refer to as the Mathematics Anxiety Measure (MAM) instrument, which was derived from the Mathematics Anxiety Inventory (MAI) and the Abbreviated Math Anxiety Scale (AMAS).

Section 1.2 that now follows, presents an overview and background to the study, while Section 1.3 outlines the four research questions contained within my study. This is followed by Section 1.4, which deals with the significance of the study, and Section 1.5 which concerns itself with paradigm issues, including ontology, epistemology and methodology, in order to intensely probe the notion of 'reality' and how it impinges on my thesis. Section 1.6 concludes by outlining the contents of the remaining chapters of this undertaking.

1.2   Context of the Study

Past research has revealed that student–teacher relationships in mathematics classes deteriorated after the transition from the primary to secondary sector (Feldlaufer, Midgley & Eccles, 1988; Ferguson & Fraser, 1999; Midgley, Feldlaufer & Eccles, 1989). Sdrolias and Triandafillidis (2008, p. 160) highlighted these student–teacher relations as being an "important determinant of students' disposition toward mathematics". Furthermore, Noyes (2006, p. 44) pointed out that, concerning previous studies, there have been "too few that examine the impact of the transfer process upon learners of mathematics". Perso (2005, p. 28) views the transition as being one of "environmental changes from a closeted 'childish/feminine' environment to an independent 'adult/masculine' environment". Hayes and

Chodkiewicz (2006) report an increase in girls' depression and hostility across this transition. Maher (2010) claims that the workload expected by secondary school teachers is unknown and that this is a cause of student anxiety. Ashton (2008) poses the question of why academic progress falters during this transition.

The context of my study was the transition from primary to secondary public and Catholic schools in South Australia, with specific reference to mathematics classes. Past research has shown that, relative to primary schools, high school environments are often perceived less favourably, with less-positive student relations and reduced opportunity for decision-making in classrooms. In my experience with year 8 secondary mathematics classes, some students come from the primary sector with negative attitudes concerning mathematics, whilst some display symptoms of 'maths anxiety'. Yates (1999, p. 37) reported that "no student in our interviews expressed much enthusiasm about it (Mathematics), or nominated it as their favourite subject".

Also based upon my own personal and fellow colleagues' experiences with teaching year 8 mathematics, I found that students come with widely differing levels of mathematics prior knowledge. This could have resulted from the fact that some year 7 classes from particular feeder schools have more lesson time devoted to mathematics instruction than others. Another possibility could be that some particular teachers at the year 7 levels did not cover the complete mathematics curriculum because they did not feel confident enough about it.

Zeedyk et al. (2003, p. 68) make the following statement in relation to this primary to secondary transition: "This period is regarded as one of the most difficult in pupils' educational careers, and success in navigating it can affect not only children's academic performance, but their general sense of well-being and mental health." Purely for this reason alone, one could find justification and significance for undertaking my study of the changes in learning environment and students' attitudes and anxiety associated with the transition from primary to secondary school mathematics.

This particular transition phase from primary to secondary schooling has been of interest to researchers for a considerable period of time that stretched back several

decades, but it appears to have picked up a greater impetus from the 1990's to the present time. Several studies point to the fact that this transition period is associated with a decline in the academic achievement of students in mathematics (Anderman & Midgley, 1997; Rice, 1997, 2001). Bru et al. (2010) cite several studies undertaken in Norway that show elementary school children as having more positive perceptions of their learning environments than their secondary school counterparts. Other studies reporting similar findings concerning the negative changes in learning environments across transition are Eccles et al. (1993), Anderman and Midgley (1997) and Feldlaufer et al. (1988).

In relation to mathematics, Midgley et al. (1989) reported that classroom environment changes during this transition were attributable to students' expectancies and values in mathematics. Several other researchers (Ashton, 2008; Galton & Morrison, 2000; Zeedyk et al., 2003) highlight the aspects of anxiety experienced by students during this transition and mention the fears of bullying, getting lost, making friends, ability to cope with work, new routines, etc.

1.3   Research Questions

- ➢ Are the What Is Happening In this Class? (WIHIC) and an attitude/anxiety questionnaires reliable and valid instruments?

- ➢ How do year 7 students (pre-transition) compare with year 8 students (post-transition) with regards to learning environment perceptions and attitudes/anxiety?

- ➢ Are any differences that exist between year 7 students and year 8 students similar or different for male and female students?

- ➢ Are there associations between students' perceptions of four aspects of classroom environment (Student Cohesiveness, Teacher Support, Involvement, Cooperation) and three attitude/anxiety scales (Attitude to Mathematical Inquiry, Enjoyment of Mathematics, Mathematics Anxiety)?

1.4   Significance

According to Rice (2001, p. 373):

> …systemic transitions are predictable events that are imposed on school communities by education policy makers. Consequently, educators have some obligation to understand their effects, attend to their consequences, and perhaps even redefine them altogether.

Schumaker (1998, p. 1) states:

> Students making the transition into middle level schools need to receive assistance prior to, during, and after the move so that their social, psychological and academic well-being is not compromised.

In view of the above statements, the importance and significance of my study become apparent. Policy-makers need to thoroughly examine the overall effects that their intended schemes have upon not only the students for whom the scheme or programme implementation is intended, but also for the teachers who have to implement such programmes. Teachers will hopefully gain a better and more comprehensive understanding of the consequences of particular policy implementations, particularly in this domain of primary–to–secondary transition, and acquire a greater appreciation of the many and diverse problems associated with such a transition, which occurs for students at a critical time in their development. This study is likely to strengthen and contribute to the field of learning environments because it could replicate past research in South Australia and elsewhere. There have been relatively few transition studies worldwide and this is possibly the first use of the WIHIC in a transition study. It adds another to the repository of prior studies of transition, but specifically focused on the primary–to–secondary transition and the school subject of mathematics, and it included students' anxiety associated with transition.

Another outcome is that the study could guide the development of transition programmes, as well as highlighting implications for teaching practices. Teachers of mathematics at both the primary and secondary levels will hopefully recognise and

accept the existence and prevalence of mathematics anxiety and take necessary measures to help to remedy and alleviate it in their classroom learning environments. Ideally, suggested strategies that are outlined in the final chapter would be adopted so that more-positive attitudes towards mathematics will hopefully be fostered amongst students and teachers alike, leading to better educational outcomes.

1.5   The Practice of Research

The following section is a consideration of research paradigms and inherent components (ontology, epistemology and methodology). This in turn gives rise to an examination of differing concepts of reality, which are explored both from a general perspective and the researcher's own personal viewpoint.

1.5.1   Paradigm

Because I have assumed the role of researcher in this study, it is important to therefore examine both the notion of paradigm and the researcher's perception of the world, in order for the reader to gain a better understanding of the research method. Aldridge, Fraser and Huang (1999, p. 49) state: "It has been widely accepted that the paradigm used will shape the way in which the researcher perceives the world."

Not only is this perception important from the researcher's perspective, but it is fundamentally critical from the individual learner's and individual teacher's point of view in the classroom environment because each has a different reality. In the mathematics classroom environment, each individual student's learning experience differs in the sense that each experiences a different reality based upon his/her prior knowledge, skill level, attitude towards the subject, and teacher–student relationship. The ultimate success or failure of the student within such a learning environment no doubt hinges in part on the proper mix and balance of these diverse entities. The quantity and quality of each entity largely determines the learning outcomes. For example, a student with weak prior knowledge, low skill level and a negative attitude towards the subject and towards the teacher inevitably will achieve poor learning outcomes. On the other hand, a student with strong prior knowledge, high skill level and a positive attitude towards the subject and towards the teacher is likely to

experience favourable learning outcomes. This recipe is far more complex than these two given examples convey, because the differing proportions and amounts of each entity produce a widely-differing blend of student outcomes. As an example, students with weak prior knowledge and low skill levels still might achieve satisfactory learning outcomes if they have a healthy attitude towards both the subject and the teacher.

A research paradigm is essentially a belief system or theoretical model made up of the three terms that are listed with it (i.e. ontology, epistemology and methodology). They are inherent within a particular research paradigm and form the foundations and shape all work and beliefs within that paradigm. The three major educational research paradigms can be referred to as Postpositivism, Critical theory and Interpretive paradigm. The Postpositivist paradigm is essentially about the discovery of truths and explanation and employs well-defined survey methods (e.g. questionnaires). The Critical theory paradigm has its roots in Marxism and its focus is on Emancipation with a desire to transform society. The Interpretive paradigm is concerned with understanding individuals and how they view reality and the world at large.

Qualitative and Quantitative paradigm methods form an overlying super-structure or shared canopy under which other research paradigms are sited (e.g. Postpositivism, Critical Theory, Interpretivism, etc.) and from which each particular paradigm takes some form of 'shelter'. By this, I mean that a particular paradigm could fall purely under the shade of either the Qualitative or Quantitative fabric or a combination of both.

Ideally, research studies should incorporate both quantitative and qualitative methods as recommended by Tobin and Fraser (1998) so as to provide a more comprehensive picture. However, in my situation, this did not occur. Initially, I wanted the study to be a longitudinal one, which would follow the students as they transitioned to secondary school, but I immediately realised that this would not be practically possible. Enormous difficulties would arise in relation to tracking students because different students would be going to different high schools, some students might not wish to participate when in the secondary sector, some students could move

interstate or overseas, etc. Another insurmountable obstacle in such a longitudinal study would be obtaining the necessary approvals from the various principals from this now significantly enlarged and scattered secondary sector. Clearly then, such an approach was not to be entertained and was quickly dismissed.

Cohen et al. (2000, p. 3) cite Hitchcock and Hughes (1995, p. 21) who relate that "ontological assumptions give rise to epistemological assumptions; these, in turn, give rise to methodological considerations; and these, in turn, give rise to issues of instrumentation and data collection". Such a perception accepts that research primarily concerns itself with an attempt to comprehend the world, and that "this is informed by how we view our world(s), what we take understanding to be, and what we see as the purpose of understanding" (Cohen et al., 2000, p. 3). For these reasons, ontology, epistemology and methodology are discussed below.

1.5.2   Ontology

The Oxford dictionary defines ontology as the "nature of being". Essentially it encompasses what one believes or what one holds to be real. It depends largely on your view of 'reality'. Your reality can be completely at odds with my perspective on reality.

A drug user's concept of reality would markedly differ from that of a non-user. He/she sees altered images of reality, which are completely different from a layperson's. The users of psychotic drugs especially experience delusions and largely divorce themselves from our 'real' external material world. Likewise, dementia sufferers, who experience delusions, often experience a different reality from others within the same environment, by imagining a parallel reality. For example, the dementia sufferer might engage in an actual conversation with a person whom he/she believes to be present but, in actual fact, there is no-one there. This is in a sense 'a reality within a reality' which appears unquestionably real to the affected person. To any individual who believes that reality is mirrored by a physical world and material objects, there are absolutely no fairies at the bottom of the garden. They simply cannot exist in such a belief system.

Another example concerns the process of transubstantiation whereby, in Catholicism, the wafer administered at Communion changes into the body and blood of Christ by consecration. For strict Catholics, this is real/reality. The reality for an outsider, however, is that this is pure nonsense and not true, but each viewpoint is equally valid and equally real for each participant in such a scenario.

Let's now raise the question of whether reality exists independently. Is it out there regardless of your viewpoint? Is reality created within the mind of the person? Constructivists hold the view that individuals construct their own knowledge through experience and thus there are many social realities all created by individuals. Radical constructivism even maintains that "there is no reality or truth in the world; individuals can only know what they perceive and believe. Each of us constructs meaning from our own experiences, but we have no way of understanding or 'knowing' the reality of others and how correct it is" (Woolfolk & Margetts, 2016, p. 322).

1.5.3   Epistemology

Epistemology is primarily concerned with the structures and theories of knowledge and their credibility. How is knowledge gained, received or created? How reliable is this Knowledge? From an Empiricist viewpoint, we acquire knowledge from the 'real world' based upon our experiences, observations and interactions within this domain. At birth, we are blank slates upon which these life experiences are written. From the Newtonian perspective, by performing experiments, one can acquire knowledge about the physical world.

1.5.4   Methodology

This refers to the overall design, collecting of data and its subsequent analysis and to finally explain and understand the research information that has been collected. It is an explanation of all the framework of a research study, whether qualitative or quantitative methods, or a combination of both, have been utilised in the particular research. It also includes a thorough explanation of all the strategies, methods and

techniques undertaken within the research study. Examples which could be cited here are Action research, Case studies, and Quasi-experimental research.

According to both Creswell (2008) and Wellington (2000), Lewin was responsible for coining the term 'action research' in the 1930s. Wellington (2000, p. 194) states that "Lewin suggested the action research 'spiral' of: plan, act, observe, reflect." Action research seeks to improve work practices and knowledge of the work environments of practitioners in the field. A Case study is essentially an in-depth examination of single cases (e.g. a person, an event, a group, a classroom, etc.) based on extensive data collection. Quasi-experiments are in a sense like true experiments but with essentially the lack of random assignment.

The Interpretive paradigm is concerned with understanding the individual and how one views reality and the world at large. It should also be noted that there are three movements that are related to the interpretive paradigm:

     i) verstehen

     ii) hermeneutics

     iii) phenomenology.

With regard to Dilthey's method of Verstehen, one must assume the perspective of an insider, thereby ensuring that the essence of understanding permeates through. This process of Verstehen essentially calls for one to recreate or live the other's experiences. (Smith, 1983). As Howe (1992, p. 242) states, it is a process of "…'going native' to be in tune with the insider's perspective". Merriam (1998) also refers to it as an 'insider's perspective' or 'emic'. Johnson and Christensen (2008, p. 37) refer to it as 'empathetic understanding' or "putting yourself into someone else's shoes". This point is echoed in the novel 'To Kill a Mockingbird' by Harper Lee, when the main character Atticus Finch says to the young Scout that "you never really understand a person until you consider things from his point of view-–until you climb into his skin and walk around in it" (1968, p. 35). Eisner (1981, p. 6) alludes to the same concept but refers to it as to "indwell" or "…to imaginatively participate in the experience of another". Howitt and Venville (2009, p. 227) also refer to this very same concept but label it 'dual vision' or essentially "observing phenomena through the lens of both participant and researcher".

Such a perspective ultimately leads to a social construction of reality and multiple realities. Walker and Evers (1999, p. 44) state that "reality is constructed with the mind". Smith (1983, p. 9) makes an interesting point by talking about reality as being made or constructed (i.e., that "reality can have no existence prior to the activity of investigation and would cease to exist if we should lose our interest").

Mulholland and Wallace (2003, p. 880) state that "in conducting this study, we call on our own experiences, knowledge and theoretical dispositions, to collect data and present our understandings". Doesn't this reflect the fact that researchers themselves bring to the study a particular worldview of their own? Not only do they have their own view of the nature of reality but in addition they hold personal values and perspectives which ultimately help flavour their own personal theory of knowledge and truth (epistemology).

While on the one hand the participants of the study have their own understandings, meanings and knowledge base, the researchers on the other hand also bring a differing knowledge depository to the table. As a consequence "differing realities based on such characteristics as gender, age, or role (e.g., employer, manager, worker)" Sale, Lohfeld and Brazil (2002, p. 48) contribute to the final mix. This knowledge base has naturally been modified over time because of differing life experiences, personally held values, education, work, family, etc. From an empiricist viewpoint, we acquire knowledge from the 'real world' based upon our experiences, observations and interactions within this domain. We are blank slates upon which these life experiences are written.

In relation to Ontology, Constructivists hold the view that the individual constructs their own knowledge through experience and thus there are many social realities all created by individuals. Reality is multi-layered and complex, as well as being individually and socially constructed. Therefore there are multiple constructed realities in existence. All researchers have lives with differing backgrounds, experiences, etc., thereby demonstrating different realities. Because of their differing life experiences, they each have their own understandings and meanings. Smith (1983. p.10) states "our values and interests will shape how we study and discuss

reality." According to Smith and Heshusius (1986, p. 5), Dilthey's "social reality was mind-dependent in the sense of mind-constructed" and "truth was ultimately a matter of socially and historically conditioned agreement".

The post-positivist paradigm assumes a theory falsification approach (Guba & Lincoln, 1994) because, no matter how much research is done, you can never really be sure that your theory is the correct one. What happens is that it is added to an accumulated body of evidence that helps to support a particular theory.

This particular paradigm is built upon the scientific method, which utilises collecting and analysing data to help understand phenomena. It emphasises measurement of behaviour and prediction and makes use of mathematical models incorporating statistical theory (Anderson, 1998). Reality is seen as being of a singular nature and independent of the observer. As Ponterotto (2005, p. 130) says, "a reality … is apprehendable, identifiable and measurable". Positivist research seeks "objectivity, measurability, predictability, controllability, patterning, the construction of laws and rules of behaviour, and the ascription of causality" (Cohen, Manion & Morrison, 2000, p. 28). Researchers attempt to divorce themselves from the observed so that objective data that are free of bias will be obtained (Phillips, 1988).

The choice of paradigm used has no doubt been influenced by the researcher's personal life experiences, cultural, educational and philosophical beliefs, etc., because it is these very elements that help to shape one's view of the world and reality. My own schooling, right through to the end of high school, was essentially based on the transmission or 'empty vessels' model, whereby a teacher disseminates knowledge to students who are considered to be 'blank slates'. This clay tablets or 'Moses model', where rote learning prevailed, dominated education during this time. For me, at this point in my life, the physical world was real and existed independent of the observer.

During the transitions from the secondary to tertiary education and later to the postgraduate worlds, the exposure to alternate theories of knowledge and education enabled me to see through different lenses and gain greater understanding. I suppose that one could liken this to putting on a pair of stereoscopic glasses or viewing

'Magic Eye' illusions. These Magic Eye pictures are essentially three-dimensional illusion images, which are hidden or contained within two-dimensional patterns waiting to be revealed. At the same time, however, the 'God's eye view' perspective upon which I had built "secure foundations of knowledge and understanding" (Scott & Usher, 1996, p. 25) was severely shaken and challenged by Postmodernism. I sense that I experienced what Bernstein called the 'Cartesian Anxiety' of either/or (cited in Smith & Heshusius, 1986). This is explained as follows:

> Either we have such a foundation for knowledge, or we are adrift in a world where nothing binds us, where there are no criteria of right and wrong, correct and incorrect, and where all is reduced to a clash of taste and opinion. (Smith & Heshusius, 1986, p. 10).

To this day, I still find it difficult to dismiss the long-established belief that reality is mirrored by a physical world and material objects. I reluctantly tend to adhere to an Empiricist viewpoint that one acquires knowledge from the 'real world' based upon experiences, observations and interactions within this domain and that, by conducting experiments, we are able to acquire knowledge about the physical world. Although my study has utilised the post-positivist paradigm, I nevertheless completely accept the notion of differing realities.

From the foregoing, it becomes obvious that researchers must not purely undertake research from an entirely personal or singular reality but from an approach that accommodates multiple realities. In relation to classroom environments and specifically mathematics classrooms, what might be taking place might appear 'obvious' to an observer but, in actual fact, as constructivists believe, there are multiple social realities, each of which is being created by individuals within the class. For these reasons, researchers need to ideally adopt multiple research paradigms in order to obtain a more comprehensive and panoramic viewpoint of what is actually happening in classroom environments and especially in mathematics classes.

1.6   Outline of Thesis Chapters

Chapter 1 provided a germinating point for the reasons behind my interest in this topic of transition and anxiety and essentially provides the growing medium for what is to follow. The context of the study was outlined and its significance discussed. This then was followed by an examination of research paradigms, ontology, epistemology and methodology, all of which are vital and necessary supplements and nutrients for a proper understanding of this entire thesis.

Chapter 2 provides a comprehensive literature review by firstly exploring the history of learning environments and then drawing attention to seven specific instruments and a focus on various studies conducted with each instrument. Six types of learning environments studies are then reviewed. Attention is then focussed upon the What Is Happening In this Class? (WIHIC) instrument (a major part of my study) and past studies that have incorporated it. Transition studies are then highlighted, together with mathematics anxiety, instruments to measure it, and past research into mathematics anxiety.

Chapter 3 concerns the methodology employed in the study, including the objectives, the sample and the three instruments used in the study, namely, the WIHIC, Test of Mathematics Related Attitudes (TOMRA) and Mathematics Anxiety Measure (MAM) described. Sections on data analyses and ethical issues follow.

Chapter 4 devotes itself to the results emerging from analyses of the data generated by the study and to the reliability and validity of the instruments used within the study. Research questions are elucidated and results examined. Consideration is given to grade-level differences in learning environment and attitude/anxiety scales, sex differences in learning environment and attitude/anxiety scales, and interactions between grade level and sex. Finally, results for associations between learning environment and student outcomes are reported.

Chapter 5 represents the omega component of this research study and thus provides a summary or overview of the complete scope or landscape of the entire thesis. The

limitations and significance of the study are also considered together with suggestions for future research.

LITERATURE REVIEW

2.1 Introduction

Because this study focused on both learning environments and anxiety during the transition from primary to secondary mathematics, it is necessary to review literature about both of these major constructs in some detail. The first sections are devoted to the field of learning environments (Sections 2.2 to 2.5), whilst other sections explore both issues of transition (Section 2.6) and anxiety (Section 2.7).

In this first section, I attempt to outline the history of the rich field of learning environments (Section 2.2). Many pioneers have contributed their work, thereby helping to till and fertilise this productive soil of learning environments research from its inception. All of these researchers have nurtured and played a role in reaping the rich and varied harvest. Secondly several questionnaires are examined, along with an overview of the types of research undertaken in the learning environments sector (Section 2.3). Thirdly the conceptualisation and development of the learning environment questionnaire used in my study (What Is Happening In this Class?, WIHIC) are described (Section 2.5). Finally a review of past studies that have used the WIHIC questionnaire is provided (Section 2.5).

2.2 History of the Field of Learning Environments

Research into classroom learning environments blossomed in the West over 40 years ago, particularly in the USA during the 1960s, but its genesis lay in the 1930s in the work and ideas formulated by pioneers like Lewin and Murray. During the 1930s, Lewin drew upon his field theory to postulate that $B= f(P, E)$, a formula which states that behaviour (B) is a function of person (P) and environment (E). He was also responsible for coining the terms *alpha* press (the environment as observed by an external observer) and *beta* press (the environment as perceived by milieu inhabitants).

Also during the 1930s, Murray contributed by taking this behaviour–person–environment relationship further. MacLeod and Fraser (2010, p. 106) state that "Murray's main contributions involved feelings, likes and dislikes, and memory, along with the idea of environmental press…". Fraser, Aldridge and Adolphe (2010, p. 552) state that: "…Murray (1938) proposed a needs–press model in which situational variables in the environment account for a degree of behavioural variance". This needs–press model essentially highlights the critical importance of the individual and the individual's interaction with the environment. Wolf and Fraser (2008, p. 322) view Murray's contribution towards scholarly knowledge from a similar viewpoint when they say "... an individual's behaviour is affected internally by characteristics of personality and externally by the environment itself ".

During the 1950s, Stern (1956) came to the realisation that there exist differences "...between an individual's perceptions, a group's perceptions, and the perceptions of an external observer of a single environment" (Wolf & Fraser, 2008, p. 322). Stern, Stein and Bloom (1956) took these entities further by expanding the ideas into *private* beta press (the individual's view of their environment) and consensual beta press (the shared view of a group as a whole).

The learning environment conjures up the inanimate physical attributes of what constitutes an actual classroom (i.e. the physical space taken up by desks, chairs, blackboard, whiteboard, floor coverings, walls, ceilings, windows and fixtures). Text books, exercise books, pens, pencils, paper, computers, etc. also contribute to the mix. This is further enhanced by lighting, heating and cooling systems of various types. Posters, student artwork, projects, models and written work can also adorn walls. All of these contribute to what is often referred to as a physical learning environment. Each of these elements in some minor part influences how pleasing the learning environment is to both the students and teachers who frequent this space and ultimately what learning takes place.

Another critical component of a physical learning environment is the human entity, made up of individuals, without whom there would not be any real, 'alive' or interactive learning environment. This is often referred to as the psychosocial environment. Without this human element, the classroom environment would be

static. This human entity is made up of the teacher (or teachers) and students. These individuals all bring prior-held beliefs, attitudes and value systems to the situation and therefore constitute perhaps the most dynamic element or component, because they interact with each other and ultimately forge better learning outcomes. It is precisely because these individuals each bring with them a certain world-view that we also need to examine the philosophical 'reality' of the learning environment. This was considered earlier in Chapter 1.

Several authors have referred to Walberg and Anderson's work with Harvard Physics Project during the 1960s as a 'seminal', 'pioneering', 'milestone' event, from which emerged the Learning Environment Inventory (LEI) which still influences instrument development today (Dorman 2008; Fraser, Aldridge & Adolphe, 2010; MacLeod & Fraser, 2010).

In the 1970s, Moos (1974) developed a classification of aspects of human environments into three dimensions, namely, relationship, personal development, and system maintenance and change. According to Dorman (2003, p. 234), this was an "...important and sustaining development" in the field of learning environments. This in turn led to Moos to develop the Classroom Environment Scale (CES) (Trickett & Moos, 1973).

The tide of learning environments research then spread and infiltrated the Netherlands where Wubbels and collaborators assumed the role of standard bearer. It was there that the Questionnaire on Teacher Interaction (QTI, Wubbels & Levy, 1991) was developed. During this period, this same tidal movement had profound effects upon the Australian scene where Barry Fraser, in collaboration with colleagues, has primarily been the vanguard of the learning environments movement. To a large degree, Fraser could be seen as a learning environments 'horticulturalist' who has been responsible for creating many hybrid varieties of evaluation instruments. Many instruments have subsequently been developed by Fraser (1998) and colleagues such as the Individualised Classroom Environment Questionnaire (ICEQ), Science Laboratory Environment Inventory (SLEI), Constructivist Learning Environment Survey (CLES), and What Is Happening In this Class? (WIHIC), which are considered further in later parts of this chapter.

From this hub or hive of activity within Australia, the seeds of learning environments research have been scattered by the four winds to different points of the compass to germinate in new fresh pastures. Subsequently, learning environments research has been grafted and propagated in countries such as Indonesia, Taiwan, India, Turkey, Singapore, Korea, Brunei, Japan, Thailand, Nigeria, South Africa, Israel, and the United Arab Emirates (see review of Fraser, 2012).

2.3   Range of Questionnaires

The following sections reviews seven instruments that have been used to assess and investigate learning environments.

2.3.1   Learning Environment Inventory (LEI)

The learning Environment Inventory (LEI) had its origins in the research area of the Harvard Project Physics (Walberg & Anderson, 1968). As discussed in Section 2.2, the LEI is historically significant as one of the first two classroom instruments ever developed. It is suited to the secondary school level and comprises 105 questions and contains 7 items per scale. The possible responses to questionnaire items range from Strongly Disagree, Disagree, Agree, and Strongly Agree. Scoring is reversed for some items.

2.3.2   Classroom Environment Scale (CES)

The CES was developed by Moos at Stanford University and evolved from research undertaken in varied settings such as prisons, psychiatric hospitals, university residences and work milieus (Trickett & Moos, 1973). Like the LEI and as discussed previously in Section 2.2, the CES is significant for it is also one of the first two classroom instruments ever developed. The final version of the CES comprises 9 scales with 10 items (each with a True/False response) per scale.

2.3.3 Questionnaire on Teacher Interaction (QTI)

The Questionnaire on Teacher Interaction (QTI), as previously mentioned, was developed by Wubbels (1993) in the Netherlands. The QTI is different from all other classroom environment instruments in that it focuses exclusively on teacher–student interactions and it is based on a theoretical model consisting of the two dimensions of proximity and influence. Within this theoretical model, teacher behaviour has been assigned a Proximity Dimension (Cooperation–Opposition) and an Influence Dimension (Dominance–Submission). This instrument is used to gauge students' and teachers' perceptions of interpersonal teacher behaviour. It has 8 scales and each item in the questionnaire has a response on a five-point scale from Never to Always. The scales are Leadership, Helping/Friendly, Understanding, Student Responsibility/Freedom, Uncertain, Dissatisfied, Admonishing, Strict Behaviour. There are two versions of the QTI, a 64-item and a shorter 48-item questionnaire.

Lee, Fraser and Fisher (2003), in seeking to determine teacher–student relationships, utilised a 48-item version of the QTI which had been translated into the Korean language. The sample comprised 439 senior high school students from three streams (science-oriented, science-independent, humanities). This particular study used a mixed-methods research approach incorporating survey, observation and interview methods. Factor analysis and Cronbach alpha reliability measures were used to validate the QTI instrument and its ability to differentiate between classes. The researchers found that the classroom environment portrayed a passive and authoritarian student–teacher relationship, which essentially mirrored the young–old relationship in the wider Korean society that is marked by a strong ancestral respect for elders.

In a Singaporean study, Goh and Fraser (1998) used both the QTI and MCI instruments to survey 1512 (grade 5) primary school students from 39 mathematics classes. A shorter 48-item adaptation of the QTI was developed to make it more suited for primary school use. As a result, the usual 5-point response scale was reduced to three (Seldom, Sometimes, Most of the Time). The QTI was used to gauge teacher–student interpersonal behaviour, whilst the MCI assessed classroom environment. Students in classes that exhibited less friction and greater cohesion in

their classroom environments had better achievement and attitudes. Male mathematics achievement surpassed that of females, but females perceived a more positive learning environment.

Zijlstra, Wubbels, Brekelmans and Koomen (2013) organised a study in the Netherlands involving 828 first- and second-graders from 40 classes in 24 primary schools. They used an adapted QTI which they called the QTI-EP (Questionnaire on Teacher Interaction–Early Primary) to examine associations between teacher–child relationships and mathematics achievement. Mathematics achievement was measured by two different national mathematics tests which were administered at mid-year and the end of year. Children's perceptions of teacher interpersonal behaviour were examined from the viewpoint of two dimensions, namely, control (High versus Low) and affiliation (Friendliness versus Opposition). Results verified their hypothesis that positive associations exist between control and affiliation and mathematics achievement. Control and affiliation were also found to be partially independent predictors of mathematics achievement. A differential association role was detected across classes for affiliation, but not for control.

In research carried out in Kashmir, India by den Brok, Fisher and Koul (2005), the QTI was used in conjunction with other instruments with 1,021 (grade 9 and 10) secondary science students from 31 classes in 18 schools to examine associations between teacher–student interpersonal behaviour and students' attitudes towards science. Students' enjoyment of science was high and there was a positive relationship of Influence and Proximity with students' attitudes.

Quek, Wong and Fraser (2005) initiated in Singapore a study of relationships between teacher–student interactions and student attitudes towards chemistry. This involved the participation of 497 (grade 10) students in 18 classes from three independent schools. Of these, 9 classes were gifted (high academic ability) and 9 classes were non-gifted (above average ability) students. The study involved the use of the QTI and QOCRA (Questionnaire on Chemistry-Related Attitudes).

For the QTI scales, alpha reliability values ranged from 0.53 (Strict) to 0.92 (Leadership), while corresponding eta² values (i.e., the proportion of variance

accounted for by class membership) ranged from 0.20 to 0.64, respectively. The eta²
statistic is the ratio of 'between' to 'total' sums of squares. Significant gender
differences were revealed for the QTI scales of Helping/Friendly, Student
Responsibility/Freedom, Dissatisfied and Strict behaviours. Gifted female students
perceived teacher–student interactions of their chemistry teachers in a more positive
manner than did their male counterparts. A significant stream effect (high vs low
ability) was identified for six QTI scales with Student Responsibility/Freedom and
Strict behaviour being exceptions. Results also indicated significant positive
associations between the Helping/Friendly scale of the QTI and students' enjoyment
of chemistry lessons.

Van Tartwijk, Brekelmans, Wubbels, Fisher and Fraser (1998) reported a study
involving the use of QTI with 12 schools in Perth, Western Australia. This study
involved 34 inservice teachers whose lessons were videotaped to help to ascertain
associations between students' perceptions of teacher interpersonal style and judges'
ratings of teacher behaviour based upon these videotaped sessions. Whole-class
teaching was compared with individual seat work. From these videotaped sessions,
two one-minute portions were chosen, with one segment representing the teacher
communicating with the whole class, and the other with the teacher interacting with
the individual or a small group of students. Judges, who were asked to rate Influence
and Proximity dimensions, comprised Dutch and Australian research personnel who
were familiar with research considerations.

For whole-class teaching, a strong correlation (0.53) was reported between students'
perceptions of Influence in teacher interpersonal style and Influence ratings of
teacher interpersonal messages. Once again, for whole-class teaching, a strong to
medium correlation (0.42) existed between Proximity ratings of teacher interpersonal
messages and students' perceptions of teacher interpersonal style with regard to
Proximity. Findings further reinforced the culturally-embedded role of the teacher at
the front of a classroom (teacher's stage) transmitting knowledge to empty vessels.

A possible weakness of van Tartwijk (1998) and colleagues' study is the short
duration of the videotaped segments being judged. Segments of one-minute duration

do not seem to be of sufficient length to confidently make strong and conclusive statements.

2.3.4   College and University Classroom Environment Inventory (CUCEI)

The College and University Classroom Environment Inventory (CUCEI) (Fraser & Treagust, 1986; Fraser, Treagust & Dennis, 1986) was developed to fill a gap in the higher-education sector by providing an instrument that could be utilised in small classes or 'seminars'. It comprises seven seven-item scales. Each item evokes one of five responses (Strongly Agree, Agree, Disagree, Strongly Disagree). The seven scales are Personalisation, Involvement, Cohesiveness, Satisfaction, Task Orientation, Innovation and Individualisation. A sample item from the Individualisation scale is: "Students are generally allowed to work at their own pace." A sample from the Satisfaction scale is: "Students are dissatisfied with what is done in class." Some items are reverse scored.

Fraser and Treagust (1986) administered the CUCEI to 372 students from 34 classes and 20 instructors from Illinois (USA) and Perth (Western Australia). Findings supported the reliability and validity of the actual/preferred forms of the instrument, as well as the actual form being able to differentiate between the perceptions of students from different classes. Both students and teachers indicated a preference for a more favourable classroom environment. Teachers also viewed classroom environments more favourably than students. The study was significant and distinctive because, according to the authors, "it focuses on the classroom-level as distinct from the instructional-level environments and because it extends research traditions in primary and secondary schools to higher education classes" (Fraser, Treagust & Dennis, 1986, p. 43).

2.3.5   Constructivist Learning Environment Survey (CLES)

This instrument grew from the need to examine classrooms from a constructivist perspective. Its development was based upon the theoretical framework of constructivist thought and utilised the following three principles (Taylor, Fraser, Fisher, 1997):

- learning as construction of knowledge
- radical constructivism
- learner as a co-constructor of knowledge.

The CLES contains 36 items embedded within the five scales of Personal Relevance, Uncertainty of Science, Shared Control, Critical Voice, and Student Negotiation.

Nix, Fraser and Ledbetter (2005) used a modified form (CLES-CS) with 1079 students from 59 classes in Texas. The intent was to gauge the classroom impact of teachers who had previously participated in a constructivist professional development science programme (ISLE). In this study, students were asked to respond to statements specifically referring to THIS and OTHER classes, so that the researchers could distinguish between the classroom environments of (ISLE) teachers from other teachers at the schools. This study confirmed the validity and reliability of the CLES-CS. In regard to implementing constructivist-based teaching in their schools, students felt that the ISLE programme was comparatively successful with reference to the Personal Relevance and Uncertainty of Science scales of the CLES instrument.

Aldridge, Fraser and Sebela (2004) conducted a study in South Africa which utilised actual and preferred versions of a modified 4-scale CLES to assess constructivist approaches in classrooms. This particular study took place in the Limpopo province and involved 1864 mathematics students from grades 4–9 in 43 classes from six schools. A second phase of the study involved action research over a 12-week period, when two teachers and one of their classes (from the original 43 classes in the initial sample) formed the basis of case studies. Reflective teacher journals, along with regular weekly class observations, took place during this phase. Interviews with four students from each class were conducted at the beginning, middle and end of this 12-week phase in order to more accurately determine students' views of the constructivist learning environment. Scales for the actual version of the CLES showed alpha reliability coefficients ranging from 0.6 to 0.63 for individuals and from 0.88 to 0.91 for classes. ANOVA revealed that each CLES scale was able to differentiate between different mathematics classes. Discriminant validity (mean correlation of a scale with other scales) was calculated for both forms of the CLES, with results indicating that each CLES scale reflected a distinct aspect of the learning

environment encountered within the classroom. Students preferred a more positive learning environment than the existing one for all CLES scales.

Peiro and Fraser (2009), in a study based in Miami, Florida, used modified Spanish and English versions of CLES and TOSRA among 739 students in grades K–3 from two schools. Various analyses revealed the factorial validity and reliability of the CLES and TOSRA instruments when used with these early childhood students. Piero and Fraser also initiated an action research study over a three-month period with the goal of achieving a more constructivist classroom. This kindergarten class was composed of 30 Spanish-speaking (Limited English Proficient) students. Support for using teacher action research in order to create more constructivist based classrooms was provided by significant and large differences between pretest and posttest scores for classroom environment, understanding of particular science topics and attitudes towards science.

Another study that used a modified CLES was orchestrated by Koh and Fraser (2014) in Singapore. Actual and preferred versions of this particular instrument were used with preservice teachers in the evaluation of a Mixed Mode Delivery (MMD) model. This MMD model essentially encapsulates a constructivist-based student-centred learning approach, utilising a spectrum of new technologies such as online games, e-learning and internet discussion forums, etc. This study compared 2216 secondary business-studies students from 82 classes in a MMD group with 991 students from 32 classes in a control group in terms of the learning environment and students' attitudes. Instruction took place over a 10-week period. This study cross-validated the CLES and found it to be a reliable instrument. The authors reported effect sizes for the control group which ranged from 0.52–1.88 standard deviations for different CLES scales in comparison with those for the MMD group (ranging from 0.19–0.74 standard deviations). This led the authors to conclude that the MMD teachers (in comparison to the control group) had achieved the intended desire of promoting a classroom environment that was more in line with students' preferences.

2.3.6   Science Laboratory Environment Inventory (SLEI)

The SLEI was developed specifically to assess science laboratory environments in the senior echelons of secondary school and higher-education platforms. It has the five scales of Student Cohesiveness, Open-Endedness, Integration, Rule Clarity, and Material Environment. It contains 35 items in cyclic order and can be hand scored. There are two forms (actual and preferred) of this questionnaire.

Fraser, McRobbie and Giddings (1993) and Fraser, Giddings and McRobbie (1995) reported a study utilising actual and preferred versions of this instrument with 3727 students in 198 upper secondary classes from 40 schools in six countries (Australia, Canada, U.S.A, England, Israel and Nigeria). To provide cross-validation of the refined 34-item SLEI, a new sample of students was used. This sample comprised 1594 chemistry students in 92 senior high classes from 52 schools in Queensland. Each of the SLEI scales displayed good internal consistency reliability and discriminant and factorial validity. In addition, SLEI scales were able to differentiate between students' perceptions in different classes. It was revealed that closed-ended activities dominate laboratory classes and that females displayed more favourable perceptions than their male counterparts.

Wong and Fraser (1996) and Wong, Young and Fraser (1997) reported a study in Singapore of students' perceptions of the chemistry laboratory environment and their attitudes towards chemistry. This study involved 1592 final year students (763 boys, 829 girls) in 56 chemistry classes from 28 government schools and it utilised a modified form of the SLEI. This modified 35-item, 5-scale instrument was named the Chemistry Laboratory Environment Inventory (CLEI). Actual and preferred versions of this particular instrument were used along with three scales of the Questionnaire on Chemistry-Related Attitudes (QOCRA): Attitude to Scientific Inquiry in Chemistry, Adoption of Scientific Attitudes in Chemistry, and Enjoyment of Chemistry Lessons. It was found that these three scales displayed an alpha reliability of 0.86, 0.69, and 0.97, respectively. Instruments were cross-validated and analysis revealed significant associations between all five scales of CLEI and each of the three attitude scales. Wong & Fraser (1996, p. 100) found that …" 'Integration' and 'Rule Clarity' were strong and consistent predictors of the attitudinal outcomes".

They also reported a negative association between 'Open-endedness' and 'Attitudes to scientific inquiry in chemistry'.

Lightburn and Fraser (2007) utilised a modified version of the SLEI with 761 high school biology students from 25 classes in the USA. This modified instrument had 4 scales each with 6 items. The Open-Endedness scale was omitted. A smaller sample of 158 students was used in the anthropometric evaluation whilst a much smaller sample of 24 students (13 male, 11 female) was used for the interviews component. Students in this research were engaged in anthropometric tasks in which data had to be collected, processed and analysed. Students' achievement was assessed by way of a Biology pretest and posttest and a final Biology report grade for the 2000–2001 school year. This particular study examined the students' achievement, attitudes towards science and perceptions of classroom learning environment.

When the data were subjected to factor analysis, the SLEI was cross-validated. The anthropometric group revealed a higher average item mean on all of the four attitude scales, with effect sizes of about one-fifth of a standard deviation, which suggests slight differences in attitudes between those students who undertook anthropometric tasks compared to those who did not. Material Environment was the only scale which revealed a statistically-significant difference between the student groups (Lightburn & Fraser 2007).

In this particular study by Lightburn and Fraser (2007), in order to gauge student performance, attitudes and perceptions of the learning environment, 'grain sizes' methodology (Fraser, 1999) was employed. Another similar term for this multiple research methods approach is 'bricolage' as cited in Tobin & Fraser (1998). I liken multiple research methods to an elaborate and comprehensive work of 'stained-glass' whereby many pieces of glass of differing sizes, shapes, colours and textures are combined by an artisan (researcher) and held together by lead, to reveal a complete kaleidoscopic work of intricate beauty and colour, when illuminated by light.

In another study conducted by Fraser and Lee (2009), 439 Korean senior secondary science students from three different streams (science-independent, science-oriented, humanities) were administered Korean translations of the SLEI and modified

TOSRA. For the three SLEI scales of Student Cohesiveness, Open-Endedness and Material Environment, science-independent stream students viewed their laboratory classroom environments more favourably than those students from other streams. For the SLEI scale of Integration, a high level was revealed for all three streams, but less Rule Clarity was reported for the science-independent stream. The SLEI was validated with respect to internal consistency, discriminant validity and ability to differentiate between classrooms. Low scores were reported for the SLEI scale of Open-Endedness for the science-oriented and humanities streams, whereas the science-independent stream was characterised by much higher scores. These low scores on the Open-Endedness scale were also prevalent in other studies (Fraser & McRobbie 1995; Wong & Fraser 1996).

2.3.7 My Class Inventory (MCI)

Because the LEI discussed in Sections 2.2 and 2.3.1 was designed for the senior high-school level, Fraser, Anderson and Walberg (1982) modified it to form the My Class Inventory (MCI) for use at the primary-school level. The MCI differs from the LEI in several ways. Firstly, with the aim of reducing fatigue in young children, the MCI contains only five scales compared to the LEI's original 15 scales. Secondly, wording and readability have been simplified and enhanced. Thirdly, its simple Yes– No answer format, as well as its low reading ability demands, renders it as an ideal instrument for primary and lower-secondary school settings. Fourthly, answers are filled in on the single question sheet, which aids in avoiding errors that could occur if responses had to be transferred to another sheet (Fraser, 1989).

The MCI's 25 items are arranged in blocks of five in cyclic order and measure Satisfaction, Friction, Competitiveness, Difficulty, and Cohesiveness. For scoring purposes, a Yes response is assigned 3 while 1 is given for a No. Some items are reverse scored, with 3 given for No and 1 is given for Yes. Incorrect or omitted responses are assigned a value of 2. Actual and Preferred versions of this instrument form are available.

Majeed, Fraser and Aldridge (2002) investigated mathematics classes in Brunei Darussalam using a 38-item version of the MCI. Their sample comprised a total of 1,565 students from 81 lower-secondary mathematics classes from 15 government schools. Some objectives of this particular study were to examine gender differences with regard to how students perceive their mathematics learning environments and their overall satisfaction with such environments. Sample items are "Schoolwork is hard to do" (Difficulty) and "Students often race to see who can finish first" (Competition). Students exhibited more satisfaction in learning environments with greater cohesiveness and less difficulty. The male population in this sample viewed the mathematics classroom environment in a more favourable manner than did females. Data analysis cross-validated the MCI.

In Fort Worth, Texas, Scott Houston, Fraser and Ledbetter (2008) undertook a study using the MCI to examine the use of science kits with a sample of 588 children from 28 classes of grade 3–5 students in three schools. One school used textbooks, another school used science kits, and another used a combination of text and science kits. Teacher and student interviews and classroom observations, as well as pretests and posttests with MCI scales, were used. The study supported the factorial validity and reliability of the MCI and reported that the use of science kits resulted in a more positive learning environment in terms of student satisfaction and cohesiveness. Classrooms that portrayed greater cohesiveness and less friction and competition provided higher levels of satisfaction among students.

Sink and Spencer (2005) utilised a revised shortened form of the MCI, referred to as MCI-SF, with 2835 students from 4th to 6th grade from 20 elementary K–6 schools in Washington state. An 18-item MCI composed of 4 scales (Cohesiveness, Competitiveness, Friction, Satisfaction) was used. Psychometric analyses demonstrated adequate internal consistency and factorial validity of the MCI and showed that it was an effective accountability tool that school counsellors could use to adequately measure aspects of classroom climate. The authors felt that counsellors could use this tool to determine the success of certain interventions by using pretest and posttest scores to gauge whether higher Cohesion and Satisfaction scale scores emerged, thus reflecting positive classroom environments.

2.4 Types of Research on Learning Environments

The field of learning environments is scattered with countless varieties of differing types of research. Fraser (1998) lists 12 category types, but I review only six of them below: (1) associations between student outcomes and environment, (2) evaluation of educational innovations, (3) differences between student and teacher perceptions of actual and preferred environment, (4) teachers' attempts to improve classroom environments, (5) cross-national studies, and (6) transition from primary to high school.

2.4.1 Associations between Student Outcomes and Environment

Using MCI and QTI with a sample of 1512 students from 39 classes of primary mathematics in Singapore, Goh and Fraser (1998) were able to identify associations between the environment in the classroom and mathematics achievement and attitudes. Wong and Fraser's (1996) study with 1592 year 10 students from 56 chemistry classes in Singapore revealed associations among students' attitudes and scores. Chionh and Fraser (2009) found associations between WIHIC scales and student outcomes (attitudes, self-esteem, examination results) in their study involving 2310 geography and mathematics students from 75 classes in Singapore. In a Taiwanese study involving 1879 students from 50 science classes (Aldridge, Fraser, Huang, 1999), relationships were found between student satisfaction and scales from the WIHIC and CLES.

Telli, den Brok and Cakiroglu (2007) surveyed 674 grade 9–11 science students from two Turkish secondary schools. Students were from 24 classes with 13 teachers. A translated and modified (62-item) form of the QTI was used with the primary focus being teacher–student relationships. Student and teacher interviews were also used in the study. Data analysis revealed good reliability and validity for the QTI in the Turkish setting. The QTI was also reported as being able to distinguish between classes. Students viewed their teachers as fairly dominant and very cooperative. Teachers' self-perceptions were found to be more positive than what students perceived.

In a Tasmanian study conducted by Fisher, Henderson and Fraser (1997), 489 students from 28 classes were administered a 35-item SLEI. This particular study involved biology classes and student outcomes in three areas: student attitudes, written examination achievement and practical performance. The SLEI was used to determine students' perceptions regarding the laboratory learning environment. Student attitudes were assessed with Attitude to Science Laboratory Work and Attitude to This Class scales, adapted from TOSRA. Students achieved higher scores and had superior attitudes when they perceived that their practical work was closely linked with the theoretical aspects of the subject matter. Also, students' attitudes were more positive towards their classrooms and laboratories when they perceived more Student Cohesiveness and Rule Clarity and a better Material Environment.

Webster and Fisher (2003), in a study involving 4,645 students and 620 teachers from 57 Australian secondary schools, used data from the Third International Mathematics and Science Study (TIMSS) along with data related to school-level environment. A 56-item School Level Environment Questionnaire (SLEQ), consisting of the eight scales of Student Support, Affiliation, Professional Interest, Mission Consensus, Empowerment, Innovation, Resource Adequacy and Work Pressure, was utilised. Affiliation, Professional Interest, Empowerment and Innovation were significant influences on instructional practices. Students from more teacher-directed classes displayed more positive attitudes towards mathematics. "The results indicate that the more teacher-centred classroom practices have a more direct effect on those students who attribute success in mathematics to more internal influences, such as ability and effort, than do those students who attribute success to external influences such as good or bad luck" (Webster & Fisher, 2003, p. 323).

Idiris and Fraser (1997) undertook a study involving 1175 Nigerian students from 50 junior and senior secondary school agricultural classes in 20 schools (13 urban, 7 rural) in eight states and the capital. Actual and preferred forms of an instrument, which borrowed scales from CLES and ICEQ, were used to gauge students' classroom environment perceptions. Student attitudes were assessed using a 14-item instrument adapted from TOSRA, while another 14-item instrument assessed students' enquiry skills. The study cross-validated the scales and revealed higher scores for Negotiation, Autonomy and Investigation than for Student Centredness

and Differentiation. Nigerian classes were teacher-centred and students preferred a more positive environment than the actual existing one, in terms of the scales of Negotiation, Investigation and Differentiation. Student Centredness was low, but students, in fact, preferred it to remain at such low levels.

2.4.2 Evaluation of Educational Innovations

According to Fraser (1998), in an evaluation of the Australian Science Education Project (ASEP), students perceived their classroom environments as being more satisfying and individualised and having a better material environment when compared with a control group.

Spinner and Fraser (2005) utilised a number of instruments, namely, the ICEQ, CLES, TOMRA and concept tests (both pretest and posttest) amongst two samples (N_1=53) (N_2=66) of grade 5 students. The study involved implementing an innovative mathematics program based upon constructivist principles (the Class Banking System, CBS). The authors combined quantitative and qualitative methods and used three case studies based upon interviews and observation. The researchers' main aim was to determine the CBS program's success in improving classroom environment, attitudes towards mathematics and mathematics concept development. Results indicated that the experimental group (CBS) had higher posttest scores on all of these items relative to the control group.

In a Singaporean setting, Teh and Fraser (1994) and Teh and Fraser (1995) investigated the learning environment and student achievement and attitudes in classrooms which used innovative micro-PROLOG computer courseware. A total of 671 students (348 experimental, 323 control group) from 24 geography classes of slow learners in the second year of high school constituted the sample. The instruments used were the Geography Achievement Test (GAT) to measure achievement and the Semantic Differential Inventory (SDI) to assess students' attitudes towards Geography. The alpha reliability was 0.95 for GAT and 0.94 for SDI. This study involved developing and validating the Geography Classroom Environment Inventory (GCEI). Statistical analysis revealed that the scales in the

GCEI displayed sound factorial validity, internal consistency reliability and discriminant validity. Each scale was also able to differentiate between students' perceptions in different classes. Findings revealed that CAL courseware helped to deliver a more investigative and innovative classroom environment, as well as considerably impacting on achievement and attitudes.

Another study that evaluated the use of computers as investigative tools was Maor and Fraser (1996). This investigation used pretests and posttests of the perceptions of the learning environment among 120 students and 7 teachers from seven year 11 applied computing classes in Perth, Western Australia. The programme involved using a 'Birds of Antarctica' database with the aim of initiating inquiry learning which would ultimately lead to learning with understanding. The 30-item Computer Classroom Environment Inventory (CCEI) consisting of five scales was utilised to assess Investigation, Open-endedness, Organisation, Material Environment and Satisfaction. The scales of CCEI displayed acceptable internal consistency reliability, with alpha coefficients ranging from 0.62 to 0.91. Both students and teachers reported improved scores on the Investigation and Open-endedness scales, thus suggesting a more positive learning environment. High levels of Satisfaction were also reported. Overall teachers saw the classroom environment in a more positive manner than did students on the three scales of Open-endedness, Organisation and Material Environment.

Martin-Dunlop and Fraser (2008) utilised a sample of 525 prospective elementary teachers from 27 classes of Californian female university students to evaluate an innovative course, A Process Approach to Science, with the intended aim of improving these students' perceptions of laboratory-based learning environments as well as their attitudes towards the subject of science. To assess the learning environment, the researchers used a combination of scales from the WIHIC and SLEI. Some items from TOSRA were used to assess attitudes. A questionnaire compared students' previous laboratory science courses with data from the completed course. Statistical analysis revealed large and significant improvements on all scales of the learning environment instrument with the largest being for Open-Endedness and Material Environment.

In the USA, a study by Wolf and Fraser (2008) used the WIHIC and a modified version of TOSRA with 1434 (grade 7) science students from 71 classes to compare inquiry-based laboratory teaching with non-inquiry approaches in terms of the learning environment, achievement and attitudes. For a subsample which comprised 165 students from 8 classes, results indicated that the inquiry approach led to greater student cohesiveness than the non-inquiry method (effect size of one-third of a standard deviation). The study's findings revealed that males gained more benefit from the inquiry approach whereas females appeared to gain more from non-inquiry methods.

2.4.3 Differences between Student Perceptions of Actual and Preferred Environment

In Singapore, Chionh and Fraser (2009) used actual and preferred versions of the WIHIC with 2310 students from 75 grade 10 geography and mathematics classes in 38 randomly-chosen schools. Data analysis confirmed the validity and reliability of the WIHIC. Geography and mathematics students held similar perceptions of their classroom environments for both actual and preferred forms. The study revealed not only a link between increased student cohesiveness and higher achievement in both mathematics and geography, but also that students preferred a more positive classroom environment than the one currently engaged in. These results replicated past research (Fisher & Fraser, 1983; Fraser, 2007). Also classrooms displaying greater teacher support, task orientation and equity were associated with more favourable self-esteem and attitudes.

Burleson and Myers (2013) assessed actual and preferred environment among 109 post-secondary students who were enrolled in an Introduction to Entomology course at the University of Florida. A refined 35-item version of the SLEI was administered to the student sample, of which 55% took the traditional lecture course and 45% took the online lecture course. Online students were required to attend on-campus laboratory classes. Mean scores were found to be higher for the preferred form on all five scales of the SLEI. Students also preferred a higher level of Integration between the lecture component and the laboratory sections of the course.

Ebrahimi (2013) reworded, rephrased and edited the CLES to form the Constructivist Translation Classroom Environment Survey (CTLES), which was used with 523 Iranian university students from 25 translation classes across four universities. The CTLES was found to exhibit satisfactory internal consistency and discriminant validity for both actual and preferred versions. For the actual form, eta^2 results ranged from 0.17 for Personal Relevance scale to 0.22 for the Uncertainty scale, and most scales were capable of differentiating between the perceptions of students in different classrooms. Alpha reliability coefficients ranged from 0.76 to 0.83 (actual form) and from 0.72 to 0.87 for the preferred form. Students displayed dissatisfaction with their current translation classroom environment and preferred an environment that was more constructivist for all scales of the CTLES.

Byrne, Hattie and Fraser (1986) investigated actual/preferred classroom environment with a sample of 1,675 students from grades 7, 9 and 11 across 18 schools in NSW, Australia. Preferred classroom environment was assessed with shortened versions of MCI, CES and ICEQ, whereas actual school environment was examined utilising three scales from the Quality of School Life (QSL) instrument. Very high alpha reliability coefficients ranged from 0.88 to 0.90 for QSL (actual), 0.90 to 0.93 for CES (preferred) and 0.88 to 0.95 for ICEQ (preferred). Boys had significantly higher scores than girls on preferred Friction, Competitiveness and Differentiation, while girls had higher scores on preferred Structure, Personalization, Participation, General Affect and Teachers. Grade 7 students displayed a preference for structure and cohesiveness, while students from grade 9 preferred friction and competitiveness. Grade 11 students had a preference for more self-initiated activities.

In a study initiated by Fraser (1984), actual and preferred forms of a short version of the My Class Inventory (MCI) were administered to 758 third-grade students in the suburban surrounds of Sydney, Australia. This survey involved 32 classes and 22 teachers from 8 schools. Both teachers and students preferred classroom environments that were more favourable than the existing ones, with students preferring more Cohesiveness, more Satisfaction, less Friction and less Competitiveness. Similar to the students, teachers preferred more Cohesiveness, more Satisfaction, less Friction, less Competitiveness and less Difficulty. Teachers also displayed perceptions of the existing classroom environment that were generally

more positive than their students in relation to more Satisfaction, less Friction and less Competitiveness.

Fisher and Fraser (1983a) conducted a study in Tasmania involving 2175 students from grades 8 and 9 in 116 classes from 33 schools. Actual and preferred forms of the ICEQ were administered to the students. Fifty-six teachers also participated by taking the 'actual' form of this classroom environment survey. For all 5 scales of the ICEQ (Personalization, Participation, Independence, Investigation, Differentiation), student preferred scores were higher than student actual scores. Teacher actual mean score profiles were higher than student actual scores on all scales with the exception of the Independence scale for which scores were identical.

Fisher and Fraser (1983b) also utilised the CES in its student real and ideal forms, as well as in teacher real forms. Students preferred a more ideal environment, with greater involvement, affiliation, teacher support, order and organization, rule clarity and innovation. Teacher real scores were higher than student real scores, thus reflecting more positive perceptions among teachers of the existing classroom environment in terms of greater involvement, teacher support, order and organization and rule clarity.

A study in Israel using actual and preferred forms of the SLEI was instigated by Hofstein, Cohen and Lazarowitz (1996) to specifically examine Chemistry and Biology laboratory learning environments. This study involved 371 eleventh grade students (188 Biology and 183 Chemistry) from 15 classes in 11 schools. Once again, students had a preference for a better learning environment than the existing one. In particular, students preferred a greater level of teacher support in the laboratory situation and greater levels of involvement. In addition, they displayed a preference for an ideal or preferred environment with greater emphasis on the dimensions of student cohesiveness, open-endedness, integration, organisation, rule clarity and material environment.

A Taiwanese study by Hsiao, Wu, Lin, Wong, Fu, Yeh and Chang (2014) utilising the Inquiry-based Laboratory classroom Environment Instrument (ILEI) involved 262 second-year senior high school students (aged 16–17) in providing perceptions

of actual and preferred laboratory environments. This study revealed that students displayed a preference for inquiry-based laboratory environments that were student-directed and teacher-guided. In relation to actual perceived laboratory environment, the majority of students viewed it as more teacher-guided and inquiry-based.

Fraser (1986) reported a study using both actual and preferred forms of the College and University Classroom Environment Inventory (CUCEI) involving 372 undergraduate and postgraduate students in 34 classes from Western Australia and Illinois (USA). A subsample of 20 teachers (16 Australian, 4 American) was also used. Mean scores for actual and preferred forms of the CUCEI revealed that students preferred a more favourable environment than the one in existence in terms of a greater emphasis on six of the seven dimensions surveyed (i.e. Involvement, Student Cohesiveness, Satisfaction, Task Orientation, Innovation and Individualization). An examination of teachers' actual/preferred scores indicated that teachers preferred a more favourable environment on all seven dimensions of the CUCEI. A comparison of student actual and teacher actual environment profiles revealed that teachers perceived that there was greater Involvement, Student Cohesiveness and Satisfaction present in the classroom than their students did.

The studies outlined above indicate that students generally favour more positive classroom environments than the ones that are in existence. Teachers, however, appear to view their classroom environments through rose-coloured glasses and thus generally rate learning environments in a more positive light than their students. Such findings are replicated in studies from the USA (Moos, 1979), Australia (Fisher & Fraser, 1983; Fraser, 1982), Netherlands (Wubbels et al., 1991) and Israel (Raviv et al., 1990). Other studies which also utilised actual/preferred forms of particular instruments include Dorman (2008), Sinclair and Fraser (2002), Allen and Fraser (2007), Yarrow, Millwater and Fraser (1997), Yuen-Yee and Watkins (1994), Fraser (1982) and Spearman and Watt (2013).

2.4.4 Cross-National Studies

MacLeod and Fraser (2010) mention that, as interest in learning environments has spread across the globe, so too has the need for translated versions of popular

learning environment questionnaires. Furthermore, they make the point that translations of these learning environment questionnaires and the evolution of new instruments in the native languages of respective countries have provided researchers with valuable tools. Fraser et al. (2010) provide two reasons why cross-national research in education can provide new insights. Firstly, variables of interest, such as student attitudes and teaching methods and approaches, display greater variation when the sample is derived from multiple countries rather than a single country. Secondly, comparing educational practices, beliefs and attitudes across countries can be discussed, analysed and questioned. A possible consequence of this is that individuals, through introspection, question their own educational practices, approaches and beliefs and perhaps this ultimately leads to change, resulting in better and improved educational outcomes and teaching.

Welch, Cakir, Peterson and Ray (2012) gauged the reliability and validity across national borders of the Technology-Rich Outcomes-Focussed Learning Environment Inventory (TROFLEI). Actual and preferred versions of the questionnaire were administered electronically to 980 grade 9–12 students in Turkey and 130 grade 9–12 students in the USA. All scales displayed satisfactory internal consistency, with alpha coefficients ranging from 0.820 to 0.920 for Turkish actual scales and from 0.842 to 0.931 for Turkish preferred scales. Reliability coefficients for the USA actual and preferred scales ranged from 0.778 to 0.919 and from 0.811 to 0.939, respectively. Confirmatory factor analysis revealed adequate model fit for both samples.

Aldridge and Fraser (2000) reported a cross-cultural study which took place in Taiwan and Australia and utilised multiple research methods (in-depth interviews, classroom observations, narratives). The sample comprised 1081 students from 50 classes in Australia and 1879 students from 50 classes in Taiwan. A Mandarin version of the WIHIC was used in Taiwan. The reliability and validity of the WIHIC were confirmed by this study. Results also indicated that the Australian sample considered their classroom environment in a more favourable light than their Taiwanese counterparts, but the Taiwanese students displayed more positive attitudes.

An Indonesian study involving 1125 secondary students from 36 classes was implemented by Schibeci and Fraser (1987) in three stages. The first stage involved 373 students from grades 8 and 9 in the process of developing and validating an eight- scale Indonesian classroom environment instrument based upon the ICEQ and CES. The second stage involved the participation of 502 grade 11 and 12 science students in the translation and validation of the Indonesian TOSRA. This instrument was renamed the TOBRA because of the emphasis on biology. The third stage used the new Indonesian-language instruments with 250 biology students to investigate the effects of classroom psychosocial environment on students' science-related attitudes. Both classroom environment and attitude instruments were found to be valid and reliable in the Indonesian setting. This study's authors reported that "more favourable science-related attitudes on several scales were found in classes perceived as having more personalization, participation, investigation and order and organization" (p. 169).

Another cross-national study involving 1720 university students from 71 science laboratory classes was reported by Fraser, Giddings and McRobbie (1992). Actual and preferred forms of the SLEI were field tested and validated in the USA, Canada, Australia, England, Israel and Nigeria. The SLEI was found to exhibit satisfactory internal consistency reliability, discriminant validity, factorial validity, predictive validity and ability to differentiate between classes, for both forms (actual and preferred) of the instrument. Apart from the Open-Endedness scales, significant positive relationships were found to exist between SLEI dimensions and student attitudes. In classes displaying higher Student Cohesiveness and Integration, attitudes among students towards laboratory work were more favourable. In addition, females perceived the classroom environment more favourably than their male counterparts. Furthermore, the study reinforced international findings regarding the closed-ended nature of science laboratory settings in education.

Fraser and McRobbie (1995) describe a cross-national study involving the development of a Class form and a new Personal form of the SLEI. The study involved 5,447 students in 269 classes spanning six countries. This sample consisted of 3,727 upper secondary students in 198 classes and 1,720 university students in 71 classes. [This latter component with university students has already been outlined

above for the study by Fraser, Giddings and McRobbie (1992)]. The SLEI subsequently was cross-validated with 1,594 Australian students from 92 classes. A smaller sub-sample of 516 students from 56 classes in 31 schools responded to actual and preferred versions of the Personal form. Among the findings were that: closed-ended activities generally monopolise science laboratory classes worldwide; Class form scores were more favourable than Personal form scores; significant associations existed between laboratory environment and attitudinal outcomes; and justification was provided for the use of separate Class and Personal forms for gauging different aspects of the learning environment.

A study initiated by Wubbels and Levy (1991) in the USA involved 31 teachers and 1,606 secondary students from 66 classes. Its main purposes were to adapt the Dutch (QTI) questionnaire to the American landscape, investigate teachers' and students' perceptions of interpersonal teacher behaviour along the two dimensions of Dominance–Submission (DS) and Cooperation–Opposition (CO), and compare American data with Dutch data. In addition to the QTI, another questionnaire based upon the 'ideal' teacher was also completed by teachers. Data were also collected from some students concerning their perceptions of 'best' and 'worst' teacher. Statistical analysis confirmed the reliability and validity of the QTI, with scale internal consistency reliabilities ranging from 0.76 to 0.84 for students and 0.74 to 0.84 for teachers.

Wubbels and Levy (1991) reported similar interpersonal behaviour by Dutch and American teachers. The researchers stated: "American teachers and Dutch teachers agree that they want to be less dissatisfied than their and their students' perceptions of reality" (p. 15). Findings indicated that both American and Dutch teachers desired to display more leadership and more friendly and understanding traits. Students' perceptions of Best/Worst teachers returned similar results. Dutch teachers emphasised student responsibility and freedom in teaching styles, whereas American teachers' emphasis was on stricter behaviour.

Dorman (2003) undertook a comprehensive and detailed analysis of a 42-item version of the WIHIC with 3,980 secondary students from year 8, 10 and 12 mathematics classes in Australia, Canada and Britain. This cross-national validation

of the WIHIC incorporated the use of reliability analyses, exploratory factor analyses and confirmatory factor analyses. Analyses supported the WIHIC's structure and its scales' validity, as well as confirming its widespread applicability across Western countries. Structural equation modelling utilising multi-sample analyses confirmed invariant factor structures for the grouping variables of country, grade level and gender. Cronbach coefficient alphas for the scales ranged from 0.76 to 0.85, while discriminant validity statistics ranged from 0.32 to 0.45.

2.4.5   Teachers' Attempts to Improve Classroom Environments

Yarrow, Millwater and Fraser (1997) aimed to generate improvements in the classroom environment of university teacher education programs and of 117 primary school classes with 117 preservice education teachers through action research. The CUCEI was utilised for the university domain, whilst the MCI was used for the primary-school situation. Researchers in this study wanted to identify student actual and preferred environments and also to engage the preservice teachers in action research aimed at improving both their university classes and primary-school classes. Quantitative data were enhanced by qualitative data involving the use of reflection, discussion and personal writing. It was felt that case writing empowered teachers by giving them 'voice'. The preservice teachers welcomed the addition of the learning environments topic within their course as well as the opportunity to undertake action research.

Fraser and O'Brien (1985) reported the use of actual/preferred forms of the MCI with 26 lower-ability grade 6 primary students in Sydney, Australia. The preferred form was presented first and the actual version two days later. Results revealed sizeable actual–preferred differences for the MCI dimensions of friction, competitiveness and cohesiveness. The teacher decided to attempt to decrease the level of competition and increase cohesiveness. During a two-month intervention period, by utilising various strategies, the teacher made attempts to change the classroom environment. At the conclusion of this teacher intervention, the actual form of the MCI was readministered. Results indicated that students perceived more satisfaction, less friction, less competition, less difficulty and more cohesiveness. A comparison of pretest/posttest actual scores revealed substantial differences for the

dimensions of competitiveness and cohesiveness (i.e. the very two dimensions that the teacher had attempted to change).

Sinclair and Fraser (2002) engaged in a three-phase study in Texas involving 745 students from 43 classes of grades 6, 7 and 8. Actual and preferred forms of an instrument based upon the WIHIC, called the Elementary and Middle School Inventory of Classroom Environments (ICE), were used. The scales of the ICE comprised Cooperation, Teacher Empathy, Involvement and Task Orientation. The first phase constituted the development and validation of the ICE instrument. The second stage utilised quantitative and qualitative data to describe classroom learning environments. The third phase of this study involved teachers engaging in action research to promote changes and improvements based upon feedback received from students' perceptions of classroom environment. In this final stage of the study, during the following year, three teachers from the original sample attempted to improve their classroom environments based on information and data obtained from the first two phases of the study. Changes were reported for all three case studies for dimensions from the ICE instrument that individual teachers wanted to improve. Sinclair and Fraser's (2002) study provided confirmation that teachers can foster change and improvements in their classroom environments by utilising feedback from learning environments instruments.

Fraser, Dryden and Taylor (1998) outlined the evaluation of a reform effort, an Urban Systemic Initiative (USI), which attempted to embed a more constructivist approach within high-school science teaching. Pretest and posttest forms of the Constructivist Learning Environment Survey (CLES) were administered to Biology and Integrated Science classes at the beginning of USI and then three years later. Observation of science classes by observers using a learning environment checklist also took place. Nine high schools were involved with the CLES as a pretest given to 440 students in 1994, and again as a posttest with 351 students in 1997; in addition, 29 classroom observations involved 5 observers. Although students perceived moderate levels of constructivist practices in 1994 on the dimensions of Personal Relevance, Critical Voice, Uncertainty of Science and Student Negotiation, no increases were visible for these scales by 1997. For both Biology and Integrated Science, the dimension of Shared Control had a low mean score on both pretest and

posttest. This suggests that practices inherent in this scale were seldom initiated, thus implying that constructivist approaches were not happening. In regard to classroom observations, Learner-Centredness (incorporating student-centeredness, student involvement, and student thinking) displayed relatively low mean scores. The authors pointed out that: "Given that Learner-Centeredness is such a key aspect of constructivism, it is noteworthy that it was observed to occur less frequently than desirable" (p. 9).

Fraser and Fisher (1986) reported two case studies of teachers' attempts to firstly assess and then improve their science classroom environments. One of these case studies has already previously been outlined (Fraser & O'Brien, 1985). The other case study involved a junior high-school class of 22 year 9 students in Tasmania and the use of actual and preferred forms of the short version of the CES. The process followed was that the preferred form was administered first, followed by the actual form a week later. Based upon feedback from the CES data profiles and a process of individual teacher self-reflection and subsequent discussion with colleagues, the teacher then decided which dimensions of the CES they would attempt to change. The variables chosen were those which displayed large actual–preferred differences. This particular teacher chose to attempt to increase the level of Teacher Support and Order and Organisation. This was followed by a period of intervention lasting for two months. Various strategies were employed during this time aimed at generating improvements in the classroom environment. At the conclusion of this intervention, students were reassessed by use of the CES actual form. Statistical tests revealed that significant pretest–posttest differences emerged for the CES dimensions of Teacher Support, Task Orientation, and Order and Organisation. Interestingly, two of these were the very dimensions that the teacher had attempted to reform.

Yarrow and Millwater (1995) outlined a project in which two university lecturers used actual and preferred forms of the CUCEI with seven tutorial classes. This enterprise involved 4 groups of first-year primary students and 3 groups of second-year secondary students. The study required, firstly, garnering students' perceptions of the preferred and actual psychosocial classroom environment at the start of the academic year. This was followed by lecturers presenting and discussing the results and students offering suggestions of strategies for improving particular dimensions

that were associated with large discrepancies between actual and preferred scores. Subsequently, during an 8-week intervention period, lecturers attempted to incorporate suggested student strategies into their classrooms. At the end of the semester, a posttest using the actual form of the CUCEI was given followed by a subsequent discussion of results. These posttest results revealed that, of the 7 groups involved, 3 primary and 1 secondary group believed that improvements had taken place for certain dimensions. The most pronounced gains occurred in Satisfaction, Cohesiveness and Individualization. Students, however, still viewed the actual classroom environment as being inferior to their preferred environment for the dimensions of Cohesiveness, Satisfaction and Innovation.

In Sydney, NSW, Fraser, Seddon and Eagleson (1982) reported how a teacher in a private secondary school administered student actual and preferred forms of the ICEQ to his 31 grade 7 male students. The actual form was administered first, and this was followed by the preferred form the following week. Feedback from student responses was provided by university staff who had performed statistical analysis on the data. After a process of personal reflection and discussion with staff from the university, the teacher then decided on whether an intervention was desired. Subsequently, the teacher decided to attempt to increase levels of Personalisation and Participation during an intervention phase lasting a month. At the end of this period, the student actual form of the ICEQ was administered. The only appreciable changes were revealed for the actual dimensions that the teacher had attempted to improve, namely, Personalization and Participation.

A more-recent study by Bell and Aldridge (2014) involved the use of the 11-scale Constructivist-Oriented Learning Environment Survey (COLES) in Western Australia with 10,345 secondary students from 684 classes in 29 schools, over a 3-year time span (2008–2010). A subsample of 6,107 students in 560 classes and 459 teachers was used to examine pre–post changes and to investigate if teachers' reflections based upon feedback from the COLES resulted in learning environment improvements. An additional stage of the study involved 45 of the 459 teachers acting as 'focus' teachers who engaged in an action research project and kept reflective journals, wrote reports and participated in a forum. There were statistically

significant pre–post differences for eight of the eleven COLES scales, with all of these changes reflecting improvements in the classroom environment.

The studies outlined above show that bringing about change in educational settings is possible when teachers possess a positive mindset and have a deep desire and motivation to instigate change for the benefit of their students (Cohen et al., 2000). These positive changes, as reflected in the prior studies reviewed above, can be instigated primarily by willing teachers using widely-available, valid and reliable learning environment instruments. All that is usually required is that, initially, teachers are made aware of this vast compendium of learning environment instruments (Fraser, 1989), are trained in their specific use and interpretation, and are encouraged to make use of them in their educational settings to foster change.

The use of actual and preferred versions of instruments can greatly assist teachers in identifying specific areas of concern to students, thereby allowing teachers to make concerted attempts to rectify these (Aldridge et al., 2004). In addition, when qualitative methods such as student interviews, reflective journals, forums, etc., are thrown into the mix, these additional ingredients all help to better diagnose and thus obtain a more-detailed view of student concerns.

2.4.6 Transition from Primary to High School

Ferguson and Fraser (1999) found positive and negative changes in learning environment perceptions which varied with gender and school-size pathway. Results indicated that, for boys, there was an improvement in Satisfaction, whereas for girls it decreased. Ferguson and Fraser (1999, p. 381) also reported that "secondary schools were perceived as having less friction and competitiveness than primary schools. But students also perceived a deterioration in the quality of teacher-student interactions (e.g. in terms of less leadership, helpful/friendly, understanding and student responsibility/freedom teacher behaviours)".

Anderman and Midgley (1997) undertook a study of 341 students from a working-class area in the mid-west of the USA. They examined changes in student motivation during the transition from 5th grade in elementary schools to 6th grade in middle

schools. Students were surveyed in 5th grade and then again when they had made the transition to 6th grade. Surveys included items from the Patterns of Adaptive Learning Survey (PALS) and comprised five scales of personal task and performance goal orientation, perceptions of the task and performance goal structure in the classroom, and perceived academic competence. English and Mathematics were both examined individually. Scale alpha reliabilities ranged from 0.65 to 0.83. Students felt that they were more attuned to task goals (improving competency) both individually and during instruction. Students also viewed themselves as being more competent academically in grade 5 than in grade 6. They also felt that there was a greater emphasis on performance goals (an emphasis on relative ability and correct answers) in grade 6 than in grade 5. This study also revealed that there was a strong decline in perceptions of academic competency, especially among high-ability students. The authors suggest that this could be because of the transition to "new types of academic tasks, changes in evaluation and grouping procedures, and changes in peer group relations" (Anderman & Midgley, 1997, p. 291).

This only serves as a somewhat brief introduction to transition and, for this reason, a more comprehensive and detailed exploration of transition appears later in Section 2.6.

Section 2.5 that follows essentially and primarily concerns itself with describing the WIHIC instrument, its scales and its general development. Various research studies that utilised the WIHIC, together with its reliability and validity, are also outlined.

2.5   What Is Happening In this Class? (WIHIC)

Because the WIHIC was used as a major part of my study, it is appropriate to devote this separate section to it. The WIHIC was initially developed by Fraser, McRobbie and Fisher (1996). It used prominent scales from a varied array of past questionnaires with additional scales that help to address more modern-day concerns such as equity and constructivism. Dorman (2008, p. 181) refers to this latter element of constructivism as "…the promotion of understanding rather than rote learning". Fraser (1998), Chionh and Fraser (2009), Aldridge, Fraser, Huang (1999) and Martin-Dunlop and Fraser (2008) all state that the WIHIC brings parsimony to the

field of classroom environment. According to Dorman (2008, p. 181): "The WIHIC is worded to elicit the student's perception of his/her individual role within the classroom, as opposed to the student's perception of the class as a whole." Several authors report that the WIHIC has "achieved almost bandwagon status in the assessment of classroom environments" Dorman (2008, p. 181). Fraser, Aldridge and Adolphe (2010, p. 553) make the statement that the WIHIC "is the most widely used instrument in the world today".

MacLeod and Fraser (2010) state that various studies around the world provide strong evidence for the validity of WIHIC. Among these are: Ogbuehi and Fraser (2007); den Brok et al. (2006); Martin-Dunlop and Fraser (2008); Wolf and Fraser (2008); Allen and Fraser (2007); Koul and Fisher (2005); Khoo and Fraser (2008); Chionh and Fraser (2009); and Dorman (2003).

The original WIHIC included 90 items in 9 scales. This version was subsequently modified by statistical analysis of data obtained from 355 junior high school students and through interviews regarding students' views of classroom environments, wording of questions and their responses to the questionnaires. Seven scales and 54 items resulted from this process. These in turn were expanded to eight scales and 80 items (Fraser, 1998). A second version underwent testing in Australia (1,081 students in 50 classes) and also in Taiwan (1,879 students in 50 classes) (Aldridge et al., 1999). This latter study utilised a questionnaire that had been translated into the native language.

Consequently, the final metamorphosis of the WIHIC came to exist with 7 scales, each containing 8 items, thereby resulting in a total of 56 items. The WIHIC also exists in Actual and Preferred forms (Chionh & Fraser, 2009). The scales and their descriptions are as follows:
- Student cohesiveness assesses the extent to which students know, help and are supportive of one another.
- Teacher Support assesses the extent to which the teacher helps, befriends, trusts and shows interest in students.

- Involvement assesses the extent to which students have attentive interest, participate in discussions, do additional work and enjoy the class).

- Investigation (emphasis on the skills and processes of inquiry and their use in problem solving and investigation).

- Task Orientation (extent to which it is important to complete activities planned and to stay on the subject matter).

- Cooperation (extent to which students cooperate rather than compete with one another on learning tasks).

- Equity (extent to which students are treated equally by the teacher).

Items in the WIHIC are scored 1, 2, 3, 4 and 5, respectively, for the frequency responses of Almost Never, Seldom, Sometimes, Often and Almost Always. Omitted or invalid responses are scored 3. To obtain the total score for each scale, one adds the scores for the eight items in each scale. Some sample items are "I explain my ideas to other students" (from the Involvement scale) and "I am treated the same as other students in this class" (Equity).

Fraser, Aldridge and Adolphe (2010) attempted to cross-validate Indonesian and English versions of the WIHIC with lower-secondary students in Indonesia and Australia. Another aim was to see if students' perceptions of classroom environments varied with country and the gender of student. Associations between students' perceptions of classroom environment and their attitudes to science were also examined. The sample comprised 1161 (584 boys and 577 girls) grade 9/10 students who were 14–15 years of age from 36 classes (18 Australian, 18 Indonesian) in private co-educational schools. The WIHIC was found to be valid and reliable when used in both countries. Some differences were apparent between countries and between sexes with regard to students' perceptions of their classroom environments. For some scales (Involvement and Investigation), Indonesian students viewed their learning environments in a more positive light than the Australian students. For other scales (Task Orientation), Australian students had a more positive outlook.

MacLeod and Fraser (2010) reported the field testing of Arabic and English versions of the WIHIC with 763 college students from 82 classes in Dubai in the United Arab

Emirates. Once again, as in previous studies, the validity of the WIHIC was confirmed. Results also revealed that "students preferred a more positive classroom environment than the one they perceived as being actually present" (MacLeod & Fraser, 2010, p. 117).

Another study also conducted in the UAE by Afari, Aldridge, Fraser and Khine (2013) utilised pretests and posttests of modified WIHIC, Enjoyment of Mathematics Lessons and Academic Efficacy scales to evaluate the effectiveness of using jeopardy-type mathematics games at the college level. This sample consisted of 33 classes of 352 students, with 8 of these classes comprising 90 students being subjected to mathematics games. The aim was to determine whether the use of such games improved the learning environment and students' attitudes towards the subject of mathematics. Modified Arabic versions of the WIHIC, as well as another survey instrument to determine attitudes, were used. The study cross-validated the WIHIC and yet again supported the validity and reliability of this instrument. The two attitude scales used (enjoyment of lessons and academic efficacy) were also found to display sound factorial validity and internal consistency reliability. The average item means revealed that, for all of the six WIHIC scales as well as the two attitude scales, posttest scores were higher than pretest scores. That is, the researchers reported an improvement in students' attitudes and perceptions of the learning environment during the mathematics games. The study also found that students who used mathematics games perceived higher teacher support, involvement, personal relevance, enjoyment and academic efficacy.

Wolf and Fraser (2008) compared inquiry and non-inquiry laboratory techniques with respect to students' perceptions of classroom learning environments, their attitudes towards science and achievement. 1,434 middle-school physical science students from 71 classes in New York constituted the data base for this study. The schools utilised in this study were co-educational and comprised 14 public schools and 4 private schools. It was found that "whereas males benefited more from inquiry methods, females seemed to benefit more from non-inquiry approaches in terms of attitudes to science and classroom task orientation, cooperation and equity" (Wolf & Fraser, 2008, p. 336). This study lent further credence to the validity and reliability of the WIHIC.

Dorman (2003) utilised a sample of 3,980 high-school mathematics students from grades 8, 10 and 12 from the UK, Canada and Australia. The study used reliability analyses, exploratory factor analysis and confirmatory factor analyses to examine the WIHIC's structure and validity. It was established that the WIHIC's factor structure was invariant for the three student variables of country, grade level and gender. This study by Dorman supported the cross-national validity of the WIHIC as well as its reliability for measuring classroom environments.

In another study, Dorman (2008) focussed on investigating the validity of the WIHIC questionnaire using modelling techniques. His sample comprised 978 students (543 males, 435 females) from 63 high school classes from year 8, 9 and 10 in Queensland. Actual and preferred forms of WIHIC were used to gauge how students saw the existing classroom environments, as well as their views of what they would like their classroom environment to be. The validity of WIHIC for measuring classroom environment was confirmed in this study. Data analysis revealed that all WIHIC scales (both on the actual and preferred forms) demonstrated good internal consistency reliability. Cronbach alpha coefficients were found to range from 0.70 for Student Cohesiveness for the preferred form to 0.90 for Equity for the actual form. Results indicated that the "WIHIC has very sound structural characteristics" (Dorman, 2008, p. 191).

Koul and Fisher (2005) study's main aim was to validate both the QTI and WIHIC and "to investigate how perceptions of learning environments and teacher interpersonal behaviour in science classrooms varies with students' cultural background" (Koul & Fisher, 2005, p. 203). A total of 1021 students from 31 science classes from grades 9 and 10 in 7 different private co-educational schools made up the sample. Results indicated that the WIHIC could be used with confidence in India. It was verified that there were differences in students' perceptions of the learning environment associated with cultural background. A Kashmiri student group had the most positive perceptions of classroom environments and teacher interactions, whereas a Dogri group held the most negative perceptions.

Allen and Fraser (2007) administered a modified WIHIC questionnaire to 520 grade 4 and 5 students and 120 parents in South Florida to investigate science classroom

learning environments based on both students' and parents' perceptions of actual and preferred environments. The students came from 22 classes in three schools. It was found that students and parents alike preferred a more positive classroom environment than the one perceived to be actually present.

In the Ogbuehi and Fraser (2007) study, modified forms of CLES, WIHIC and TOMRA (Test of Mathematics Related Attitudes) were administered to 661 middle school mathematics students in California. These 13–14 year-old, grade 8 students from low socioeconomic backgrounds came from 22 classes in four inner-city schools. A subsample of 101 students was also used in evaluating an innovative teaching strategy involving Cramer's rule for teaching systems of linear equations. The results once again confirmed the validity of the WIHIC as well as positive associations between learning environments and students' attitudes to mathematics.

Opolot-Okurut (2010) used a modified version of the WIHIC with a sample of 81 students (19 male, 62 female) from senior three level (S3) whose ages ranged from 14–20 years. Two schools in Uganda were used, with one school being high performing (HP) and the other being low performing (LP). The study sought to identify differences concerning student perceptions of classroom environments by school type. It also investigated whether the WIHIC could reveal associations between student perceptions of mathematics classroom learning environments and motivation towards the subject. It was found that differences did exist in their perceptions by school type, with students in HP viewing classroom environments more favourably than LP students. Results also indicated that there was a positive and significant association between motivation and all WIHIC scales, with the exception of the Cooperation scale in the LP school.

Waldrip, Fisher and Dorman (2009) used the WIHIC with 150 teachers and 3000 middle-school students (years 5–9) in 150 classrooms in Australia to identify exemplary teachers by using students' perceptions of their science classroom learning environments. As in many previous studies, the validity of WIHIC was once again confirmed. It was found that exemplary teachers could be identified through the use of WIHIC scales.

Wahyudi and Treagust (2004) undertook a cross-validation of an Indonesian-language version of the WIHIC in lower-secondary school science classes in urban, suburban and rural areas of Indonesia. 1,400 students from 16 schools and 72 classes constituted the sample. Results indicated that the WIHIC was reliable and valid. Students preferred a more favourable learning environment than what was actually experienced. Females had more positive perceptions of learning environments than did males. School location also affected students' perceptions of learning environments.

Zandvliet and Fraser (2005) investigated internet-resourced settings in Australia and Canada. The sample consisted of 1040 secondary students from 81 senior classes. The WIHIC, case studies and student/teacher interviews were utilised in this study. Ergonomic features, as well as physical and psychosocial aspects of the learning environment, were examined. Five scales from the WIHIC were used (Student Cohesiveness, Involvement, Autonomy, Task Orientation and Cooperation). Items from TOSRA were also used to assess students' satisfaction with regards to their learning. The study supported the reliability of the five WIHIC scales used in the research. Students saw the learning environment in a positive light. Both students and teachers reported high degrees of student cohesiveness, involvement, task orientation, cooperation and satisfaction. Both groups also viewed autonomy/independence in these environments as low.

Aldridge, Fraser and Huang (1999) incorporated the WIHIC and TOSRA instruments in their cross-national study involving 1,081 year 8 and 9 science students from 25 schools in the Western Australian setting and 1,879 year 7–9 students from 25 Taiwanese schools. The researchers used English and Chinese versions of instruments and also made use of qualitative data involving interviews, narratives and observations. According to WIHIC scales in this study, Australian students viewed their learning environments in a more favourable light, whilst Taiwanese students held more positive attitudes. Because of its multiple research methods, this study unearthed interesting and differing socio-cultural circumstances that influence classroom environments. Once again, the reliability and validity of the WIHIC were demonstrated in this study.

Having now discussed the WIHIC instrument used in my research and examined numerous studies involving its use, it is now appropriate to turn attention to the topic of transition, which is a major focus of this particular study.

2.6   Transition

This primary–to–secondary school transition coincides with puberty and thus developmental changes accompany this particular journey. Barber (1999) refers to this transfer process as a set of five bridges which all have to be crossed at once: bureaucratic; social and emotional; curriculum; pedagogy; and management of learning. This problem of transition in the context of the teaching of mathematics was also highlighted by the Cockroft Report (1982, paragraph 429) which stated: "We believe that the greatest problems exist on transfer to secondary or upper school." In view of the above, it is not surprising that this transition is often a difficult one for many students to traverse.

Obvious changes that mark this transition are (1) changes in the size of the school, (2) changes in the number of teachers and (3) departmentalised teaching. In relation to the first point, changes in school size refers usually to moving from a small primary school with few buildings (usually single storied), few classrooms and fewer students to a larger secondary school campus with many students and multiple buildings (usually two storied). These secondary school buildings usually contain many classrooms, laboratories, specialised areas for Drama, Music, Art, Technical studies, Computing, Home Economics, resource areas, and administration areas, etc. In addition, the secondary school sector generally has considerably larger and superior sporting facilities such as multiple sports ovals and gymnasiums. This change in the physical environment can be overwhelming for some students, who express fear of getting lost or being bullied (Ashton 2008; Power & Cotterell, 1979; Yates 1999; Zeedyk, Gallacher, Henderson, Hope, Husband and Lindsay, 2003). In an English and Scottish study involving primary and secondary students conducted by Zeedyk et al. (2003), it was found that bullying (31% primary and 48% secondary) and getting lost (13% primary and 23% secondary), along with peer relations and workload, were aspects of secondary school that worried children the most, with 30% of primary parents also concerned about bullying. Arowosafe and

Irvin (1992) found that the chief concerns of students making the transition were about getting lost, personal safety, making friends and academic success. Urdan, Midgley and Wood (1995) point out that, in middle schools, there is less parent involvement, students are usually separated by ability, schools are larger and more bureaucratic, there are more administrative positions (e.g. principal, assistant principal, seniors, etc.), and subject specialists tend to identify with their department rather than the school. Also the time allocation for lessons is externally determined in middle schools whereas, in the elementary-school setting, individual teachers determine this.

Noyes (2006) contends that three intersecting fields to help shape and determine a student's 'turbulent' transition from primary to secondary school. These three fields of peer, family and school have competing tensions and struggles exist between fields, resulting in differing levels of harmony/dissonance and compliance/resistance. Noyes (2006) states that "school transfer acts like a prism, diffracting children's social and learning trajectories" (p. 43).

In a study initiated by Mitman and Packer (1982), a Concerns Questionnaire was administered to 208 students in their first year of junior-high school. The questionnaire listed 32 potential concerns and was administered during the 5th week of school to gauge and compare students' concerns on first entering high school and again five weeks later. It was found that most students did not have any great concerns regarding the listed items. Most of the concerns held by students both at the beginning and now stages comprised: excessive homework; making it to class on time; being given difficult schoolwork; and ability to complete work on time. A possible weakness of this study is the relatively short time span (five weeks) allowed for students to acclimatise and develop proper work and study routines in a new learning environment. A better approach would have been to delay the survey until at least several months had elapsed.

Rice (1997) refers to this transition as disruptive and unsettling and likens it to changing jobs in the adult world, in order to convey the sense of apprehension, fear, anxiety and uncertainty that adults themselves face in such scenarios. Furthermore, she mentions that discontinuities occur in the three areas of physical environment,

work environment and social structures during this school transition, with students being unsure of the rules and expectations of teachers, what classrooms and where, what teachers they will get, what friends they will make and which students to avoid. Rice (1997) also reports findings of the Longitudinal Study of American Youth (LSAY, 1992) which examined the academic progress of 7th to 11th grade students in mathematics and science during middle–to–high school transition. She reported that a negative effect occurs in students' academic progress in mathematics during this transition phase. She recommends that more meaningful orientation programmes be instigated in high schools and that greater continuity could be achieved by greater and better degrees of communication between teachers by exchanging information on the child's interests, learning styles, etc.

In a similar vein, and specifically with relation to mathematics, Cockroft (1982, paragraph 430, p. 125) contends that "both primary and secondary teachers need to acquaint themselves with the methods and materials which each uses". Some 30 years later, nothing much seems to have changed in this regard, when one considers the following statement cited in Howe and Richards (2011): "…the dominant education system in England has resulted in the creation of 'two tribes', namely primary and secondary teachers. In general there is very little understanding and valuing of the diversity of experience and expertise across these 'two tribes'" (Sutherland et al., 2010, p. 62). I believe that, from a historical and current perspective, the Australian system also reflects this 'two tribes' mentality. In a study tracking design and technology project work of students across transition, Stables (1995) found a discontinuity between primary and secondary activities in technology, as well as believing in a need for greater collaboration across the two sectors.

Midgley, Feldlaufer and Eccles (1989) undertook a longitudinal study in Michigan, USA, of 1301 students and the teachers whom they had for mathematics before and after the transition to high school. The study investigated differences in students' perceptions of teacher supportiveness before and after transition and the influence of the changes on students' valuing of mathematics. When students changed from primary teachers whom they viewed as providing low support to secondary teachers deemed as providing high support, the intrinsic valuing of mathematics was

enhanced. On the other hand, sharp declines in intrinsic value, usefulness and importance of mathematics were reported for students who moved from teachers viewed as providing high support to teachers seen as being low in support. Low-achieving students who moved from more-supportive to less-supportive teacher environments faced a sharp decrease in the value of mathematics. A possible explanation is that such low-achieving students possibly give up early in this subject and never choose it as an elective when it is not a compulsory subject in later years of schooling. Similar findings were conveyed by Bru, Stornes, Munthe and Thuen (2010) in a Norwegian study in which teachers were perceived as being less supportive by secondary students than their counterparts in primary school, with the authors reporting "no abrupt negative changes between primary and secondary school, but, rather, a linear downwards tendency for perceived teacher support" (p. 529).

In another study, Feldlaufer, Midgley and Eccles (1988) examined student and teacher perceptions of classroom environment during mathematics instruction in 117 sixth-grade elementary classes and then, in the following year, 138 seventh-grade junior-high school classes. A deterioration in student/teacher relationships also emerged after transition. Students felt that teachers in high school were less friendly and caring and awarded grades less fairly than their primary mathematics teachers. This was confirmed by classroom observations by observers. Feldlaufer et al. stated that: "After transition students were given less opportunities for input, interaction and cooperation; whole class task organisation and the use of social comparison increased…" (p. 133).

In an American study, Felner, Primavera and Cauce (1981) examined 250 secondary students' records to determine the relationship between school transfer and academic adjustment. They found that transition had a significant negative effect on academic performance and attendance, with the proportion of students achieving less than an average grade of C increasing from 22% in eighth grade to 40% in ninth grade. Absences for more than 20 days increased from 23% to 45% across the transition.

Elias (2002) views the transition from elementary to middle school as effectively destabilising students and thus requiring them to re-establish their sense of identity in

an environment that is more mature and demanding. Similar to other researchers, Elias cites challenges that students face during the transition as being: bullying and harassment; being disciplined; conflicts with teachers; and peer connections. Furthermore he makes the following statement: "It is a transition that often signals increased referrals to mental health services; the failure of previously successful methods for academic success to match up with more rigorous workloads; the start of smoking, alcohol, drug, violence, and attendance problems; and damage to self-esteem–especially for girls" (p. 41). Felner, Primavera and Cauce (1981) express similar views when they state: "Points of transition have been identified as periods of psychological disequilibrium, marked by both an increased opportunity for psychological growth; and a heightened vulnerability to psychological disturbance" (p. 449). The negative elements contained within both of these statements can be construed as being quite alarming and disturbing when one considers that we are referring to young adolescents in these scenarios.

Within the Australian context, similar disturbing trends seem to be appearing to emerge when one considers the recent report in the *Sunday Mail* dated January 10th, 2016, in which it was reported that 26,000 children under 16 years of age were using antidepressants in 2012–2013. The article reports that, according to the Department of Human Services, the use of such antidepressant drugs for this age bracket increased 42% in the four years to 2013. There should be great concern voiced and raised about this, because such drugs have been reported to be associated with suicidal tendencies amongst teenagers. This is a very frightening and extremely worrying aspect to any person in the wider community, but especially to parents, teachers and those involved with the care and well-being of teenagers. A more perturbing and alarming statistic reported within the article and attributed to the Australian Institute of Health and Welfare reveals that 95,425 children under the age of 15 years were using some form of mental health drug.

Lester, Waters and Cross (2013) conducted a longitudinal study involving 3,459 students from Catholic schools in Perth, Western Australia, to investigate the association between connectedness and mental health. The students were surveyed on four occasions from grade 7 to the end of grade 9. Reciprocal relationships were found between connectedness and mental health: increased connectedness with

school was associated with decreased depression and anxiety; and decreased connectedness with school was associated with increased depression and anxiety. The prevalence of symptoms of depression ranged from 9% to 17%, and of anxiety symptoms ranged from 12% to 17%. Both symptoms of depression and anxiety increased after the transition. Depressive symptoms exhibited by males rose from 9% at the end of grade 7 to 15.1% at the start of grade 8, while for females it rose from 8.9% to 12%. Symptoms of anxiety for males rose from 12% at end of grade 7 to 17.4% at start of grade 8, while for females it rose from 11.8% to 15%. More males at the end of year 8 exhibited symptoms of anxiety than females (15.4% compared to 12.8%).

School connectedness refers to the student-held belief that adults in the school care about their learning and about them as individuals (Blum & Libbey, 2004). This concept of connectedness or sense of belonging is also highlighted as being an important factor in studies reported by Ganeson and Ehrich (2009) and Barber and Olsen (2004). Other terms interchangeable with school connectedness and often encountered throughout the literature to describe it are school bonding, school climate, teacher support, school engagement, school attachment, and school involvement (Libbey, 2004). After reviewing the literature, Blum and Libbey (2004) stated that school connectedness is related to better attendance, classroom engagement and educational motivation, as well as to lower rates of behaviour management issues, psychological distress, drug and tobacco use and early commencement of sexual activity. Furthermore, they claim that academic performance, fighting, truancy and drop-out rates can all be impacted by school connectedness. Libbey (2004) lists 9 significant constructs that are related to school connectedness: (1) academic engagement, (2) belonging, (3) discipline/fairness, (4) extracurricular activities, (5) likes school, (6) student voice, (7) peer relations, (8) safety and (9) teacher support.

Earlier, Clarke (1985) also highlighted this lack of a sense of 'belonging' as negatively impacting upon transition as well as the loss of the security and the closeness of the primary school situation, in addition to an increased pace of instruction, greater teacher expectations and more-frequent testing with regards to mathematics. Many authors, such as Demetriou, Goalen and Rudduck (2000), Elias

(2002), Coffey, Berlach and O'Neill (2011) and Chambers and Coffey (2013), refer to this transition from primary to secondary schooling as being a 'rite of passage', while others consider it a 'mismatch' between the learning environment and the demands of emerging adulthood (e.g. Eccles et al., 1993; Feldlaufer et al., 1988; Ganeson, 2006). Demetriou et al. (2000) refer to the decline in motivation after transition and attribute this to the loss of self-esteem in a new, larger and much more competitive learning environment. They emphasise the significance and importance of social interactions and student affiliations during this period of transition. Anderson, Jacobs, Schramm and Splittgerber (2000) also report the negative impact that transition has on self-esteem as well as the disruption it causes for girls' peer relations. They also suggest that prior problem behaviour and low academic achievement impede successful transitions because the latter means that students are not properly prepared for the next level of schooling. Zanobini and Usai (2002) are amongst others who also share the view that transition affects self-esteem, in addition to motivation and scholastic achievement.

This sense of 'belonging' is also reflected in a study by Humphrey and Ainscow (2006) and listed as a key benefit of their Transition Club initiative. They believe that "the instilment of a sense of belonging…is a crucial feature as pupils struggle to adjust to the complex and often daunting secondary environment" (p. 324). They also contend that providing this sense of belonging helps to develop a sense of 'community' and positive self-esteem. A recent South Australian study by Skrzypiec, Askell-Williams, Slee and Rudzinski (2015) also examined, amongst other things, school connectedness and support, bullying and mental health amongst 1,930 students aged 13–15 years with special educational needs and disabilities. Results revealed that 82.3% of students without special needs reported a sense of school connectedness compared with 68.5% of students with special needs. 85.1% of students without special needs felt supported at school in comparison to 75% of those with special needs.

Bond, Butler, Thomas, Carlin, Glover, Bowes and Patton (2007) surveyed 2,678 students from 26 secondary schools in Victoria, Australia, in the study of social connectedness and school connectedness. Their purpose was to research how these two entities, at the commencement of secondary school, impacted on mental health

and drug abuse two years later and academic achievement four years later. The best outcomes were associated with having had both good school connectedness and good social connectedness in year 8. Consequently, such students were found to be less likely to experience mental health issues and to engage in behaviours creating health risks. These students also attained good educational outcomes.

Connectedness, referred to as 'relatedness', also appears in a study on Quality of Life (QoL) conducted by Gillison, Standage and Skevington (2008) involving 63 year 7 students in the United Kingdom. Quality of Life (QoL) involves physical and mental health as well as emerging health risk behaviours. The study's authors made a pertinent point when they state: "A time period that poses a particular challenge or threat to adolescent well-being and QoL across several domains is the transition from primary to secondary school" (p. 150).

Topping (2011), in reviewing 88 transition studies, found that students' main concerns were peer relations, self-esteem and external support networks. Teacher concerns were academic decline, curriculum problems and how to rectify them, students with disability and special groups. 40% of students still struggled to adjust after one year had elapsed. He also mentions that the peer standing of students changes as they move from being "big fish in a little pond (the BFLP effect) to minnows in an uncharted ocean" (p. 270). Tonkin and Watt (2003) also refer to this BFLP.

Chambers and Coffey (2013) outline the development of a mobile-optimised website designed to ease the transition of students with special needs. Six key areas identified and addressed by the website are preparation (getting ready), friendships (social skills), planning and organisation, cyber safety, frequently-asked questions, information about classes and teachers, and key contacts (My Info). The authors contend: "As technology is now being used for a wide range of purposes, it can also be a potential tool in supporting the transition of students with special needs from primary to secondary settings" (p. 83).

A phenomenological psychological study conducted by Ganeson and Ehrich (2009) required 16 students from one school in NSW, Australia, to keep a journal and record

their experiences and feelings for the first ten weeks of school. The school utilised year 11 students to act as peer support leaders. The authors reported that: "The friendly and informative support of the Peer Support leaders eases transition and allows year 7 students to feel safe" (p. 68). They also maintain that a sense of self-assurance and achievement of goals can facilitate and improve the transition to high school. In addition, the integration of students into secondary school, and whether or not their learning is enjoyable or boring, depends upon the skills and approaches of individual educators/teachers. Their perspective is that, essentially, tensions during the transition can be reduced if support is provided by peers, high-school teachers and older peers.

The Wigfield et al. (1991) four-wave design study in the USA involved 1850 students from elementary and junior-high schools and examined achievement self-perceptions in four domains (mathematics, English, social activities, sports). It involved two waves of data being gathered in the year before transition (grade 6) and two waves in the year following transition (grade 7). There was a steady decline in the students' liking of mathematics and sports across all four waves. Students' self-concepts of ability and liking of activities across all four domains were found to be more negative immediately after transition, as was lower self-esteem. The authors contend that such declines can be attributed to the disruption of young adolescents' social networks during such transitions. Other reasons given for the declines were the existence of less positive student–teacher relationships in high school, stricter and more demanding assessment practices, and less efficacious high-school mathematics teachers. It was also found that the differing classroom environments between elementary and junior-high school played a major role in declines in students' self-perceptions of ability in the mathematics and English domains. Among other findings were that: boys revealed higher self-esteem for all four waves; for mathematics and sport, boys possessed higher self-concepts of ability compared with girls; and, with respect to mathematics, girls held less positive views of their ability. Two other studies that support the hypothesis of a negative decline in girls' beliefs and attitudes concerning mathematics across transition to junior-high school are Eccles (1984) and Eccles et al. (1983).

As evidenced in the foregoing, the transition from primary to secondary schooling is largely associated with a host of numerous and wide-ranging negative features. A recent study by Jago et al. (2012) even reports a decline of 12–16% in physical activity. That study examined Moderate to Vigorous Physical Activity (MVPA) in students and reported that an increase in the number of friends between primary and secondary school was associated with an increase in after-school and weekend MVPA. There was a decline of 16% in boys' after-school MVPA compared with a 12% decline for girls after the transition.

Primary–to–secondary transition, along with the difficulties inherent in such transfers, has been explored in this section together with specific studies relevant to this transfer process. The following Section 2.7 examines the notion of mathematics anxiety, which was an important construct included in my study, from a historical vantage point. Specifically, Section 2.7.1 considers the measurement of mathematics anxiety and Section 2.7.2 is devoted to past research on mathematics anxiety.

2.7   Mathematics Anxiety

Literature appears to suggest that research interest in the area of mathematics anxiety evolved during the 1950s with the coining of the term 'mathemaphobia' in a 1954 article written by Sister Mary Gough (a mathematics teacher) titled Why Failures in Mathematics? Mathemaphobia: Causes and Treatments. Sister Mary Gough likens it to an insidious disease as prevalent as the common cold and points out that "it has usually reached the chronic stage long before the pupil-patient recognises it or the teacher-physician even suspects its presence. All too often the disease has proved fatal before its presence is detected" (Gough, 1954, p. 290). Dreger and Aiken's (1957) publication The Identification of Number Anxiety in a College Population is also attributed with generating further research interest in this phenomenon of mathematics anxiety. Another term for this type of anxiety is 'mathophobia' or 'numerophobia' which Crypton (1981, p. 121) describes as a "fear and loathing of dealing with even the most elementary numbers and numerical functions". Lazarus (1975) credits the coining of the term 'mathophobia' to Jerrold Zacharias, a physicist and educator.

However, my view is that it is safe to surmise that mathematics anxiety or 'maths anxiety' (as it is more commonly referred to) has existed and permeated throughout the ages. Primitive stone-age man, when drawing representations on cave walls of his hunting encounters with wild animals, was probably the first to experience some type of mathematics anxiety, especially if there were more than three animals involved. Primitive societies and their notions of 'one', 'two', 'many' (Smeltzer, 1962) are prevalent in such scenarios. The biblical figure of Noah would probably have also experienced some form of mathematics anxiety when God commanded him to build a three-storied ark with a length of 300 cubits, breadth of 50 cubits, and height of 30 cubits (Holy Bible, 1911, p. 9). The further added stress of collecting specified pairs of animals in the limited timeframe for building before the flood would have contributed to enormous anxiety and stress levels for Noah. The human sacrificial practices of the Aztecs and Mayans would have also placed considerable stress upon the priests who engaged in the process of offering human sacrifices to appease the gods. The number of human sacrificial victims required for the Aztec re-consecration of the Great Pyramid of Tenochtitlan in 1487 has been estimated by Hassig (2003) and Hanson (2000) to have been between 10,000 and 80,400. This would have, at the very least, caused some form of mathematics anxiety among the priests who had to preside and oversee the sacrificial festivities and subsequent catering arrangements.
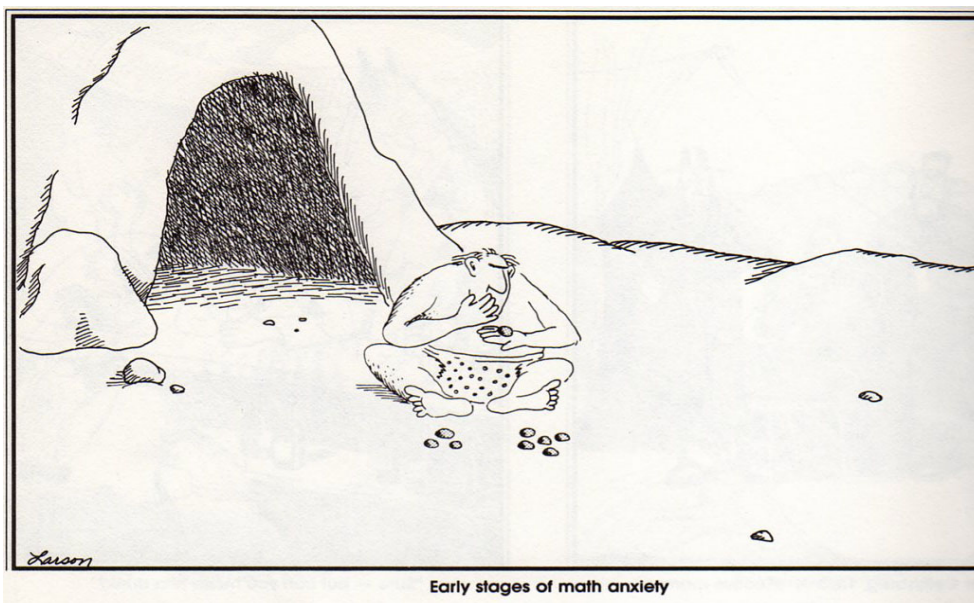
Early stages of math anxiety

Further examples of probable mathematics anxiety existed throughout the annals of history. Right across the historical spectrum, from Babylonian, Egyptian, Ancient Greek and Arabian societies, etc., some school children, as well as certain adults, would have experienced a much milder and weaker strain of this affliction when confronted with mathematical situations. Warwick (2000) relates that, in ancient Greece, education was based on gender, with boys at age seven years beginning to study the subjects of literacy, music, physical education and mathematics. The education of girls was not considered to be of high importance both in ancient Greek and Roman times. In Roman education, up to the age of 12 years, reading, writing and arithmetic were taught to children, with advanced arithmetic available in middle school. According to Sanford (1958), Plato held the view that free-born citizens should partake in the study of calculation, the theory of numbers, mensuration and astronomy. Many sources report that the words "Let no one ignorant of geometry enter here" were carved above the entrance to Plato's Academy in ancient Greece. This surely must have contributed to much consternation and to considerable mathematics anxiety amongst certain prospective students who entered the academy.

This notion of mathematics anxiety would have existed to a significantly lesser or minimal degree in these ancient societies, firstly because of the general lack of mass formal schooling during these eras, during which the lofty domain of mathematics and its study was confined to learned scholars or select groups of "priests of ancient Egypt, the merchants and astrologers of Babylonia, the philosophers of Greece, the practical Romans, the scholar-monks of the Dark Ages and of medieval times, the poet-minded writers of India, and the Arabs…" (Sanford, 1958, p. 71). A second

reason for the lesser severity of mathematics anxiety during these periods is the reduced content or repository of mathematics knowledge available at these times compared with the present era (Sanford, 1958; Smeltzer, 1962). For example, the more-recent history of mathematics has provided us with new branches of mathematics such as algebra, calculus, newer non-Euclidean geometries (Bolyain, Lobachevskyian and Riemannian), statistics, topology, set theory, game theory, etc. Devlin (2000) succinctly highlights this point when he mentions that, at the beginning of the 20th century, about 80 books would have held the world's mathematical knowledge, whereas today it would need about 100,000 volumes! Some of this former university-domain content has been diluted and filtered down into the secondary-school mathematics curriculum, which has resulted in an expansion of subject matter for the student to assimilate, which in turn could contribute to increased levels of mathematics anxiety.

According to Sanford (1958), the Renaissance period (1300–1700) generated interest in education and, as a result, led to the establishment of schools referred to as gymnasia in Germany, grammar schools in England, and Schools of the Teaching Orders in France and Italy. Gutenberg's invention of the printing press in around about 1440 enabled mass printing and further widespread dissemination of textbooks, etc. The establishment of such schools in conjunction with the availability of text print material would have made education, and in particular mathematics education, more accessible to a much wider audience and, as a result, mathematics anxiety levels would have increased substantially during this period.

Naturally, for the non-academic or lay populace who are not conversant with this scourge or malady, certain questions might begin to emerge. Is it spread through physical contact with carriers of the disease or is it insidiously airborne or perhaps even hereditary in its nature? Like many modern ailments, has it become resistant to antibiotics? Can one be vaccinated against it? Will a cure ever be discovered, so that it can be permanently eradicated from all learning environments? Such questions will hopefully be addressed in what is to follow.

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Adams (2001), in a highly-humorous and purely-facetious account, refers to mathematics anxiety as the 'poison ivy of the soul' and outlines a 26-item checklist of its symptoms. He outlines a process by which one can determine if one has it: "For each of the symptoms that you checked off, write down the number 6.9986. Add these numbers together. Divide by 2π. Take the natural log of the result. Add 1.145 and subtract 1.946. Exponentiate the result. If you are now sweating profusely and feel as if you have eaten bad tuna, you have math anxiety" (p. 49).

Ashcraft and Moore (2009, p. 197) refer to mathematics anxiety as "a person's negative affective reaction to situations involving numbers, math and mathematics calculations." Hunt (1985, p. 32) explains it as follows: "The term maths anxiety has been used to describe the panic, helplessness, paralysis and mental disorganisation that arises among some people when they are required to solve a mathematical problem". Richardson and Suinn (1972) define mathematics anxiety as involving "feelings of tension and anxiety that interfere with the manipulations of numbers and solving of mathematical problems in a wide variety of ordinary life and academic situations" (cited in Aksu & Saygi, 1988, p. 391). Guillen (1984, p. 2) states that "math anxiety is the pathological dread and unabashed humility that mathematics

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evokes in hundreds of millions of people". This statement suggests that the ailment itself exists in epidemic proportions! Furthermore, in an article in *The Guardian* dated 1st May 2012, it is stated that more than 2 million schoolchildren and thousands of teachers suffer mathematics anxiety. Maloney et al. (2014) estimate that 20% of the population have a high degree of mathematics anxiety.

Catlioglu, Birgin, Costu and Gurbuz (2009, p. 1578) claim that mathematics anxiety "should be regarded from a larger perspective as a complex construct of "affective, behavioural and cognitive responses to a perceived threat to self-esteem which occurs as a response to situations involving mathematics" (Atkinson, 1988, p. 18). Furthermore, Catlioglu et al. (p. 1578) explain that "feelings of anxiety can lead to panic, tension, helplessness, fear, distress, shame, inability to cope, sweaty palms, nervous stomach, difficulty breathing, and loss of ability to concentrate". Sheila Tobias (2013) contends that "math anxiety is a response, over time, to stress in the math classroom where tests are frequently given under time pressure, in the home where there is competition with siblings, or at the workplace" (in Finlayson, 2014, p. 100). Hembree (1990) views mathematics anxiety as an omnibus construct which poses a threat to overall achievement and participation in mathematics. He sees students' avoidance of mathematics as leading to reduced career options, thereby ultimately affecting the nation's science and technology foundations. Guillen (1984, p. 2) appears to be in agreement with this view when he makes the following statement in relation to one being afflicted with mathematics anxiety: "it means being deprived of any intimate understanding of our complex technological world. And without such an understanding, a person is merely a spectator, rather than a participant, in the world".

Susan Greenfield, a leading neuroscientist, says "anxiety is a persistent worry, a compulsive iteration and reiteration of a suite of events that have not actually happened—an abnormally extensive and enduring neuronal constellation" (2001, p. 122). She further notes that the use of antianxiety drugs such as Librium and Valium have been successful in lessening the effects of anxiety. By no means am I suggesting or advocating the use of such drugs to combat mathematics anxiety amongst the ranks of students who may be afflicted by it.

2.7.1   *Measurement of Mathematics Anxiety*

Many instruments have been constructed, adapted or modified over time in attempts to measure mathematics anxiety. The initial pioneering work in this sphere is

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considered to be the Math Anxiety Rating Scale (MARS; Richardson & Suinn, 1972). This 98-item instrument had a 5-point response scale ranging from (1) low anxiety to (5) high anxiety. Because the MARS was widely considered to be lengthy, cumbersome and time-consuming, researchers have attempted to construct shorter and more practical instruments.

Over the years, the MARS has been subjected to many transformations to emerge in the form of new instruments designed to measure mathematics anxiety. The Fennema-Sherman Mathematics Anxiety Scale (MAS; Fennema & Sherman, 1976) then appeared on the research scene followed by the Sandman Anxiety Towards Mathematics Scale (ATMS; Sandman, 1980). A compact 24-item version developed by Plake and Parker (1982) from the original MARS, and known as the Math Anxiety Rating Scale – Revised (MARS-R) was soon added to the stockpile of instruments. The MARS-E, designed for children in grades 4 to 6, was introduced to the academic community in a study by Suinn et al. (1988).

Attempts to create shorter instruments to measure the type of anxiety under consideration followed. One of these was the 11-item Mathematics Anxiety Questionnaire with a 7-point response scale developed by Wigfield and Meece (1988). This was soon followed by the Abbreviated Math Anxiety Rating Scale (sMARS; Alexander & Martray, 1989). Chiu and Henry (1990) presented the Mathematics Anxiety Scale for Children (MASC) as suitable for use with children from 5th grade to middle school. Another instrument, developed to examine test and problem-solving anxiety among children in grades 3 through 6, was the Mathematics Anxiety Survey (MAXS) of Gierl and Bisanz (1995). Thomas and Dowker (2000) produced a Math Anxiety Questionnare intended for 6 to 9 year-old children. Later, a compact 9-item instrument known as the Abbreviated Math Anxiety Scale (AMAS; Hopko, Mahadevan, Bare, & Hunt, 2003) then entered the array of instruments available to researchers in this field. A more-recent addition is the Scale for Early Maths Anxiety (SEMA), which was developed by Wu et al. (2012) and which contains 20 questions and specifically caters for 2nd and 3rd grade children. Quite surprisingly, there also exists, as the name suggests, a Single-Item Math Anxiety Scale (SIMA) reported by Nunez-Pena et al. (2014). This particular SIMA

instrument simply asks: "On a scale from 1 to 10, how math anxious are you?" Responses are on a scale ranging from 1 (not anxious) to 10 (very anxious).

2.7.2 Past Research on Mathematics Anxiety

There are many studies that have explored this concept of mathematics anxiety, with many reporting similar findings. When Finlayson (2014) attempted to gauge the experiences of mathematics anxiety amongst 70 Canadian preservice teachers, the causes of this type of anxiety were a lack of self-confidence, a fear or failure, teaching styles, ineffective learning practices and non-engagement of students.

Among suggestions for teacher strategies were encouraging risk taking, practising in mathematics, diversifying teaching strategies and assessment practices, presenting mathematics in a slow pace and engaging students.

Dossel (1993) outlines eight factors which lead to creating mathematics anxiety:
- Personality factors
- Pressure of perceived authority figures
- Time pressure
- The effect of public failure
- The right-wrong dichotomy
- Constructive criticism
- Competitive classrooms
- Student perceptions of the causes of difficulty in learning environment.

There are conflicting claims as to when mathematics anxiety begins. Scarpello (2007, p. 34) states that "Math anxiety can begin as early as fourth grade and peaks in middle school and high school", while Ramirez et al. (2013) suggest that children as young as first and second grade display symptoms of mathematics anxiety. Jackson and Leffingwell (1999) found that, for some children, this type of anxiety began as early as kindergarten or first grade. Scarpello (2007) also goes on to outline the causes of mathematics anxiety as being past classroom experiences, parental influences, and remembering poor past mathematics performance.

Birgin et al. (2010) outlined a Turkish study involving 220 grade 6–8 students who were surveyed with the Personal Information Form and Mathematics Anxiety Scale for Elementary School Students (MASSES) to determine mathematics achievement levels, perceived enjoyment of mathematics teaching method (PET), perceived enjoyment of mathematics (PEM), and perceived help with mathematics from parents (PPM). Boys in eighth grade revealed the lowest levels of all of the above but displayed the highest level of mathematics anxiety. Mathematics anxiety scores were interpreted as medium-high for both girls and boys in year 8.

In a study to determine the first occurrence of mathematics anxiety in a group of students from kindergarten to college, Jackson and Leffingwell (1999) surveyed 157 beginning teachers (average age 26 years) from a senior-level elementary-mathematics class. Eleven students reported having had only positive mathematics experiences throughout Kindergarten to college, while the remaining 146 students surveyed, formed three evident clusters of grade levels:

1. Elementary level, especially grades 3 and 4
2. High-school level, especially grades 9-11
3. College level, especially freshman year.

Approximately 16% of those surveyed indicated experiencing mathematics anxiety during elementary level schooling, 26% during high school and 27% during college. The high-school level cluster reported that certain aspects of teacher behaviour negatively impacted on student attitudes and achievement. These included angry behaviour and unrealistic expectations of instructors, embarrassing students by forcing them to do problems on the board that they could not understand, girls being ridiculed for not understanding material, and insensitive and uncaring attitudes of teachers.

Gierl and Bisanz (1995) examined students' measures of mathematics anxiety, school test anxiety and attitudes towards mathematics in a study involving 95 students (47 from grade 3 and 48 from grade 6). They utilised several instruments: the Maths Anxiety Survey (MAXS) to assess mathematics test anxiety and mathematics problem-solving anxiety; the School Test Anxiety Survey (STAS) to

differentiate mathematics test anxiety from school test anxiety; and the Mathematics Attitude Survey (MATS) to determine students' attitudes in relation to mathematics. Results indicated that grade 6 students displayed higher levels (low to moderate) of mathematics test anxiety than younger students. Older students also displayed more positive attitudes towards mathematics in comparison with younger students. Students at both grade levels reported mathematics test anxiety results which were lower, on average, than school test anxiety results. Six attitudes were examined, namely, usefulness of mathematics, intrinsic value, worry, confidence, perceptions of parents' attitudes towards mathematics, and attitude towards success. Older students returned higher scores on attitude towards success, worry, and usefulness of mathematics than did younger students. There was no difference between the two groups on intrinsic value, confidence and parents' attitudes towards mathematics. Additionally, no notable sex differences in anxiety or attitude measures were discernable.

In a Turkish study, Olmez and Ozel (2012) examined mathematics anxiety among 120 6th grade and 124 7th grade elementary students in Fethiye. They made use of a Math Anxiety Scale (MANX) comprised of 45 questions which utilised a 4-point frequency response scale (1=Never, 4=Always). In addition, a Personal Information Form (PIF) was used to gauge gender, grade level, perceived appreciation of the mathematics teacher, mathematics achievement, type of school, parents' education and number of siblings. Among the findings were that males displayed greater anxiety. Also, and not surprisingly, students who reported enjoying mathematics returned lower anxiety scores than students who did not enjoy mathematics, and students who liked their teachers more had lower anxiety levels. There was also a negative correlation between students' mathematics anxiety levels and students' mathematics achievement, with this correlation being larger for seventh graders.

Aarnos and Perkkila (2012) developed a pictorial test of 37 pictures for children aged 6 to 8 years in order to look for early signs of mathematics anxiety. The Picture Test comprised 16 photographs, 12 drawings and 9 mathematical tasks. Children were required to look at one picture at a time and write down spontaneously their emotional and mathematical ideas. A total of 300 children in 23 classes from preschool to grade 2 constituted the sample. A three-point smiley-face Likert scale

(3=happy, 2=neutral, 1=sad) was used. Children's mathematical expressions related to each picture were assigned scores on a 0–6 scale with 0=nothing, 1=numbers, 2=exercises (e.g., 2 + 3), 3= solved exercises (e.g., 2 + 3 = 5), 4=amount expressions and comparisons, 5=word problems and 6=mental models. Children were asked the following:

1. Is there any kind of mathematics in the picture?
2. How do you feel while finding mathematics in the picture?
3. Please write down your own mathematical ideas about the pictures.

The researchers reported the following: "Children expressed the saddest emotions towards the fairy-tale pictures of a spider, a cat, and a bee without making any mathematical marks. These difficulties and sad emotions might be an early sign of math anxiety" (Aarnos & Perkkila, 2012, p. 1497). This latter statement, I feel, needs to be looked at with a lens of greater magnification and critical focus. Firstly, linking sadness with difficulties is quite a significant jump, because these difficulties could have been attributed to other factors. Secondly, why and for what reasons did these pictures evoke the saddest responses? Thirdly, this age group (6–8 years) is at a developmental stage that does not enable them to make fine distinctions and connections in a mathematical sense. Lastly, the wording of the last question in the Picture Test ("Please write down your own mathematical ideas about the pictures") is somewhat complex and difficult for such young children to fully comprehend, and therefore it could have presented difficulties for many of the children surveyed. The study reported statistically significant Pearson correlations ranging from -0.41 to -0.62 between the subject matter of the Pictorial Test and children's sadness. A high negative correlation was also found between sadness and mathematics productions (r=-0.60). In order to lessen mathematics anxiety, Aarnos and Perkkila advocate the use of animated pedagogical agents and a Regio Emilia Approach which engages children in real-life mathematics activities.

In a study in North Cyprus by Yaratan and Kasapoglu (2012), 188 eighth-grade students from urban and rural schools were administered attitude and anxiety scales to examine the differences in anxiety, attitudes and achievement in mathematics based on gender and school location. The Mathematics Attitude Scale and the

Mathematics Anxiety Scale, which the researchers report had excellent Cronbach alpha reliability coefficients of 0.937 and 0.920, respectively, were used. Students' mid-term mathematics examination scores, obtained from the school, were also used in the study. The researchers reported that urban school students had higher achievement and less positive attitudes in mathematics than their rural counterparts. There was no significant difference between students' anxiety scores based on school location and gender. Generally, females displayed more positive attitudes and attained higher mathematics scores than males. Multiple regression analysis revealed that gender, school location, attitudes and anxiety accounted for about half of the variance in mathematics achievement. The strongest contributor to variance was students' anxiety levels, while the weakest was gender. The authors concluded that attitude and anxiety are strong predictors of mathematical achievement over and above gender and school location.

Yaratan and Kasapoglu (2012) also identified the factors that researchers have found to shape and determine the nature of attitudes towards mathematics: parents, teachers, teaching methods, peer groups, society, students' self-confidence, students' motivation, students' previous experiences and teachers' evaluations. They hold the view that anxiety towards mathematics develops because of negative classroom experiences, poor mathematics performance, negative teacher behaviours, environmental pressure and parental influences.

Heydari and Abdi (2013) reported a study of the relationship between students' mathematics anxiety and the personality characteristics of their mathematics teachers. Their sample consisted of 480 students from first, second, third and pre-university grades and 60 of their mathematics teachers. The researchers used the Maths Anxiety Rating Scale (MARS) and the Neo Personality Inventory (Neuroticism, Extraversion, Flexibility, Pleasance, and Responsibility). The authors concluded that "there is a significant relationship between the personality characteristics of male mathematics teachers and boys' anxiety in both extroversion and responsibility factors. While in the measurement of personality factors of female math teachers, there is a significant relationship between four personality factors of neuroticism, flexibility, pleasance and responsibility, and mathematics anxiety" (p. 1136).

Sengul and Dereli (2010), in a semi-experimental study in Bolu, Turkey, utilised cartoons during the teaching of an Integers topic in mathematics classes to assess its effect on mathematics anxiety. A total of 61 seventh-grade students in primary education were used. Of these, 30 students comprising an experimental group and 31 students in a control group were administered pretests and posttests of the Mathematics Anxiety Rating Scale. There was a six-week gap between testing. Experimental and control groups were selected from two classes which returned close mathematics anxiety levels according to pre-anxiety scale measures. Post-anxiety scale points revealed students' average of 68.80 for the experimental group and 79.90 for the control group. An Independent Sample t-Test resulted in a significant value (p=0.002). The experimental group which used cartoons to assist instruction had a lower level of anxiety than the control group.

The experimental group students' pre-anxiety average was 76.13 compared to the post-anxiety average of 68.80. There was a significant difference between students' pre- and post-anxiety scores for the experimental group. The researchers stated: "When the averages are examined, it can be commented that instruction of integers subject with the aid of cartoons affected experiment group students positively and decreased their mathematics anxiety" (Sengul & Dereli, 2010, p. 2179). The researchers are of the view that the use of cartoons in mathematics instruction can lead to educational improvements, reduce mathematics anxiety and provide success for students. In essence, they believe that the use of cartoons facilitates permanent learning, because it is an activity that is not only entertaining, but also it is visually appealing and requires mental effort.

An interesting study by John-Henderson, Rheinschmidt and Mendoza-Denton (2015) involved 97 female undergraduates at the University of California, Berkeley, USA who underwent a difficult 17-item mathematics examination of 30 minutes duration. This examination was rated as being gender-biased or gender-fair, with participants either receiving reappraisal instructions or not receiving such instructions. As the authors of the study remarked, "the reappraisal instructions encouraged participants to view arousal and anxiety as helpful to test performance" (p. 204). Samples of oral mucosal transudate (OMT) were provided by participants at three stages (pre-

examination, post-examination and recovery) to determine changes in the levels of an immune inflammation marker, cytokine Interleukin-6 (IL-6). These samples provided the following data:

Pre-examination (M=0.45pg/L, SD=0.30)
Post-examination (M=1.98pg/mL, SD=2.52)
Recovery (M=1.82pg/mL, SD=2.44).

Those who received reappraisal instructions (versus no instructions) displayed lower levels of the inflammatory marker (IL-6) at post-examination time. For the gender-biased test framing condition, participants who had not been given reappraisal instructions revealed higher peak levels of IL-6 than all others. Reappraisal also resulted in better test performance under stereotype threat. The researchers point out that one of the limitations of their study is that they did not check upon the smoking behaviour of the participants. I feel that this oversight could be as a serious threat to the validity of this particular study, primarily because of the role that smoking plays as a possible predictor of oral inflammation.

Primi et al. (2014) carried out a study in Tuscany, Italy that involved 215 high-school students and 249 first- and second-year university Psychology students. Primi et al. utilised several instruments, namely, the Abbreviated Maths Anxiety Scale (AMAS), Test Anxiety Inventory (TAI) and Attitudes Towards Mathematics Inventory (ATMI) in the study. An additional questionnaire comprised of three questions was developed for the high-school students in order to obtain details of their future plans. These three questions were as follows:

- Have you already planned your academic/vocational future? Yes/No
- What is your choice? Studying/Working
- If you have decided to continue studying, which major are you going to choose? Humanities and Social Sciences/Science and Technology.

Students who were highly mathematics anxious displayed attitudes that were negative towards mathematics (Betz, 1978). A relationship was found between students' future study choices and major degree faculty, with those who displayed

higher mathematics anxiety avoiding career and degree pathways that required considerable background in mathematics. High-school students revealed higher mathematics anxiety than university students, with Italian high-school girls reporting more mathematics anxiety than male students.

In a South African study, Verkijika and De Wet (2015) wanted to determine if the use of a BCI mathematics educational game (Math-Mind) could assist in reducing mathematics anxiety among students. Convenience sampling was used to gather 36 participants, with the requirement that they had to be aged 9 to 16 years. Data were collected over two different sessions on separate days in an eight-wave data-gathering approach. BCI is a brain-computer interface which decodes brain signals from scalp recordings using a headset which is low-cost and non-invasive. A pretest questionnaire was administered in order to obtain demographic data in addition to mathematics anxiety levels derived from the FSMAS instrument. Participants were able to manage and control anxiety levels with the aid of BCI visual neuro-feedback. It was found that mathematics anxiety is able to be trained and reduced with the use of a BCI mathematics game. The researchers reported that the link between high mathematics anxiety and poor mathematics performance, established by previous studies, was also supported by this study.

Haciomeroglu (2013) administered the Mathematics Anxiety Rating Scale Short Version (MARS-SV) and the Mathematical Belief Instrument (MBI) to 301 elementary preservice teachers in Turkey to determine the relationship between mathematical anxiety and the mathematical beliefs of these teachers. Preservice teachers who displayed higher levels of mathematics anxiety had lower mathematical beliefs, while preservice teachers who displayed low levels of mathematics anxiety had higher mathematical beliefs. This latter group felt that they had the confidence and necessary skills and abilities to become effective teachers.

In another study concerning anxiety, Al Mutawah (2015) used the Revised-Mathematics Anxiety Survey (R-MANX) with 1,352 (grade 8–11) students from 14 middle and high schools in Bahrain. Results indicated that anxiety increases with grade level, with the highest level of anxiety evident among those students who perceived themselves as having low achievement. Al Mutawah reported that the

highest mean anxiety score was obtained for the grade 11 students, while grade 9 students displayed the lowest anxiety levels. According to Al Mutawah, likely reasons for this high level of anxiety in the grade 11 student group could be the complexity of the mathematics curriculum and the more-advanced nature of mathematical concepts.

White (1997) surveyed 48 students (25 acting as a control group, 23 as experimental group) enrolled in Algebra 1 classes across grade levels 9–12 in West Virginia, USA, to determine if teaching techniques and teacher attitudes would help to reduce mathematics anxiety. Both the experimental and control groups were taught by the same teacher who administered the MARS instrument at the outset and then again at the end of 12 weeks. A pretest and posttest on basic algebra skills was also given. The experimental group was provided with positive teacher attitudes and modified teaching techniques which included group, partner, cooperative learning, projects and hands-on activities. No significant differences in mathematics anxiety or academic achievement emerged between the two groups.

Schact and Stewart (1990) found that the use of cartoons in an undergraduate statistics course at Colorado State University reduced mathematics anxiety in the two classes involved. The MARS was administered to students on the first day and the last day of the semester course. Moderate to high levels of mathematics anxiety were prevalent before the course for most students, whereas low to moderate levels of anxiety were reported after the course.

In a similar vein, Godbey (1997) considers that the use of humour reduces anxiety and facilitates learning. She makes an interesting and important statement when she says: "Mathematical cartoons, jokes, puns, riddles, and even certain spontaneous behaviors that contain unexpected or out of context elements become memorable events in the mind of students" (p. 9).

An Iranian study by Abbasi et al. (2013) involving 480 high-school and pre-university students and their 60 mathematics teachers, which utilised the MARS instrument, revealed that mathematics anxiety was significantly higher for females than males. The study also reported a significant negative relationship between the

students' self-esteem and mathematical anxiety. In addition, a significant relationship was found between the mathematics anxiety of students and the personality characteristics of their teachers.

In an innovative study by Wang et al. (2014) in Ohio, USA, 514 twins (average age 12.25 years) involved in a longitudinal study responded to various instruments. Among these were the Revised Mathematics Anxiety Rating Scale of Elementary Students (MARS-E), the Spence Children's Anxiety Scale to measure general anxiety, and mathematics problem solving and reading comprehension tests. In order to determine twin zygosity, genotyping was carried out by saliva sample or buccal swab. The researchers reported that: "Genetic factors accounted for roughly 40% of the variation in mathematical anxiety, with the remaining being accounted for by child-specific environmental factors" (p. 1054).

Another ground-breaking study by Young, Wu and Menon (2012) highlighted the use of functional magnetic resonance imaging (fMRI) with 46 children aged from 7 to 9 years. Data from brain imaging scans taken during arithmetic problem solving by students using the MathWise program was used, in conjunction with the Scale for Early Mathematics Anxiety (SEMA) to measure mathematics anxiety, as well as intelligence and cognitive tests. Mathematics anxiety was found to be associated with hyperactivity in the right amygdala regions of the brain that are considered to be important in the processing of negative emotions and fear. It was found that these particular regions revealed increased activity, while other regions which are associated with working memory and number reasoning had decreased activity. This suggests that mathematics anxiety effectively robs the brain from accessing valuable working memory while it is engaged in processing this flood of negative emotions. The researchers concluded that "math anxiety is stimulus and situation-specific" (p. 500). This particular study is significant because it provides biological evidence for this type of anxiety and helps confirm its existence.

An identical study by Supekar et al. (2015) in San Francisco, USA, also utilised this same functional magnetic resonance imaging (fMRI) with 46 third-grade elementary school children who participated in an intensive MathWise program of one-to-one mathematics tutoring over a period of 8 weeks. The purpose of the study was to

determine if this type of intervention would reduce and remediate mathematics anxiety. The tutoring sessions took place three times per week, with each session lasting approximately 50 minutes. As in the previous study, the SEMA was used to determine the pre-tutoring and post-tutoring levels of students' mathematics anxiety. MRI scans of participants took place before the commencement of the 8-week course and at its completion. This study confirmed Young et al.'s (2012) findings of an association between childhood mathematics anxiety and amygdala hyperactivity. The researchers summarised their study as providing "novel evidence that an intensive well validated math-tutoring program not only reduces math anxiety but also normalizes atypical functional responses and connectivity in emotion-related circuits anchored in the amygdala and in the frontoparietal mathematical information processing system" (p. 12581). These two pinnacle studies by Young et al. (2012) and Supekar et al. (2015) highlight the critical role of the amygdala in mathematics anxiety and demonstrate that the reduction of this type of anxiety can be achieved at both the neuro-biological and behavioural levels. These and other similar fMRI studies, which no doubt will follow, could provide the catalyst for effective strategies to combat and treat mathematics anxiety.

Numerous studies concerning mathematics anxiety abound in the literature and, because further subsequent detailed analysis is beyond the scope of this current enterprise, an attempt is made to briefly summarise several other relevant studies. Marchis (2011) examined anxiety and attitudes towards mathematics among 337 (grade 5–8) secondary-school students in Romania. Students displayed high levels of anxiety, with over 50% being worried about mathematics marks and almost all students feeling nervous before a mathematics class. In a Dutch study with 207 children in grades 3 to 6, Jansen et al. (2013) used the Math Anxiety Scale for Children (MASC), a mathematics performance test and a computer-adaptive program (Math Garden) over a six-week period and found that mathematics anxiety scores improved. In a Latvian study involving 3,077 students from 9th grade, Kvedere (2014) noted that, while the mathematics self-efficacy and self-concept of students from provincial towns and country were higher, their mathematics anxiety was lower when compared with students in towns. Males also revealed a more positive mathematical self than females. Sarkar et al. (2014) reported that the application of transcranial direct-current stimulation (tDCS) to the dorsolateral prefrontal cortex

resulted in improved arithmetic performance and an amelioration of mathematics anxiety among high mathematics anxiety (HMA) adults. However, for low mathematics anxiety (LMA) subjects, this same procedure impaired performance on arithmetic tasks and increased mathematics anxiety, which was measured and marked by an increase in cortisol concentrations (a stress biomarker).

2.7.3   Practical Suggestions for Reducing Mathematics Anxiety

Teachers are likely to be able to reduce mathematics anxiety by incorporating novels, books, comics, films and humour into their teaching of mathematics. In addition, teachers could inject elements from the rich history of mathematics into the subject in order to give it a more human and relevant emphasis. Such calls for 'relevance' and this 'human' aspect abound in the literature and especially in many NCTM statements. All of these combined elements would not only endear the subject of mathematics to students, but they would find it more interesting and it could help reduce mathematics anxiety.

Justification for the use of films in the teaching of mathematics comes from Hebert and Speirs Neumeister (2001) who refer to it as 'guided viewing' that has the potential for therapeutic effects and suggest its use especially among gifted students who might be experiencing personal problems. Newton (1995) refers to it as 'cinematherapy' because its intended purposes, aims and outcomes can be considered identical to those of bibliotherapy. However, the process of cinematherapy does not imply simply viewing a film. The teacher-guided process involves discussions of emotions, feelings, beliefs, attitudes and values with follow-up activities which Hebert and Speirs Neumeister (2001, p. 227) suggest could include "reflective writing, role-playing, creative problem solving, or self-selected options for students to pursue individually". Justification and support for such a view is to be found in Greenwald and Nestler (2004b, p. 29) who state: "The Simpsons is an ideal source of fun ways to introduce important mathematical concepts, motivate students, and reduce math anxiety". Furthermore, these authors mention that a course specifically dealing with the geometry of the universe typically begins with a discussion of the film Flatland (p. 35). Coencas (2007) also regards films as valuable tools that could be used by teachers in many disciplines to help to reduce feelings of

anxiety. He also remarks that "teachers of . . . and math can use movies to transport us to unfamiliar worlds and introduce us to people and ideas beyond the realm of our daily lives" (Coencas, 2007, p. 67). Golden (2001) also advocates the use of film by teachers to engage students.

Among many films that could be considered for the purpose of providing such cinematherapy and a better student appreciation and disposition towards mathematics are *The Simpsons, The Wizard of Oz* (Greenwald & Nestler, 2004b), *Good Will Hunting, Stand and Deliver, Enigma, The Theory of Everything, A Beautiful Mind, The Phantom Tollbooth, Flatland* (Greenwald & Nestler, 2004b), *The Man Who Knew Infinity,* and *Donald Duck in Mathmagic Land.* I have personally found this latter animated film (of approximately 30 minutes duration) to be especially useful for use with both year 7 and 8 students who have always received the film with great appreciation and still fondly remember it many years later. Another film worthy for consideration for this particular age group is the humorous BBC documentary *The Story of 1 (One the Number)* narrated by Terry Jones of Monty Python fame. Further support for the use of films to help reduce mathematics anxiety is provided by Greenwald and Nestler (2004a, p. 2) who claim that films "can alleviate math anxiety, energise shy and quiet students, and provide a creative introduction to an in-depth study of the related mathematics".

Bibliotherapy has been suggested as a means to reduce or overcome mathematics anxiety by many researchers (Furner & Berman, 2003; Furner & Duffy, 2002; Furner & Kenny, 2011; Hebert & Furner, 1997; Lenkowsky, 1987). Dictionary.com defines it as "a form of psychotherapy in which selected reading materials are used to assist a person in solving personal problems or for other therapeutic purposes". Lenkowsky (1987, p. 123) defines bibliotherapy as "the use of reading to produce affective change and to promote personality growth and development". Furner and Kenney (2011, p. 1) state that, "within the past decade or two, children's and adolescent literature has been recognised as a means of teaching mathematics concepts to students through the use of stories to make mathematics ideas relevant and meaningful". Whyte and Anthony (2012) maintain that teachers play a critical role in reducing or preventing mathematics anxiety and suggest a variety of ways in which teachers can achieve this through "building positive attitudes towards mathematics,

… bibliotherapy, and maths related fiction books" (p. 9). Furthermore they suggest that "appropriate children's literature (an example they give is the book 'Math Curse') can also provide a way past the obstructions to understanding and engagement that are erected by those who experience maths anxiety" (p. 10).

Books that could be read personally by teachers with the purpose of perhaps reducing their own mathematics anxiety include *Flatland* by Edwin Abbott, *The Planiverse* by Alexander Dewdney, and *Flatterland* by Ian Stewart. Similarly, books with a mathematical flavour or essence intended to stimulate one's mathematical palate and suitable for student consumption include *The Phantom Tollbooth* by Norton Juster, *Alice's Adventures in Wonderland* by Lewis Carroll, *Gulliver's Travels* by Jonathan Swift, and *The Number Devil: A Mathematical Adventure* by Hans Enzensberger. Other books suited for primary-school students include *Math Curse* (Jon Scieszka & Lane Smith), *Counting on Frank* (Rod Clement), *One Grain of Rice – A Mathematical Tale* (Demi), *A Place for Zero – A Math Adventure* (Angeline Lopresti), and *The Boy Who Loved Math* (Deborah Heiligman). By way of illustration, a sample bibliotherapy lesson plan, each taken from Furner and Kenney (2011) and Hebert and Furner (1997) and based on, respectively, the books *Counting on Frank*, and *Math Curse*, are included in Appendix L and Appendix M, respectively.

Because the roots of mathematics anxiety can be traced back to early childhood, it is of paramount importance for teachers, parents and carers of such children to foster positive attitudes and ignite a love of mathematics amongst their charges so that mathematics anxiety is not permitted to grow in such an environment. In this regard, bibliotherapy, and therefore books, once again come under consideration. Possibilities are countless but could include *The Very Hungry Caterpillar* by Eric Carle, *365 Penguins* by Jean–Luc Fromental, *Leaping Lizards* by Stuart Murphy, and *My Grandmother's Clock* by Geraldine McCaughrean.

Both parents and schools can help to prevent mathematics anxiety. The National Council of Teachers of Mathematics (NCTM, 2000) in its Recommendations for Preventing Math Anxiety lists 10 suggestions (see Figure 2.1). Among other suggestions given by Hackworth (1992), cited in Furner and Duffy (2002), for

reducing mathematics anxiety are to encourage students to write and openly discuss their feelings concerning mathematics, and to incorporate calming approaches such as relaxation methods, visualisation and breaks to avoid frustration. Hembree (1990) also recommends relaxation training and systematic desensitisation to reduce mathematics anxiety levels. Williams (1988, p. 101), in paraphrasing a Chinese proverb, makes a pertinent statement:

> Tell me mathematics and I will forget; show me mathematics and I may remember; involve me in a tension-free atmosphere in small group work and with manipulative aids in mathematics and I will understand. If I understand mathematics, I will be less likely to have math anxiety, and if I become a teacher of mathematics I can thus begin a cycle that will produce less math anxious students for generations to come.

Recommendations for Preventing Math Anxiety

- accommodate for different learning styles
- create a variety of testing environments
- design positive experiences in math classes
- remove the importance of ego from class-room practice
- emphasize that everyone makes mistakes in mathematics
- make math relevant
- let students have some input into their own evaluations
- allow for different social approaches to learning mathematics
- emphasize the importance of original, quality thinking rather than rote manip-ulation of formulas
- characterize math as a human endeavor

Note. Based on material from *Principles and Standards for School Mathematics* by National Council of Teachers of Mathematics, 2000, Reston, VA: Author.

Figure 2.1: Recommendations for Preventing Mathematics Anxiety
(Source: Furner & Duffy, 2002)

Blazer (2011) outlines parental strategies for the reduction of mathematics anxiety in their children. Among these are that parents should avoid conveying their own negative attitudes regarding mathematics to their children and having unrealistically high expectations of their children's mathematics success. Several other suggestions

made by Blazer are that parents should: provide encouragement and support in the area of mathematics; carefully monitor their children's progress in the subject; and demonstrate to their children the positive ways in which mathematics can be used in hobbies, sports, home repairs, number games and puzzles.

Furthermore, Zemelman, Daniels and Hyde (1998), cited in Furner and Duffy (2002), outline what research has identified as being best practices for the teaching of mathematics. These include the use of cooperative group work, problem-solving instructional approaches, the use of all forms of technology, and the use of manipulatives (i.e. concrete materials). All of these approaches are reiterated in the NCTM (1995b) brochure. The National Council of Teachers of Mathematics (NCTM, 1995a) recommended that teachers make use of more qualitative types of assessment (rubrics, portfolios, observations, group assessments, etc.) in order to reduce mathematics anxiety.

Teachers both at the primary and secondary levels should not only display a more-infectious enthusiasm for the subject of mathematics (Whyte & Anthony, 2012) but also endeavour to convince their students of the critical importance of mathematics for their future job prospects (Furner & Berman, 2003; NCTM, 2000). Collaborations among teachers from across school subject departments (NCTM, 1989) should also be encouraged, in order to highlight and explore associations between mathematics and Music, Art, Humanities, Home Economics, Science, Geography, Information Technology, Physical Education, etc. Such collaborations could take place throughout the school year or simply be assigned to a particular week (e.g. Mathematics Awareness Week). By adopting and engaging in practices such as those outlined above, students, parents and teachers will hopefully not see mathematics as an alienating subject that generally induces fear, but one that holds much promise and hope for the future.

The NCTM (2000, 2013) recommendations include significant professional development opportunities for mathematics teachers. The NCTM's (2013) Supporting the Common Core State Standards for Mathematics called for:

> Substantial opportunities for ongoing professional development to ensure that all teachers understand and are prepared to implement the Common Core

State Standards for Mathematics and that all administrators and policymakers understand teacher' needs.

In view of this, both state and federal government should allocate more funding towards STEM (science, technology, engineering and mathematics) education programs in schools and ensure that teacher-training courses within universities are geared and adequately funded to supply graduates in these areas. State education departments could provide more inservice training for teachers of mathematics and offer scholarships for teachers wishing to pursue further postgraduate studies in mathematics education. All this combined would help to ensure that teachers of mathematics are better prepared to tackle this unremitting scourge of mathematics anxiety.

2.8   Summary

This chapter began with a focus on the historical underpinnings of the learning environments' monolith and the foundational contributions provided by pioneers in the field such as Lewin and Murray during the 1930s. Further developments during the 1950s through to the 1970s were then expounded with particular reference to Stern, Walberg and Anderson and Moos. The Australian learning environments landscape and the development of varied instruments by Fraser and colleagues were then brought under sharp focus.

Section 2.3 reviewed seven learning environment instruments (the LEI, CES, QTI, CUCEI, CLES, SLEI and MCI), their validity and studies conducted using these instruments. Section 2.4 then highlighted and reviewed six types of research on learning environments, namely: (1) associations between student outcomes and environment, (2) evaluation of educational innovations, (3) differences between student and teacher perceptions of actual and preferred environment, (4) teachers' attempts to improve classroom environments, (5) cross-national studies and (6) studies of transition from primary to high school.

Section 2.5 was primarily devoted to the WIHIC (the instrument chosen for my study) and a review of numerous studies that utilised it. The development of the

WIHIC, its final 7 scales and scoring procedure were described. The validity and reliability of the WIHIC in past research were also reviewed and emphasised.

Section 2.6 dealt with the primary–to–secondary transition and the changes and difficulties associated with it. The negative effects of such transitions were highlighted and findings of past research studies were discussed.

Finally, Section 2.7 concentrated on mathematics anxiety, a construct that constituted a major or key component of my study. Firstly, a historical perspective was undertaken, and this was followed by consideration of a host of instruments used to measure mathematics anxiety. Secondly, some causes of mathematics anxiety were explained and research studies conducted on mathematics anxiety were reviewed.

The following chapter outlines the research methods undertaken in this particular study. Initially, the objectives are identified, the sample is discussed and instruments used are described. Data analyses and ethical issues are then explored.

Chapter 3

METHODOLOGY

3.1 Introduction

In this chapter, I outline the methods used in this study which focussed upon changes in learning environment and students' attitudes and anxiety during the transition from primary to secondary school mathematics. Firstly, the objectives of the study are recapitulated (Section 3.2). Secondly, the sample and its collection are discussed (Sections 3.3 and 3.4), followed by a description of the three instruments used, namely, the WIHIC, TOMRA and MAM (Section 3.5). A section on data analyses (Section 3.6) is followed by ethical issues (Section 3.7). Finally, Section 3.8 summarises the chapter.

3.2 Objectives of the Study

The initial objective was to examine the reliability and validity of the WIHIC and attitude questionnaire (Research Question 1). My second research question focused on comparing Year 7 students (pre-transition) with Year 8 students (post-transition) in terms of learning environment perceptions and attitudes/anxiety. Attention then shifted to my third research question involving whether any differences existing between students in Years 7 and 8 are similar or different for male and female students. Finally, my fourth research question was focussed upon associations between students' perceptions of four aspects of classroom environment (Student Cohesiveness, Teacher Support, Involvement, Cooperation) and three attitude/anxiety scales (Attitude to Mathematical Inquiry, Enjoyment of Mathematics, Mathematics Anxiety).

Figure 3.1 provides a diagrammatic representation of the variables/scales and relationships included in Research Questions 2 and 3.

```
┌─────────────────┐                    ┌──────────────────────────────┐
│  GRADE LEVEL    │ ──────┐            │ LEARNING ENVIRONMENT:        │
│                 │       │            │ - Student Cohesiveness       │
└─────────────────┘       │            │ - Teacher Support            │
                          ▶            │ - Involvement                │
                                       │ - Cooperation                │
                                       │                              │
┌─────────────────┐       ▶            │ ATTITUDES/ANXIETY:           │
│     SEX         │ ──────┘            │ - Attitude to Mathematical   │
│                 │                    │   Inquiry                    │
└─────────────────┘                    │ - Enjoyment of Mathematics   │
                                       │ - Mathematical Anxiety       │
                                       └──────────────────────────────┘
```
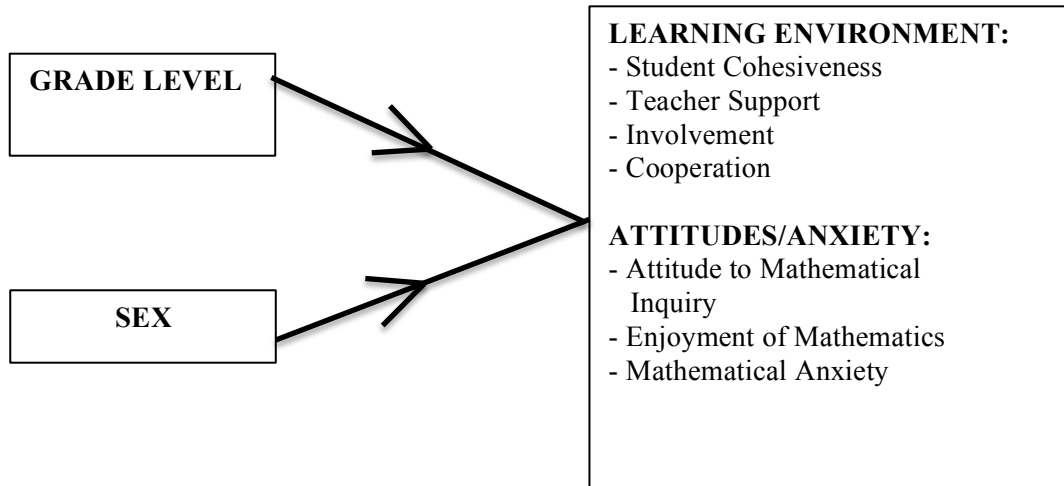
Figure 3.1:   Variables and Relationships for Research Questions 2 and 3

3.3   Sample

The sample for my study comprised a total of 541 students from both primary (year 7) and secondary (year 8) schools in country and metropolitan areas of South Australia. South Australia differs from many other Australian states in that year 7 is the final year of primary school and year 8 represents the first year of secondary school. The schools came from both the government and Catholic sectors of the educational spectrum. In total, there were 15 schools (5 secondary, 9 primary, 1 area) that made up my sample. The Catholic primary school sector provided 72 (year 7) students and 189 (year 8) students, while the Government sector provided 135 (year 7) and 145 (year 8) students for my sample. This resulted in a combined total of 207 (year 7) and 334 (year 8) from both sectors, thereby yielding a grand total of 541 for my entire sample (see Table 3.1)

Table 3.1   Primary/Secondary Student Numbers for Each School Type

School Type	Sample Size		
	Primary Year 7	Secondary Year 8	Total
Catholic	72	189	261
Government	135	145	280
Total	207	334	541

Three of the secondary schools in my sample were Catholic, with two being girls' schools and the other co-educational. These were all metropolitan schools. The students from these schools most likely would come from middle-class sections of the community, and so they would represent a good cross-section of the middle-class population. Survey findings for this group can thus be generalised to other middle-class schools within the metropolitan area. The remainder of the secondary schools in my sample were government schools from regional areas which would most likely be typical examples of schools within these regional areas.

In relation to the primary schools in my sample, two schools were Catholic metropolitan, two schools were government metropolitan and the rest comprised regional government schools. These metropolitan primary schools would also, most likely, represent middle-class suburbia and thus results could be indicative of a wider middle-class population. The government (both primary and secondary) schools in my sample came from the regional areas, that possibly were lower socio-economic areas with greater unemployment, single-parent families, welfare recipients, etc. Their results could more than likely be generalised to other schools within the particular regional areas.

3.4   Gaining Access to Schools

Before any approach to schools could be undertaken, certain procedures had to take place. In order to carry out research in South Australian government schools, approval had to be given by the Department for Education and Child Development (DECD). This required completing a lengthy form and then waiting about four weeks for a decision. When this approval was given, I then could approach schools. The Catholic sector approval was in fact much easier to obtain and only required a letter from me outlining my request to the Catholic Education Director (see Appendix A), who granted approval in about a week.

3.4.1   Approaching schools

After receiving approval from DECD, I initially began to make telephone contact with the various schools in the government sector. The reason behind this was that I

wanted to determine the approximate numbers of students in the particular year level at the schools and thus determine whether the schools were suitable for inclusion in my sample. I attempted to seek this information regarding student numbers in particular year levels by searching the individual schools' websites, but this proved fruitless because no such information was available.

In order to gauge the number of students at these selected schools, I telephoned the school office to obtain this information. The majority of schools were very guarded about disclosing such information and I usually was asked why I needed it. Many schools referred me to senior staff, such as deputy principals or principals, to obtain such information. One particular principal of a government primary school would not disclose this information unless I had written authority from DECD.

3.4.2 *Formal Approach to Schools*

The next stage was for me to formally approach the principals of the schools that I felt had sufficient student numbers to warrant sending letters outlining my request to undertake research in their schools (see Appendix B & C). In order to expedite matters, this was done via email rather than traditional letter post. A copy of the Ethics Approval from Curtin University was also forwarded (Appendix D). Also, and most importantly, included in the email package was a copy of approval letters from DECD (Appendix E) or the Catholic Education Office (Appendix F) because, without these, I would have been unable to ever conduct research within schools.

As one can imagine, a period of anxious, nervous waiting was about to take place. Day after day, I would regularly check my emails, hoping for a response from the schools that I had approached. A few responded within several days declining to take part in my research. Most principals gave reasons, such as their participation in other research, lack of time, unwillingness of teachers to be involved, etc. One primary school principal stated that the students had been very busy preparing for the school fete for the last three months and could not participate in the study!

After about three weeks had elapsed from the time when I had sent the initial emails, only three positive responses had been received. Many schools did not respond at all.

Nevertheless, because I was determined not to give up in my quest, I contacted the same unresponsive schools either by telephone or a follow-up email to seek clarification of whether teachers would participate or not. I made it quite clear that I needed to know, either way, by a certain date. Several schools did not even bother to respond to this second email! Some schools wanted me to resend the original email package because they had deleted it or could not locate it. This proved to be more time consuming.

I then decided to compile an additional list of further schools to approach and the same process began yet again. Slowly, positive responses began to appear in my email inbox and I began to feel more confident in being able to reach my target sample.

Because some teachers made it clear that they could not force students to return the consent form, the researcher did not know if these parents had actually sighted it! Needless to say, the promised and anticipated numbers of surveys did not eventuate. In total, about 500 printed unused (five-page) surveys were never returned. In addition to this, the various information sheets were also wasted. This amounted to about 4000 single printed pages.

3.4.3   *Protocol for Administration*

The next stages were to liaise with the designated coordinator of the schools where teachers had agreed to participate, to determine the number of printed materials required, and then to deliver the printed materials. I personally delivered and explained the various information and survey forms to coordinators in most of the metropolitan schools around Adelaide, South Australia. However, for the regional or country schools, packages were couriered by commercial companies with the cost borne by myself. Teachers in the participating schools had to hand out all the information sheets that I had provided in the package, including parent/guardian/student information sheet (Appendix G) and parent/guardian consent form (Appendix H). Now began the perilous journey of actually getting these information and consent forms home to the parent and then getting the consent form back to the class teacher.

Teachers were also required to administer the actual survey in their particular mathematics classes. The timing of this was left to the individual teachers, with the request that surveys be completed and ready to be picked up by the end of the current school term. I gave schools ample time to administer the survey by making sure that the surveys were in schools by early in the first or second week of term. By the end of the school term, several schools had still not administered the survey. I indicated to these particular schools that they could administer the survey early the following term if they so wished. Some did take up the offer and did complete surveys in the initial weeks of the following school term. At the end of this tortuous journey, I finally had a total of 541 students from 47 classes in 15 schools participating in my study.

The next phase required me to pick up the completed surveys from the metropolitan schools involved. For the country schools, courier or post options were used, depending upon volume of material.

3.5   Instruments Used

The three particular instruments used in my study were a shortened version of the What Is Happening In this Class? (WIHIC), a modified Test of Mathematics Related Attitudes (TOMRA) and an instrument which I have called MAM (Mathematics Anxiety Measure). A copy of components of the actual survey is included in Appendices I, J, K. The survey consisted of three separate parts, comprising five single-sided response sheets, stapled together to form one complete entity. The three instruments had to be shortened or modified owing to the need for the survey to be completed within a single lesson of approximately 40 minutes duration, especially within the secondary-school sector. This time constraint was not critical in the primary school sphere because teachers were usually with the same class of students for longer periods of the school day and were much more flexible with regards to time management.

As mentioned previously, the WIHIC was developed by Fraser, McRobbie and Fisher (1996). This particular instrument has been used extensively throughout the world and many studies have attested to its validity and reliability. This was one of

the main reasons for selecting it as one of the main instruments for this particular study. A review of the literature (see Section 2.5) shows that the WIHIC demonstrated good validity and reliability among studies such as the Fraser, Aldridge and Adolphe (2010) with 1161 students in Australia and Indonesia, 763 college students in UAE (MacLeod & Fraser, 2010), 352 mathematics students in UAE (Afari, Aldridge, Fraser & Khine, 2013), and 1434 students in New York (Wolf & Fraser, 2008). Additional validation studies include Allen and Fraser (2007), Koul and Fisher (2005), Khoo and Fraser (2008), Chionh and Fraser (2009), Dorman (2003, 2008) and Ogbuehi and Fraser (2007).

The shortened version of the WIHIC consisted of four scales each containing 8 items (32 items in total) (Appendix I). The scales of Student Cohesiveness, Teacher Support, Involvement and Cooperation were chosen because they were considered relevant to my study. The three original WIHIC scales of Task Orientation, Investigation and Equity were omitted. The responses to this modified WIHIC instrument were on the original frequency scale of (1) Almost Never, (2) Seldom, (3) Sometimes, (4) Often and (5) Almost Always. The Student Cohesiveness scale essentially measures the extent or degree to which students know, help and are supportive of one another. The Teacher Support scale assesses the extent to which the teacher helps, befriends, trusts and shows interest in students. The Involvement scale assesses the extent to which students have attentive interest, participate in discussions, do additional work and enjoy the class. The Cooperation scale gauges the extent to which students cooperate rather than compete with one another on learning tasks. Appendix I contains the version of the WIHIC used in my study.

The modified TOMRA (Appendix J) consisted of a total of 20 items chosen from the two scales of Attitude towards Mathematics Inquiry and Enjoyment of Mathematics Lessons, each of which required a response consisting of Strongly Agree, Agree, Not sure, Disagree and Strongly Disagree. These two scales of Attitude towards Mathematics Inquiry and Enjoyment of Mathematics Lessons were selected because they are considered important and fundamental to both mathematics education and the transition process. The scales of Normality of Mathematicians and Adoption of Mathematics Attitudes were omitted. An important reason for selecting only two

scales was so that the complete questionnaire could be administered in a single class period.

The Test of Science Related Attitudes (TOSRA) was originally developed by Fraser (1978, 1981). Because of the links and similarities between science and mathematics, the TOSRA instrument was easily able to be adapted to gauge mathematics attitudes. Essentially the TOSRA underwent a morphogenesis to transform itself into the TOMRA. Like the WIHIC, the TOSRA instrument has been widely validated and used by researchers throughout the world, which is the reason why I chose it to become the second main instrument for my study. Literature reviewing (see Chapter 2) indicates past studies that attest to the validity and reliability of TOSRA include Ogbuehi and Fraser (2007) who used the modified WIHIC and TOMRA with 661 mathematics students in California, Martin-Dunlop and Fraser (2008) with 525 prospective elementary teachers in California, and 439 Korean secondary science students (Fraser & Lee, 2009). Among other studies that also lend credence to the TOSRA are Wolf and Fraser (2008), Aldridge, Fraser and Huang (1999) and Spinner and Fraser (2005).

The final component, the MAM (Appendix K) consisted of eight items with each requiring a response on a scale of (1) Low Anxiety, (2) Some Anxiety, (3) Moderate Anxiety, (4) Quite a Bit of Anxiety and (5) High Anxiety. This MAM instrument drew its inspiration from the 24-item Mathematics Anxiety Rating Scale-Revised (MARS-R) as well as the 9-item Abbreviated Math Anxiety Scale (AMAS).

Since the pioneering work of Richardson and Suinn (1972) who developed the initial 98-item Math Anxiety Rating Scale (MARS), many abbreviated instruments to measure mathematics anxiety have followed. In particular, Plake and Parker (1982) constructed a 24-item shortened version of the MARS which is known as the Math Anxiety Rating Scale-Revised (MARS-R). This mid-western USA research involved a two-stage study, firstly, with a group of 50 university students and then secondly with a group of 170 university students. This MARS-R instrument displayed an alpha reliability coefficient of 0.98 and a correlation of 0.97 with the full-scale MARS.

Hopko, Mahadevan, Bare and Hunt (2003) involved 1239 undergraduate students in developing a much shorter 9-item Abbreviated Math Anxiety Scale (AMAS) which, upon statistical testing, revealed good to strong measures of internal consistency reliability and validity. Furthermore, the authors believed that "the Abbreviated Math Anxiety Scale (AMAS) represents a more parsimonious and valid approach to assess mathematics anxiety" (Hopko et al., 2003, p. 178). Primarily for these reasons and for the sake of brevity, I decided to borrow from this instrument to arrive at the third and final component of my survey. To summarise, the entire survey was comprised of three different individual modified tests (i.e. WIHIC, TOMRA and MAM), resulting in a grand total of 60 questions.

3.6   Data Analyses

Responses from the surveys had to be coded and transferred to Microsoft Excel spreadsheet software. Information regarding school, class and gender were coded and entered as numbers into the Excel database. This was rechecked to ensure accuracy. The entire process took a considerable length of time. When this task of transferring the survey responses to the database was complete, the data underwent statistical analysis via SPSS (Statistical Package for the Social Sciences).

In order to attempt to address the first research question involving the validation of the WIHIC and attitude questionnaire, the data underwent principal axis factoring with varimax rotation and Kaiser normalisation. The two criteria for an item's retention were that it had to have a factor loading of at least 0.35 on its own scale and less than 0.35 on each of the other scales. Factor analysis revealed that each of the 32 WIHIC items satisfied the criteria and thus were retained. Similarly, for the 20-item attitude and 8-item anxiety scales, each of the 28 items satisfied the above requirements for their retention.

To determine the extent to which items with the same scale assess a common construct, internal consistency reliability was calculated using Cronbach's alpha coefficient for each WIHIC and attitude/anxiety scale for two units of analysis (the individual student and the class mean).

To investigate the ability of each WIHIC scale to differentiate between classrooms, one-way analysis of variance (ANOVA) was used with class membership as the independent variable. The eta^2 statistic (the ratio of 'between' to 'total' sums of squares) was calculated for each of the four WIHIC scales to portray the proportion of variance accounted for by class membership.

In examining my second research question (concerning differences between grades 7 and 8 students in terms of learning environment perceptions and attitudes/anxiety) and third research question (concerning whether grade-level differences are different for males and females), data were subjected to a two-way MANOVA. The four learning environment scales and three attitude/anxiety scales comprised the seven dependent variables, while grade level and sex constituted the two independent variables. If MANOVA reveals significant results for grade level, sex and the grade-by-sex interactions for the set of dependent variables as a whole, using Wilks' lambda criterion, the univariate ANOVA results would be interpreted separately for each dependent variable. Effect sizes, using Cohen's *d,* which express a difference between two groups in standard deviation units, were calculated to portray the magnitude of differences. According to Cohen (1988), effect sizes range from small (0.2) to medium (0.5) to large (0.8).

To answer the fourth research question concerning the relationships between students' perceptions of their learning environment and student attitudes and anxiety, simple correlation and multiple regression analyses were used. Simple correlation analysis was undertaken to determine the bivariate relationship between each of the four learning environment scales and each student attitude/anxiety scale. Multiple regression analysis was carried out to ascertain the joint influence of the set of correlated learning environment scales on each attitude/anxiety scale. To describe the multivariate association between an attitude/anxiety scale and the set of all learning environment scales, the multiple correlation was used. Regression coefficients were used to extract information regarding which environment scales significantly contributed to the variance in students' attitude/anxiety when all other environment scales were mutually controlled.

A detailed report of the results of all of the statistical analyses appears in Chapter 4.

3.7   Ethical Issues

First and foremost in this entire lengthy process was the obvious mandatory requirement to obtain ethics approval from Curtin University. This ethics process required submitting various forms along with a full research proposal to the Human Research Ethics Committee (HREC). After review by the ethics committee, I was advised in due course that approval had been granted to commence research. The ethics approval number for my research is SMEC-22-12 and is dated 6 June 2013 (see Appendix D).

The Oxford Pocket Dictionary defines `ethics' as essentially being a set of "moral principles, rules of conduct". The National Statement on Ethical Conduct in Research Involving Humans (1999), cited in Curtin University Guide to Preparing Your Application For Candidacy (2006, p. 23), states "When conducting research involving humans, the guiding ethical principle for researchers is respect for persons which is expressed as regard for the welfare, rights, beliefs, perceptions, customs and cultural heritage, both individual and collective, of persons involved in research".

Ethical concerns should always be predominant and at the forefront of the researcher's mind, so that all one's bases are covered, for any eventuality concerning ethical problems that might occur at any stage of the research undertaking. Cohen et al. (2000, p. 49) refer to ethical concerns as being a "hydra-headed creature". For this reason alone, the researcher needs to proceed into this ethics labyrinth with extreme caution and armed with a sufficient arsenal of weapons, in the form of values and principles, in order to emerge triumphant from this encounter with the `beast'. Throughout this entire process, one needs to address the ethical protocols of Information, Permission, Privacy and Confidentiality, Consideration, and Acknowledgement in order to maintain high levels of ethical standards. These protocols are listed and clarified below:

Information

> The aims of the research and purpose of the study and the fact that I would be a stranger to the various data-collection sites were provided to participants.

Permission

Written permission was obtained from the principals, teachers and parents in each specific school situation. In addition, participants were made aware of the fact that participation was voluntary and that they could withdraw at any time for whatever reason.

Privacy and Confidentiality

A written statement was provided to clarify that the privacy and confidentiality of individuals and schools would be maintained at all times. Names of students and schools would be changed so they could not be identified.

Consideration

There would be minimal disruption to the schools and their teaching/learning programs.

Acknowledgement

The contribution and co-operation of people involved in the study would be acknowledged in a manner that would ensure that confidentiality was maintained.

I believe that I adhered to such standards throughout the entire research process.

3.8   Chapter Summary

The methodology inherent in this study was outlined in this chapter. The study's research questions were recapitulated in Section 3.2. The sample of 541 students sourced from 15 schools, together with the data-collection process, were considered in Sections 3.3 and 3.4 along with the difficulties faced in the task of approaching schools to gain access for my research. Section 3.5 described the three instruments and the individual scales selected from each (i.e. WIHIC, TOMRA and MAM). The WIHIC scales chosen were Student Cohesiveness, Teacher Support, Involvement and Cooperation, while the TOMRA scales selected were Attitude towards Mathematics Inquiry and Enjoyment of Mathematics Lessons. The final 8-item MAM scale required responses for each item based on a 5-point scale which ranged from 1 (low anxiety) to 5 (high anxiety). In addition, some background information

regarding each instrument was provided as well as reasons for its inclusion in my study.

Mention was then made of data being entered into Excel database and undertaking SPSS (Statistical Package for the Social Sciences) analysis (Section 3.6). The data underwent statistical analyses so as to investigate factor structure, internal consistency reliability and ability to differentiate between classrooms (to answer my first research question about questionnaire validity). Simple correlation and multiple regression analyses were conducted to determine the relationships between students' perceptions of their learning environments and student attitudes and anxiety (to answer Research Question 4). In order to answer my second and third research questions concerning changes across transition, data were subjected to a two-way MANOVA. Effect sizes, using Cohen's d, were calculated to reveal the magnitude of differences between students in years 7 and 8. Ethical issues were then explored in Section 3.7.

Results from the data analyses concerning the validation of instruments used in this study and the comparison of pre-transition and post-transition students in terms of learning environment perceptions and attitudes/anxiety are presented in Chapter 4.

Chapter 4

ANALYSES AND RESULTS

4.1   Chapter Introduction

This study utilised three instruments to identify changes across the transition from primary to secondary school in terms of the classroom learning environment and students' attitudes/anxiety towards mathematics. The research aimed to firstly examine the reliability and validity of the learning environment and attitude questionnaire. The next aim was a comparison of year 7 and year 8 students with regards to learning environment perceptions and attitudes/anxiety. A third aim was to examine whether any differences existing between year 7 and year 8 students were similar or different for male and female students. The final research aim was to examine associations between students' perceptions of four aspects of classroom environment (Student Cohesiveness, Teacher Support, Involvement, Cooperation) and three attitude/anxiety scales (Attitude to Mathematical Inquiry, Enjoyment of Mathematics, Mathematics Anxiety). A total of 541 students in 47 classes from both primary and secondary schools in South Australia comprised the sample or body of evidence.

The chapter that follows focuses on the statistical analysis of the data inherent in this study and the overall reliability and validity of the instruments used. Essentially then, the researcher must assume the role of a detective, in order to investigate, search for clues and establish the facts of the case. Firstly, factor structure and reliability are examined (Section 4.2). Secondly, grade-level and sex differences in learning environment and student attitudes are investigated (Section 4.3). Finally, associations between learning environments and students' outcomes are explored (Section 4.4).

4.2   First Research Question Involving Validation of WIHIC and Attitude Questionnaire

I assessed the learning environment with four 8-item scales from the WIHIC (Student Cohesiveness, Teacher Support, Involvement and Cooperation). My attitude

questionnaire consisted of two 10-item scales from the TOMRA (Attitude to Mathematical Inquiry and Enjoyment of Mathematics Lessons) and an 8-item mathematics anxiety scale. See Chapter 2 (Sections 2.4 to 2.5) for reviews of literature about these instruments and Chapter 3 (Section 3.4) for further details about the scales.

The sample for validity analyses consisted of 541 students in 47 classes in 15 schools as described in Chapter 3, Section 3.3. In order to answer the first research question the factor structure of the WIHIC (Section 4.2.1) and factor structure of the attitude questionnaire (Section 4.2.2) were investigated along with the internal consistency reliability (Section 4.2.3) of the WIHIC and attitude scales. Section 4.2.4 reports the ability of the WIHIC scales to differentiate between classrooms by conducting an ANOVA for each scale.

4.2.1   *Factor Structure of WIHIC*

To check the structure of my four-scale 32-item version of the WIHIC, I conducted principal axis factoring with varimax rotation and Kaiser normalisation. According to Fink (1998, p. 112): "Factor analysis is often conducted to determine the number of dimensions included in a measure. This statistical procedure identifies factors or relationships among the items or questions." As the SPSS survival manual (p. 172) states, factor analysis is a 'data reduction' technique whereby a large body of data is reduced by narrowing down the components. SPSS mentions that "it does this by looking for 'clumps' or groups among the inter-correlations of a set of variables". Salkind (2008, p. 277) sees "factor analysis (as) a technique based on how well various items are related to one another and form clusters or factors".

The two criteria for the retention of any item were that it must have a factor loading of at least 0.35 on its own scale and less than 0.35 on each of the other three WIHIC scales. The results of the factor analysis are shown in Table 4.1. This table, which provides the factor loadings, shows that each of the 32 WIHIC items satisfied the above two criteria and therefore were retained. In fact, 24 of the WIHIC's 32 items had a factor loading exceeding 0.50.

Table 4.1   Factor Analysis Results for Learning Environment Scales

Item	Factor Loadings			
	Student Cohesiveness	Teacher Support	Involvement	Cooperation
SC1	0.64			
SC2	0.42			
SC3	0.55			
SC4	0.72			
SC5	0.57			
SC6	0.37			
SC7	0.62			
SC8	0.35			
TS1		0.64		
TS2		0.73		
TS3		0.71		
TS4		0.66		
TS5		0.72		
TS6		0.75		
TS7		0.69		
TS8		0.61		
IN1			0.73	
IN2			0.80	
IN3			0.47	
IN4			0.62	
IN5			0.41	
IN6			0.58	
IN7			0.42	
IN8			0.44	
CO1				0.53
CO2				0.54
CO3				0.56
CO4				0.61
CO5				0.47
CO6				0.61
CO7				0.59
CO8				0.60
% Variance	5.73	35.98	4.04	9.51
Eigenvalue	1.83	11.51	1.29	3.04

N=541 students

Factor loadings less than 0. 35 have been omitted from the table.

Principal axis factoring with varimax rotation and Kaiser normalization

The bottom of Table 4.1 shows that the proportion of variance accounted for ranged from 4.04% to 35.98% for different WIHIC scales. The total proportion of variance was 55.26%. The bottom of Table 4.1 also shows that scale eigenvalues ranged from 1.29 to 11.51.

4.2.2 *Factor Structure of Attitude Questionnaire*

To check the structure of the 28 attitude and anxiety items in 3 scales, principal axis factoring with varimax rotation and Kaiser normalization was undertaken for my

sample of 541 students. The two attitude scales (Attitude to Mathematical Inquiry and Enjoyment of Mathematics Lessons), each comprising 10 items, were derived from the TOMRA. The mathematics anxiety scale itself consists of 8 items and forms the Mathematics Anxiety Measure (MAM). The results of the factor analysis are revealed in Table 4.2.

Again, the criteria for the retention of any item was that it must have a factor loading of at least 0.35 with its own scale and less than 0.35 with the other scale(s). Table 4.2 shows that each of the 28 items satisfied the requirements and therefore was retained. Of the 28 factor loadings in Table 4.2, 19 exceeded 0.50 in magnitude.

The bottom of Table 4.2 shows the proportion of variance accounted for ranged from 7.46% to 29.59% for the different attitude and anxiety scales. The total proportion of variance was 48.81%. The bottom of Table 4.2 shows that scale eigenvalues ranged from 2.08 to 8.28.

4.2.3   *Internal Consistency Reliability of WIHIC and Attitude Scales*

Internal consistency reliability is a measure of the extent to which items within the same scale assess a common construct. As Wikipedia states, internal consistency "is typically a measure based on the correlations between different items on the same test (or the same subscale on a larger test)". Cronbach's alpha coefficient is frequently used to measure internal consistency. An acceptable level of reliability of an instrument is 0.70 or greater (Urdan, 2010, p. 178). For my sample of 541 students in 47 classes, the internal consistency reliability was calculated for each WIHIC and attitude scale for two units of analysis (the individual student and the class mean) using Cronbach's alpha coefficient.

Table 4.2   Factor Analysis Results for Attitude and Anxiety Scales

Item	Factor Loadings		
	Maths Inquiry	Maths Enjoyment	Maths Anxiety
MI1	0.46		
MI2	0.37		
MI3	0.36		
MI4	0.47		
MI5	0.35		
MI6	0.43		
MI7	0.57		
MI8	0.60		
MI9	0.35		
MI10	0.59		
ME1		0.82	
ME2		0.76	
ME3		0.64	
ME4		0.73	
ME5		0.74	
ME6		0.52	
ME7		0.87	
ME8		0.49	
ME9		0.86	
ME10		0.67	
MAM1			0.43
MAM2			0.68
MAM3			0.55
MAM4			0.68
MAM5			0.66
MAM6			0.67
MAM7			0.76
MAM8			0.62
% Variance	7.46	29.59	11.76
Eigenvalue	2.08	8.28	3.29

N=541 students

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

Principal axis factoring with varimax rotation and Kaiser normalization.

Table 4.3 shows that the alpha coefficient for the four WIHIC scales ranged from 0.83 to 0.90 with the student as the unit of analysis and from 0.91 to 0.95 with the class as the unit of analysis. For the three attitude scales, the alpha reliability ranged from 0.65 to 0.96 with the student as the unit of analysis and from 0.83 to 0.96 for class means.

Table 4.3   Mean, Standard Deviation, Internal Consistency Reliability (Cronbach Alpha Coefficient) and Ability to Differentiate Between Classrooms (ANOVA Results) for Learning Environment and Attitude/Anxiety Scales

Scale	Form	Mean	SD	Alpha Reliability	ANOVA Eta²
Student Cohesiveness	Student	4.05	0.59	0.83	0.24**
	Class	3.97	0.35	0.92	
Teacher Support	Student	3.64	0.82	0.90	0.25**
	Class	3.56	0.45	0.93	
Involvement	Student	3.43	0.76	0.87	0.17**
	Class	3.40	0.37	0.91	
Cooperation	Student	3.82	0.73	0.87	0.23**
	Class	3.73	0.44	0.95	
Maths Inquiry	Student	3.36	0.56	0.96	
	Class	3.34	0.26	0.83	
Maths Enjoyment	Student	3.19	0.93	0.65	
	Class	3.21	0.51	0.96	
Maths Anxiety	Student	2.36	0.83	0.85	
	Class	2.40	0.42	0.89	

**$p<0.01$
N=541 students in 47 classes

The results in Table 4.3 attest to the high reliability of all learning environment and attitude scales for my sample of students in South Australia because they satisfy Urdan's criteria in every case except for Mathematics Enjoyment with the student as the unit of analysis.

4.2.4   *Ability of WIHIC Scales to Differentiate Between Classrooms*

Another desirable characteristic of any classroom learning environment scale is that students within the same class have relatively similar perceptions, but that mean class perceptions vary from class to class. (This characteristic is not relevant for attitude scales.)

This characteristic was investigated for each WIHIC scale by conducting an ANOVA with class membership as the independent variable. The eta^2 statistic (the

ratio of 'between' to 'total' sums of squares) was used to represent the proportion of variance in a scale's scores attributable to class membership.

Table 4.3 shows that each of the four WIHIC scales was capable of differentiating significantly ($p<0.01$) between the perceptions of students in different classrooms. The eta^2 statistic ranged from 0.17 to 0.25 for different scales.

4.2.5 *Consistency with Past Studies*

My results replicate past research studies around the world that provide strong evidence for the validity of WIHIC. In a Queensland study by Dorman (2008), all of the WIHIC scales demonstrated good internal consistency reliability, with Cronbach alpha coefficients ranging from 0.70 to 0.90. Among other research that provided evidence for the validity of the WIHIC are studies conducted in the USA (Allen & Fraser, 2007; Martin-Dunlop & Fraser, 2008; Ogbuehi & Fraser, 2007; Wolf & Fraser, 2008), India (Koul & Fisher, 2005), Singapore (Chionh & Fraser, 2009; Khoo & Fraser, 2008) and Australia, Canada and Britain (Dorman, 2003). Other studies that have supported the validity and reliability of the WIHIC were undertaken in the UAE (Afari, Aldridge, Fraser & Khine, 2013; MacLeod & Fraser, 2010), Indonesia and Australia (Fraser, Aldridge & Adolphe, 2010), Taiwan and Australia (Aldridge & Fraser, 2000), Australia (Dorman, 2008; Waldrip, Fisher & Dorman, 2009) and Indonesia (Wahyudi & Treagust, 2004).

My study replicated past research with regards to the validity and reliability of original or modified forms of either TOMRA or TOSRA. These various studies worldwide include those in the USA (Martin-Dunlop & Fraser, 2008; Ogbuehi & Fraser, 2007; Wolf & Fraser, 2008), Australia and Taiwan (Aldridge, Fraser & Huang, 1999) and Indonesia and Australia (Fraser, Aldridge & Adolphe, 2010). Several other studies that attest to the reliability of actual or modified TOSRA or TOMRA instruments are those carried out in the USA (Peiro & Fraser, 2009; Spinner & Fraser, 2005), Korea (Fraser & Lee, 2009), Singapore (Wong & Fraser, 1996) and Nigeria (Idiris & Fraser, 1997).

Since the pioneering work of Richardson and Suinn (1972) with the Math Anxiety Rating Scale (MARS), there have been numerous instruments developed to measure mathematics anxiety (see Section 2.7.1 for a description of these). Studies that have used such anxiety scales abound. In a Cyprian study, Yaratan and Kasapoglu (2012) used the Mathematics Attitude Scale and the Mathematics Anxiety Scale with eighth grade students. Cronbach alpha reliability coefficients of 0.937 and 0.920 respectively, were reported. Other studies that attest to the validity and reliability of anxiety scales have been conducted in such countries as Latvia (Kvedere, 2014), Romania (Marchis, 2011), Turkey (Haciomeroglu, 2013; Sengul & Dereli, 2010), Italy (Primi et al., 2014), Iran (Abbasi et al., 2013; Heydari et al., 2013), South Africa (Verkijika & De Wet, 2015) and Bahrain (Al Mutawah, 2015). Additionally, other studies have been undertaken in the USA (Schact & Stewart, 1990; Supekar et al., 2015; Wang et al., 2014; White, 1997; Young, Wu & Menon, 2012).

4.3 Second Research Question Involving Differences Between Grades 7 and 8 and Third Research Question Concerning Whether Grade-Level Differences are Different for Males and Females

My second research questions focused on a comparison of Year 7 students (prior to transition) with Year 8 students (after transition) in terms of learning environment perceptions and attitudes/anxiety. My third research question involved whether any differences existing between students in Years 7 and 8 are similar or different for male and female students.

Both of these research questions were investigated simultaneously by conducting a two-way MANOVA with my whole sample of 541 students with my four learning environment scales and three attitude/anxiety scales as the set of seven dependent variables. Grade level and sex were the two independent variables. The presence or absence of a statistically significant interaction between grade level and sex was used to identify whether grade-level differences were different or similar for males and females.

Initially conducting MANOVA for the entire set of seven dependent variables reduced the Type I error rate associated with conducting separate univariate tests for individual dependent variables. Using Wilks' lamda criterion, MANOVA revealed

significant results for grade level, sex and the grade−by−sex interaction for the set of dependent variables. Therefore I was justified in interpreting the ANOVA results for each dependent variable.

Table 4.4 provides the ANOVA results for grade level, sex and the grade−by−sex interaction separately for each learning environment and attitude/anxiety scale. Both the F value and eta^2 statistic (representing the amount of variance accounted for) are provided for each dependent variable.

Table 4.4   Two-Way MANOVA/ANOVA for Grade-Level and Sex Differences in Each Learning Environment and Attitude/Anxiety Scale

Scale	Grade Level		Sex		Grade x Sex Interaction	
	F	Eta^2	F	Eta^2	F	Eta^2
Learning Environment						
Student Cohesiveness	0.86	0.00	24.27**	0.04	0.87	0.00
Teacher Support	0.54	0.00	1.72	0.00	1.46	0.00
Involvement	11.56**	0.02	2.19	0.00	3.08	0.00
Cooperation	1.09	0.00	16.24**	0.03	0.04	0.00
Attitudes/Anxiety						
Attitude to Maths Inquiry	21.09**	0.04	0.94	0.00	6.11*	0.01
Enjoyment of Mathematics	30.93**	0.05	9.49**	0.02	5.42*	0.01
Mathematics Anxiety	10.68**	0.02	7.90**	0.01	0.09	0.00

*$p<0.05$, **$p<0.01$
Sample Size: Males = 209 and Females = 332; Grade: 7=207 and Grade: 8=334

Table 4.4 shows that statistically significant results emerged for: grade level for the learning environment scale of Involvement and every attitude/anxiety scale (Attitude to Mathematical Inquiry, Enjoyment of Mathematics and Mathematics Anxiety); for sex for the two learning environment scales of Student Cohesiveness and Cooperation and for Enjoyment of Mathematics and Mathematics Anxiety; and for the grade−by−sex interaction for Attitude to Mathematical Inquiry and Enjoyment of Mathematics.

4.3.1 *Grade-Level Differences in Learning Environment and Attitude/Anxiety Scales*

Table 4.5 provides for each learning environment and attitude/anxiety scale the average item mean, the average item standard deviation, and the ANOVA results repeated from Table 4.4. The average item mean is simply the scale mean divided

by the number of items in a scale. It is useful for comparing the means of scales containing different numbers of items.

As well, Table 4.5 provides an effect size for the grade-level difference for each scale. Cohen's d is the difference between the means of the two grade levels divided by the pooled standard deviation for each learning environment and attitudinal/anxiety scale. The effect size conveniently expresses a difference between two groups in standard deviation units. According to Cohen (1988), effect sizes range from small (0.2) to medium (0.5) to large (0.8).

Table 4.5   Average Item Mean, Average Item Standard Deviation and Grade-Level Difference (ANOVA Result and Effect Size) for Each Learning Environment and Attitude/Anxiety Scale

Scale	Item Mean		Item SD		Difference	
	Year 7	Year 8	Year 7	Year 8	F	Effect Size
Learning Environment						
Student Cohesiveness	4.04	4.05	0.63	0.56	0.86	0.01
Teacher Support	3.65	3.63	0.888	0.78	0.56	-0.02
Involvement	3.55	3.36	0.76	0.76	11.56**	-0.25
Cooperation	3.83	3.81	0.77	0.71	1.09	-0.02
Attitudes/Anxiety						
Attitude to Maths Inquiry	3.49	3.27	0.58	0.54	21.09**	-0.39
Enjoyment of Mathematics	3.47	3.01	0.95	0.87	30.93**	-0.51
Mathematics Anxiety	2.18	2.47	0.82	0.82	10.68**	0.35

**$p<0.01$
Sample size: Yr 7 *(n = 207)*; Yr 8 *(n = 334)*

Table 4.5 shows that, for the four scales for which grade-level differences were statistically significant, scores were less favourable in Year 8 than in Year 7. That is, relative to students in Year 7, Year 8 students perceived less Involvement and reported a less positive Attitude to Mathematical Inquiry, less Enjoyment of Mathematics and greater Mathematics Anxiety. For these scales, effect sizes ranged from 0.25 to 0.51 standard deviations, which are in the small to medium range according to Cohen's (1988) criteria.

However, because of the existence of significant grade−by−sex interactions for both Attitude to Mathematical Inquiry and Enjoyment of Mathematics (Table 4.4), grade-level differences for these two scales are revisited in Section 4.3.3.

4.3.2 *Sex Differences in Learning Environment and Attitude/Anxiety Scales*

Table 4.6 provides ANOVA results (repeated from Table 4.4) and effect sizes for sex differences in the seven learning environment and attitude/anxiety scales. Interestingly, females held somewhat more favourable perceptions than males for all four learning environment scales, but males had somewhat more favourable attitude/anxiety scores than females on all scores (i.e. a higher Attitude to Mathematical Inquiry scores, higher Enjoyment of Mathematics scores and lower Mathematics Anxiety scores).

These differences were statistically significant for four scales (Student Cohesiveness, Cooperation, Enjoyment of Mathematics and Mathematics Anxiety) for which effect sizes ranged from 0.32 to 0.44 standard deviations, which would be classified as small to modest according to Cohen's (1988) criteria.

Table 4.6   Average Item Mean, Average Item Standard Deviation and Sex Difference (ANOVA Result and Effect Size) for Each Learning Environment and Attitude/Anxiety Scale

Scale	Item Mean		Item SD		Difference	
	Male	Female	Male	Female	F	Effect Size
Learning Environment						
Student Cohesiveness	3.89	4.15	0.61	0.56	24.27**	0.44
Teacher Support	3.57	3.68	0.75	0.86	1.72	0.13
Involvement	3.38	3.46	0.77	0.75	2.19	0.11
Cooperation	3.66	3.92	0.77	0.69	16.24**	0.35
Attitudes/Anxiety						
Attitude to Maths Inquiry	3.40	3.33	0.61	0.54	0.94	-0.12
Enjoyment of Mathematics	3.37	3.07	0.95	0.89	9.49**	-0.32
Mathematics Anxiety	2.20	2.46	0.81	0.83	7.90**	0.32

**p<0.01
Sample size: males *(n = 209)*; females (*n* = 332)

However, because of the existence of a significant grade−by−sex interaction for Enjoyment of Mathematics (see Table 4.4), sex differences in Enjoyment need to be reconsidered in Section 4.3.3.

4.3.3   *Interaction Between Grade Level and Sex*

Table 4.4 shows that the grade−by−sex interaction was statistically significant for Attitude to Mathematical Inquiry and Enjoyment of Mathematics. This suggests that the interpretation of results for these two scales separately for grade level (Table 4.5) and sex (Table 4.6) is oversimplified. Therefore a graph of mean scores is provided for those two scales in Figure 4.1 in order to depict the scores of four groups: Year 7 males, Year 7 females, Year 8 males and Year 8 females.

For Inquiry, scores were significantly higher in Year 7 than Year 8 (Table 4.5) but were similar overall for males and females. Figure 4.1, however, suggests a more refined pattern. Although Inquiry scores were higher in Year 7 than Year 8 for students of both sexes, the magnitude of the sex difference in inquiry scores was somewhat greater in Year 7 than in Year 8.

For Enjoyment, it previously was noted that scores were significantly higher for Year 7 than Year 8 (Table 4.5) and for males than females (Table 4.6). Figure 4.1 now can be used for a more sophisticated interpretation of grade-level and sex differences in Enjoyment. Although both males and females reported greater Enjoyment in Year 7 than Year 8, sex differences in Enjoyment favoured males in Year 7 but were virtually non-existent in Year 8.

4.3.4   *Consistency with Past Research*

Past research has revealed deterioration across transition. Ferguson and Fraser (1999) found deteriorations in teacher−student interactions, and that males and females experienced different changes across transition. For example, whereas girls' perceptions of class satisfaction deteriorated across transition, they improved for boys. Feldlaufer, Midgley and Eccles (1988) reported a deterioration in student/teacher relationships after the transition from elementary to junior-high school mathematics classes; students felt that high-school teachers were less friendly and caring and gave grades less fairly than their primary-school teachers. In a Norwegian study by Bru, Stornes, Munthe and Thuen (2010), secondary students

perceived their teachers as being less supportive than their counterparts in primary school.

Similarly, Rice (1997), in examining the academic progress of students in mathematics and science during middle–to–high school transition reported negative effects in students' academic progress in mathematics. In an American study, Felner, Primavera and Cauce (1981) found that transition had a significant negative effect on academic performance and attendance. Other studies, such as Demetriou et al. (2000), Anderson et al. (2000), Wigfield et al. (1991) and Zanobini and Usai (2002), reported a loss of self-esteem during this transition. A negative decline in girls' beliefs and attitudes concerning mathematics after the transition to junior-high school was reported by Wigfield et al. (1991), Eccles (1984) and Eccles et al. (1983). My own research results appear to replicate these past studies.

Midgley, Feldlaufer and Eccles (1989) investigated students' perceptions of teacher supportiveness pre- and post-transition in terms of students' valuing of mathematics. When students changed from primary teachers whom they viewed as providing low support to secondary teachers deemed as providing high support, the intrinsic valuing of mathematics was enhanced. On the other hand, sharp declines in intrinsic value, usefulness and importance of mathematics were reported for students who moved from teachers viewed as providing high support to teachers seen as being low in support. Low-achieving students who moved from more-supportive to less-supportive teacher environments faced a sharp decrease in their valuing of mathematics. Other studies that also identify teacher support as an important factor in the transition from primary to secondary school are Ganeson and Ehrich (2009) and Barber and Olsen (2004).

Inquiry

Enjoyment

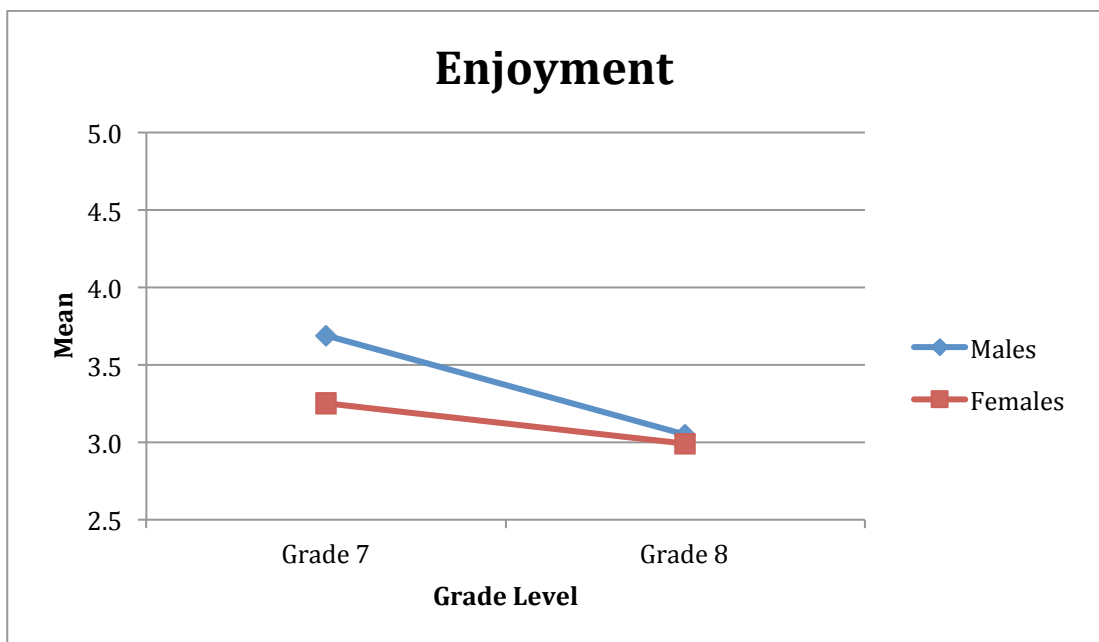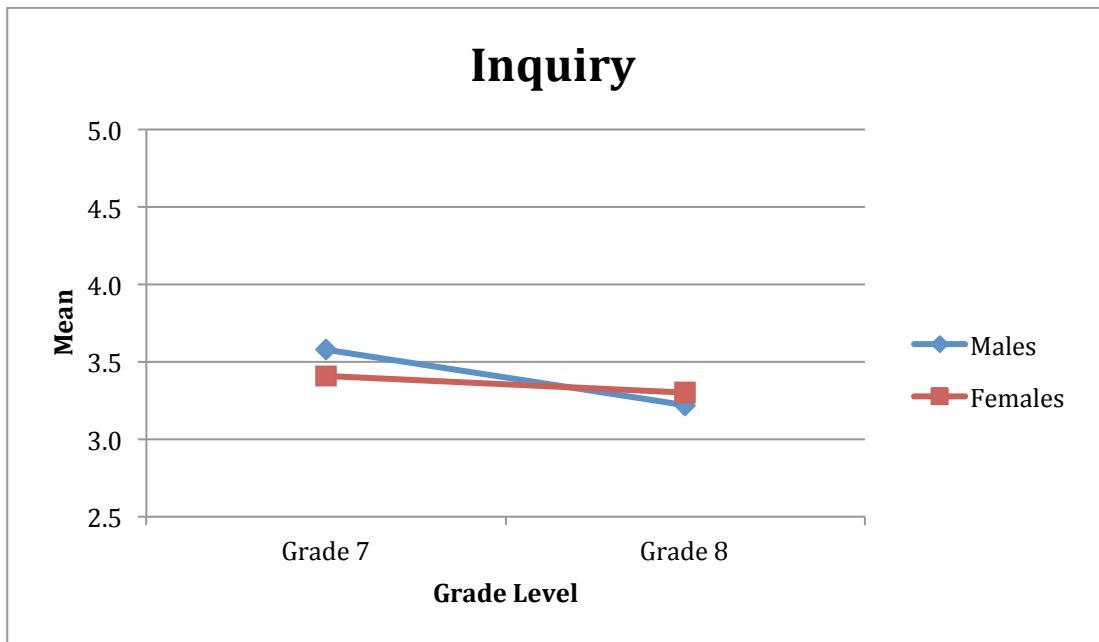Figure 4.1:   Grade−by−Sex Interactions for Attitude to Mathematical Inquiry and Enjoyment of Mathematics.

4.4   Associations Between Learning Environment and Student Outcomes

My fourth research question involved associations between students' perceptions of four aspects of classroom environment (Student Cohesiveness, Teacher Support, Involvement, Cooperation) and three attitude/anxiety scales (Attitude to

Mathematical Inquiry, Enjoyment of Mathematics, Mathematics Anxiety). Data from my combined sample of 541 Year 7 and Year 8 students were used.

To investigate the relationships between students' perceptions of their learning environment and student attitudes and anxiety, simple correlation and multiple regression analyses were conducted. Simple correlation analysis examined the bivariate relationship between each student attitude/anxiety scale and each of the four learning environment scales. Multiple regression analysis was conducted to determine the joint influence of the set of correlated learning environment scales on each attitude/anxiety scale. The multiple correlation was used to describe the multivariate association between an attitude/anxiety scale and the set of all learning environment scales. Regression coefficients were used to provide information about which environment scales contributed significantly to the variance in students' attitude/anxiety when all other environment scales were mutually controlled.

Table 4.7 shows that the simple correlation was statistically significant for every learning environment scale and every attitude/anxiety scale. Higher levels of classroom Student Cohesiveness, Teacher Support, Involvement and Cooperation were linked to higher Inquiry and Enjoyment scores and lower Anxiety scores.

For every attitude/anxiety scale, the multiple correlation with the set of four environment scales was statistically significant. Inspection of the regression coefficients revealed that:

- Involvement was a positive independent predictor of Attitude to Mathematical Inquiry.
- Teacher Support and Involvement were positive independent predictors of Enjoyment of Mathematics.
- Involvement was a negative independent predictor of Mathematics Anxiety.

Table 4.7   Simple Correlation and Multiple Regression Analyses for Associations Between Learning Environment and Attitude/Anxiety Scales

Scale	Attitude to Inquiry		Enjoyment		Anxiety	
	r	β	r	β	r	β
Student Cohesiveness	0.17**	-0.02	0.24**	-0.05	-0.13**	0.03
Teacher Support	0.17**	0.01	0.36**	0.22**	-0.11**	0.03
Involvement	0.29**	0.27**	0.38**	0.26**	-0.24**	-0.24**
Cooperation	0.19**	0.04	0.28**	0.06	-0.16**	-0.05
Multiple Correlation R		0.29**		0.43**		0.24**

N=541
***p*<0.01

These results are consistent with past research. In Singapore, Goh and Fraser (1998) identified associations between the classroom environment and mathematics achievement and attitudes. Chionh and Fraser's (2009) Singaporean study of 2310 geography and mathematics students found associations between WIHIC and student outcomes (attitudes, self-esteem, examination results). Ogbuehi and Fraser (2007) conducted a study of middle-school students in California and reported positive associations between learning environments and students' attitudes to mathematics. Other studies that also investigated associations between the learning environment and student attitudes as part of their research brief include a New York study by Wolf and Fraser (2008) and one in the UAE by Afari, Aldridge, Fraser and Khine (2013).

In an Australian study involving 4645 students and 620 teachers, Webster and Fisher (2003) reported that students from more teacher-directed classes displayed more positive attitudes towards mathematics. Fisher, Henderson and Fraser (1997), in a Tasmanian study involving 489 students from biology classes, found that students achieved higher scores and had superior attitudes when they perceived that their practical work was closely linked with the theoretical aspects of the subject matter.

4.5   Chapter Conclusion

As with any research undertaking, one needs to be able to have confidence in the results so that they can be disseminated to the wider community. With regards to quantitative research, Basit (2010, p. 64) says that "…validity can be dealt with through paying meticulous attention to sampling, development of instruments and statistical analyses". On the question of reliability, Bell (2010, p. 119) maintains that "reliability is the extent to which a test or procedure produces similar results under constant conditions on all occasions". It is hoped that this chapter has addressed these issues adequately so that one can be confident in the conclusions reached.

This chapter attempted to answer the four research questions posed in this study. The first research question involved the validity and reliability of the 4-scale 32-item WIHIC and the 3-scale 28-item attitude/anxiety scales based upon the TOMRA and MAM. Data obtained from 541 students were subjected to principal axis factoring with varimax rotation and Kaiser normalisation separately for the WIHIC and attitude/anxiety items. Every item was retained because it satisfied my two criteria for retention, namely, that an item must have a factor loading of at least 0.35 with its own scale and less than 0.35 with all other scales in that instrument. The total proportion of variance accounted for was 55% for the WIHIC scales and 49% for the attitude/anxiety scales. All scales also displayed sound reliability with Cronbach alpha coefficients ranging from 0.83 to 0.90 for WIHIC scales and from 0.65 to 0.96 for attitude anxiety scales with the student as the unit of analysis. Finally, when the ability of WIHIC scales to differentiate between classrooms was investigated by conducting an ANOVA with class membership as the independent variable, each of the four WIHIC scales was found to be capable of differentiating significantly between the perceptions of students in different classes. Results, overall, attested to the satisfactory validity and reliability of the learning environment and attitude/anxiety scales used in my study.

The second research question focused on changes across transition by comparing year 7 students with year 8 students in terms of learning environment perceptions and attitudes/anxiety. My third research question concerned whether any differences existed between students in Years 7 and 8 were similar or different for male and

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female students. Both of these research questions were investigated simultaneously by conducting a two-way MANOVA with the sample of 541 students with the four learning environment scales and three attitude/anxiety scales as the set of seven dependent variables. Grade level and sex comprised the two independent variables (see Figure 3.1 in Chapter 3). Relative to year 7 students, year 8 students perceived significantly less classroom Involvement, reported a less-positive Attitude to Mathematical Inquiry and less Enjoyment of Mathematics, and experienced greater Mathematics Anxiety. Effect sizes for these scales ranged from 0.25 to 0.51 standard deviations which, according to Cohen's (1988) criteria, are in the small to medium range.

Changes across transition were somewhat different for male and female students in two cases: the magnitude of sex differences in Attitude to Inquiry was somewhat greater in year 7 than year 8; and sex differences in Enjoyment of Mathematics favoured males in year 7 but were negligible in year 8.

Finally, the fourth research question involved associations between students' perceptions of four aspects of classroom environment (Student Cohesiveness, Teacher Support, Involvement, Cooperation) and three attitude/anxiety scales (Attitude to Mathematical Inquiry, Enjoyment of Mathematics, Mathematics Anxiety). Simple correlations were statistically significant for every learning environment scale with every attitude/anxiety scale. Also, for every attitude/anxiety scale, the multiple correlation with the set of four environment scales was statistically significant. Regression coefficients revealed that Involvement was a positive independent predictor of Attitude to Mathematical Inquiry, Teacher Support and Involvement were positive independent predictors of Enjoyment of Mathematics, and Involvement was a negative independent predictor of Mathematics Anxiety.

Chapter 5

CONCLUSION

5.1   Introduction

This chapter represents the culmination of a dedicated and forthright work whose initial seeds were planted in Chapter 1.

For my particular study, initial preparations essentially required meeting the requirements for obtaining candidacy, ethics approval and successful completion of compulsory coursework units. Next, my research questions were formulated and selected and work on my thesis began. I used tested and proven tools (the WIHIC, TOMRA and MAM) for data collection and analysis and I ensured that rigorous procedures were followed. Ethical issues dominate and pervade all aspects of our world and therefore the researcher is also responsible for meeting ethical requirements set by particular governing institutions.

The present chapter attempts to provide a summary of the thesis, along with its significance and limitations. As well, I furnish suggestions for future research undertakings and make closing comments. What follows is presented as:
- Summary of previous chapters (Section 5.2);
- Limitations (Section 5.3);
- Suggestions for future research (Section 5.4);
- Significance (Section 5.5);
- Conclusion (Section 5.6).

5.2   Summary of Previous Chapters

Chapter 1 introduced this thesis that is concerned with the changes in learning environment and students' attitudes and anxiety associated with the transition from primary to secondary mathematics classes. The background for my interest in this subject was explained along with the notion of paradigm and the researcher's and students' perception of the world, which ultimately and inevitably led to an

examination of the concept of 'reality', which was encapsulated within the headings of Ontology, Epistemology and Methodology. For a study of learning environments, it is crucial that the 'reality' of such learning environments is explored and put under the microscope so that things which, at first sight, might not be discernible can be examined under the lens of greater focus and magnification and thereby revealed.

The study's aims were also presented in this chapter. The first aim was to determine the reliability and validity of the learning environment and attitude/anxiety questionnaires. The second aim was to compare year 7 and year 8 students with respect to learning environment perceptions and attitudes/anxiety. An additional aim involved whether any differences existing between year 7 and year 8 students were similar or different for male and female students. A final aim focused on associations between students' perceptions of four aspects of classroom environment (Student Cohesiveness, Teacher Support, Involvement, Cooperation) and three attitude/anxiety scales (Attitude to Mathematical Inquiry, Enjoyment of Mathematics, Mathematics Anxiety).

In the literature review in Chapter 2, the compost of past studies provided the nutritional fodder for subsequent growth and development of this enterprise. Firstly, historical aspects of the field of learning environments and its abundant bounty of produce were explored, beginning with the work of Lewin and Murray in the 1930s, followed by Stern in the 1950s, and then Walberg and Anderson during the 1960s and Moos in the 1970s. Instruments developed by Fraser and colleagues for use in learning environments research were then outlined. A range of questionnaires was reviewed (i.e. LEI, CES, QTI, CUCEI, CLES, SLEI and MCI) along with studies that utilised such instruments. Because the WIHIC formed a major part of my study, a separate section in Chapter 2 was devoted entirely to it and a review of past studies that incorporated it into their fabric. This was followed by a review of six types of learning environments research: (1) associations between student outcomes and environment, (2) evaluation of educational innovations, (3) differences between student and teacher perceptions of actual and preferred environment, (4) teachers' attempts to improve classroom environments, (5) cross-national studies and (6) transition from primary to high school.

Sections of Chapter 2 were devoted to reviewing transition studies and mathematics anxiety. Attention then was turned to instruments for measuring mathematics anxiety and examining past research into this particular type of anxiety.

Chapter 3 concerned itself primarily with the methodology inherent in my study. It began by describing the harrowing process of securing the sample of 541 students comprising year 7 and year 8 students from 15 schools in South Australian metropolitan and regional areas. Next a description was provided of the modified instruments used (i.e. the WIHIC, TOMRA and MAM) and their administration. This was followed by an outline of the statistical-analysis procedures that were carried out to answer my research questions. Finally a section on ethical issues concluded the chapter.

Chapter 4 was devoted primarily to analyses and results of the study, beginning with the validity and reliability of the WIHIC and attitude questionnaire. Principal axis factoring with varimax rotation and Kaiser normalisation was carried out for the sample of 541 students to determine the factor structure of the four-scale version of the WIHIC, with the two criteria for retaining an item being that it must have a factor loading of at least 0.35 on its own scale and less than 0.35 on each of the other three WIHIC scales. Each of the 32 WIHIC items satisfied these criteria and thus was retained. For the different WIHIC scales the proportion of variance ranged from 4.04% to 35.98% with the total proportion of variance being 55.26%. Scale eigenvalues ranged from 1.29 to 11.51.

The two 10-item attitude scales (Attitude to Mathematical Inquiry and Enjoyment of Mathematics Lessons) along with the 8-item mathematics anxiety scale underwent factor analysis similar to the WIHIC. Identical criteria for the retention of any item were used. Each of the 28 items was found to satisfy the criteria and thus none were removed. For the different attitude and anxiety scales, the proportion of variance ranged from 7.46% to 29.59% with the total being 48.81%. Scale eigenvalues ranged from 2.08 to 8.28.

To determine the extent to which items with the same scale assessed a common construct, internal consistency was measured using Cronbach's alpha coefficient. For

the four WIHIC scales, the alpha coefficient ranged from 0.83 to 0.90 with the student as the unit of analysis and from 0.91 to 0.95 with the class as the unit of analysis. For the three attitude scales, using the student as the unit of analysis, the alpha coefficient ranged from 0.65 to 0.96 and, when using class means, it ranged from 0.83 to 0.96. Such results lend weight to the satisfactory factorial validity and high reliability of the learning environment and attitude scales used within my study.

The ability of the WIHIC scales to differentiate between the perceptions of students from different classrooms was determined by the use of ANOVA with class membership as the independent variable. The eta^2 statistic was statistically significant and ranged from 0.17 to 0.25 for different scales.

My second research question concerning changes across transition involved comparing year 7 and year 8 students with regards to learning environment perceptions and attitudes/anxiety. My third research question considered whether any differences existing between year 7 and year 8 students were similar or different for male and female students. These research questions were both investigated simultaneously with a two-way MANOVA with the four learning environment scales and three attitude/anxiety scales as the set of seven dependent variables. Grade level and sex were the two independent variables. Statistically significant results emerged for: grade level for the learning environment scale of Involvement and every attitude/anxiety scale (Attitude to Mathematical Inquiry, Enjoyment of Mathematics and Mathematics Anxiety); for sex for the two learning environment scales of Student Cohesiveness and Cooperation and for Enjoyment of Mathematics and Mathematics Anxiety; and for the grade−by−sex interaction for Attitude to Mathematical Inquiry and Enjoyment of Mathematics.

For the four scales for which grade-level differences were statistically significant, scores were less favourable in Year 8 than in Year 7. That is, relative to students in Year 7, Year 8 students perceived less Involvement and reported a less positive Attitude to Mathematical Inquiry, less Enjoyment of Mathematics and greater Mathematics Anxiety. For these scales, effect sizes ranged from 0.25 to 0.51 standard deviations, which are in the small to medium range according to Cohen's (1988) criteria.

ANOVA results and effect sizes for sex differences in the seven learning environment and attitude/anxiety scales revealed that females held somewhat more favourable perceptions than males for all four learning environment scales, but males had somewhat more favourable attitude/anxiety scores than females on all scores (i.e. higher Attitude to Mathematical Inquiry scores, higher Enjoyment of Mathematics scores and lower Mathematics Anxiety scores). These differences were statistically significant for four scales (Student Cohesiveness, Cooperation, Enjoyment of Mathematics and Mathematics Anxiety) for which effect sizes ranged from 0.32 to 0.44 standard deviations, which would be classified as small to modest according to Cohen's (1988) criteria.

The grade−by−sex interaction was statistically significant for Attitude to Mathematical Inquiry and Enjoyment of Mathematics. For Inquiry, scores were significantly higher in Year 7 than Year 8 but were similar overall for males and females. Although Inquiry scores were higher in Year 7 than Year 8 for students of both sexes, the magnitude of the sex difference in Inquiry scores was somewhat greater in Year 7 than in Year 8. For Enjoyment, scores were significantly higher for Year 7 than Year 8 and for males than females. Although both males and females reported greater Enjoyment in Year 7 than Year 8, sex differences in Enjoyment favoured males in Year 7 but were virtually non-existent in Year 8.

My fourth research question involved associations between students' perceptions of four aspects of classroom environment (Student Cohesiveness, Teacher Support, Involvement, Cooperation) and three attitude/anxiety scales (Attitude to Mathematical Inquiry, Enjoyment of Mathematics, Mathematics Anxiety). To investigate the relationships between students' perceptions of their learning environment and student attitudes and anxiety, simple correlation and multiple regression analyses were conducted. The simple correlation was statistically significant for every learning environment scale and every attitude/anxiety scale. Higher levels of classroom Student Cohesiveness, Teacher Support, Involvement and Cooperation were linked to higher Inquiry and Enjoyment scores and lower Anxiety scores. For every attitude/anxiety scale, the multiple correlation with the set of four environment scales was statistically significant. Inspection of the regression

coefficients revealed that: Involvement was a positive independent predictor of Attitude to Mathematical Inquiry; Teacher Support and Involvement were positive independent predictors of Enjoyment of Mathematics; and Involvement was a negative independent predictor of Mathematics Anxiety.

5.3   Limitations

A possible limitation of this study is that it did not involve qualitative methods. Tobin and Fraser (1998) advocate the combining of quantitative and qualitative approaches within a particular study because such approaches essentially complement and reinforce each other, thereby making the study's findings more dependable, robust and clear. By way of example, Fraser's (1999) study involved multiple researchers utilising observations, student diaries, video recordings and field notes, as well as interviews with a wide array of participants including teachers, students, parents and administrators. Another study by Aldridge, Fraser and Huang (1999) made use of narrative stories, observations and interviews.

However, qualitative methods have their limitations too. In considering this question of validity within qualitative research, Eisner states that "...it is the product of the persuasiveness of a personal vision; its utility is determined by the extent to which it informs. There is no test of statistical significance, no measure of construct validity…" (Eisner, 1981, p. 6). With qualitative methods, there is always the question of adequate validity and reliability but, at the same time, qualitative methods permit us "to see things that could be other than they are" (Burns, 1994, p. 14). Here the notion of 'reality' mentioned previously comes into play once again.

Smith and Heshusius (1986, p. 10) state: "For quantitative inquiry, these phrases ('research has shown…' and 'the results of research indicate…') are claims to an accurate reflection of reality or the claim of certitude that one has discovered how some bit of the social or educational world really is". My study, being quantitative in nature, essentially mirrors these statements and thus can be considered to reflect a particular reality.

Another limitation in qualitative approaches is the assumed role (actor) of the researcher participant or investigator within a group setting and the subsequent influence and emotional involvement of such a participant within these groups. This ultimately leads one to question the reliability of the observations reported and also to note the extreme subjectivity that can result from the situation in which one considers himself/herself as the main instrument in the study (Taft, 1999).

Nisbet and Watt (1984), cited in Cohen, Manion and Morrison (2000), identify various strengths of qualitative methods: they catch unique features that might otherwise be lost in larger-scale data (e.g. surveys) and that might hold the key to understanding the situation; and they are strong on reality. But Nisbet and Watt also identify weaknesses in qualitative methods: the results might not be generalisable except where other readers/researchers see their application; and they are not easily open to cross-checking and therefore might be selective, biased, personal and subjective. Merriam (1998, p. 202) lists various challenges to the trustworthiness of qualitative research, including:

- How can you generalise from a small non-random sample?
- If the researcher is the primary instrument for data collection and analysis, how can we be sure the researcher is a valid and reliable instrument?
- How do you know the researcher isn't biased and just finding out what he or she expects to find?

A further limitation was that my survey was paper-based instead of an electronic one. The latter would have proved more efficient, less-time consuming and easier for participants to complete. Furthermore, survey results would have been available more speedily.

Also, as in all educational studies, my sample was of limited size. My possible sample could have potentially doubled in size if the principals of certain schools had not declined to participate. This aspect, however, was completely beyond my control. A limited sample size limits the statistical power of data analyses. With larger and more-representative samples, one can more confidently generalise findings to a wider population. Because data collection also was primarily influenced by which

schools approached actually agreed to be involved, it could be argued that the sample was, in a sense, not truly representative.

An additional possible limitation of this study concerns the notion of reliability of the study's findings. As Merriam (1991, p. 170) states: "Reliability in a research design is based on the assumption that there is a single reality which if studied repeatedly will give the same results". Mahajan (1997, p. 68) contends that "it is difficult to assert that a particular paradigm provides a true and correct representation of the external reality, or that it corresponds to the world outside". Pateman (1989, p. 36) defines it as "a reality … that we cannot 'really know' ". From my earlier discussion of 'reality', I acknowledged the existence of multiple realities, and this impinges directly on the findings. Therefore, it could be argued that my study neither reflects a singular reality nor provides a true worldview and thus brings the notion of reliability into question.

Differing socioeconomic backgrounds of both school locality and students themselves could also possibly have influenced the results obtained. As an example, schools situated in affluent areas could yield different results from schools found in poorer zones. Some students also might not be able to read or fully comprehend the questionnaires. This could be as a result of ethnic background and poor language skills, particularly among recent arrivals from overseas who could be unfamiliar with completing questionnaires. Students with learning difficulties might also find the questionnaires difficult to complete. Because data collection also was primarily influenced by which schools approached actually agreed to be involved, it could be argued that the sample was, in a sense, not truly representative.

Another limiting factor could have been that I was not present when surveys were administered to students and thus I could not answer any questions that students might have had; however, I doubt that this would have affected the results in any important way. Among other limitations that come into consideration are that: there were no achievement measures; there was no pilot study conducted; and the study was cross-sectional, not longitudinal. An additional limitation could be related to the timing of the surveys. Some schools administered the questionnaires in a different school term from others and usually towards the end of the term when lessons were

coming to an end. This could have affected student responses in some way. The study could also have surveyed teachers and used both actual and preferred forms of survey instruments to better gauge the learning environment from both students' and teachers' perspectives.

5.4   Suggestions for Future Research

An examination of widespread studies in the field of learning environments has revealed a considerable body of knowledge within the domain. As suggested by Tobin and Fraser (1998), combining qualitative and quantitative research methods within future studies is to be encouraged because this could yield richer and more-comprehensive results. In future research on transition, teachers, students and parents could be interviewed so as to obtain an extensive body of additional data that would help to supplement the quantitative data collected in my study.

Teachers should also be encouraged to make greater use of valid and proven instruments, both actual and preferred, to guide improvements in their classroom environments (Fraser, 2007). By utilising such instruments, teachers would be provided with an invaluable 'reality' snapshot of their classroom environments from students' perspectives or frames of reference. Using the student feedback provided by such questionnaires would hopefully lead to improvements in classroom teaching and result in more productive and pleasant learning environments.

Additionally, teachers themselves could be surveyed in future transition studies to determine their own personal views of particular learning environments (both actual and preferred) so that comparisons/contrasts could be drawn between students and teachers perceptions of their classroom environments.

Furthermore new questionnaires written in native languages, that specifically address differing cultural values and the uniqueness of classrooms in other countries, could be developed. In particular, further research would be beneficial in countries where the use of learning environments instruments and mathematics anxiety measures has as yet not been undertaken. Also, because of the widespread use of and rapid development of technology, new electronic versions of questionnaires should be

developed for on-line use. Not only would this be beneficial for the researcher, but also it would have the added benefit of eliminating significant paper wastage (as was evidenced in my situation). This not only refers to the hundreds of actual completed paper surveys, which ultimately end up as waste, but also to the huge number of unused and discarded paper surveys sent to schools. An on-line survey would make the researcher's task easier, as well as creating a better environment for delivering, collecting and storing surveys, as well as further reducing the carbon footprint.

In order to facilitate future studies intended to be undertaken in schools, State Education Departments along with their administrators could provide more assistance with regards to researchers being given access to possible school sites. Perhaps a designated 'research studies' officer at the departmental level could liaise with schools directly (e.g. in particular departments with heads and principals) to initially determine which schools would be willing to participate in a particular proposed research study and then facilitate initial contact among both parties. At present, these Education Departments (government and independent) basically only provide a cover letter to prospective researchers that gives permission for them to approach schools. Ultimately, school principals have the final say but generally could be more understanding, sympathetic, receptive and conducive to allowing research to take place within their schools. Without such support from these upper echelons of power, how can the next generation of teachers/researchers undertake research in schools? Furthermore, by principals allowing research to take place within their schools, they would not only facilitate the researcher's often-difficult task of data collection and thereby help to reduce stress, worry and anxiety from the researcher's reality, but also their participation probably would provide unforeseen, longer-term educational benefits to the wider educational community at large.

Future transition studies could also be initiated with larger and more representative samples, which could include schools from across all sectors (i.e. government, Catholic, and Independent). Larger samples would enhance the statistical power of analyses and more-representative samples would improve the generalisability of findings.

My cross-sectional study involving learning environment and attitude criteria yielded many valuable results. However, it would be desirable in future transition studies also to include achievement measures and be longitudinal in scope in order to track changes in students' achievements, attitudes and anxiety over time.

The methods of data analysis employed in my study (e.g. exploratory factor analysis, MANOVA and multiple regression) were appropriate and sophisticated and yielded significant insights. However, in future research, it could be worthwhile to supplement these approaches with other data-analysis methods such as confirmatory factor analysis, hierarchical linear model (HLM) analysis and structural equation modelling (SEM).

5.5   Significance and Implications

This research built upon previous studies that have utilised learning environment and attitude instruments (especially the WIHIC, TOMRA and MARS) in examining changes that occur during primary–to–secondary transition, especially for the school subject of mathematics. This study contributes substantively to the field of learning environments by providing a folio of work that adds to the already-expansive tome and is significant because there have been very few prior studies of transition from year 7 to year 8 mathematics and its associated effect on learning environment and attitudes/anxiety.

The research also makes a methodological contribution by validating the WIHIC, TOMRA and MAM within the South Australian setting and thereby making these instruments accessible to future researchers and teachers.

Practical benefits of this research are that teachers hopefully will gain a greater awareness and understanding of this critical transition period and implement strategies to diminish and alleviate the negative effects of this transition on the learning environment and students' attitudes and anxiety. This study could help to guide the development of transition programmes as well as highlighting implications for teaching practices. Teachers could also benefit from this study by gaining a greater awareness of the problems that accompany students in such a transition and

take steps to reduce them. In addition, as a result of this study, teachers could gain a better understanding and appreciation of mathematics anxiety and consequently attempt to reduce it and its effects. It also could possibly lead to some teachers adopting better and improved classroom practices. From a practical perspective, teachers could easily implement some of the suggestions made, as well as to use the instruments to possibly improve their own classroom learning environments.

5.6   Conclusion

It is hoped that this research has in some way contributed to the field of learning environments, to our understanding of the primary–to–secondary transition, and to a more-informed understanding of not only this transition stage but also learning environments research and the wide array of instruments available to teachers. One also hopes that it leads to a greater acknowledgement and awareness of the affliction of mathematics anxiety and how to combat it.

It is also hoped that this study will encourage teachers to improve the quality of their own classroom environments so as to inspire, cultivate and nurture positive attitudes and reduce anxiety towards mathematics among their students. In the final analysis, if merely one teacher heeds the call, then my work will have succeeded and borne fruit.

Like the Olympic Torch, the 'flame' of learning environments has been passed from one researcher to another in its journey around the globe. Through the continued efforts and contributions of these past, present and future custodians of the 'flame', the fertile fields of learning environments and mathematics education will continue to produce a rich harvest or cornucopia of rewards for researchers, teachers and students alike.

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APPENDICES

Curtin University
Science and Mathematics Education Centre

Letter of Inquiry: Director of Catholic Education

Dear Sir,

My name is Don DeIeso and I am currently working on my doctoral degree with Curtin University in Perth, Western Australia. I seek your approval to approach Catholic Primary/Secondary schools to request their permission to administer surveys to year 7 and year 8 students. The purpose of the research is to investigate the changes in learning environments and students' attitudes and anxiety associated with the transition from primary to secondary school mathematics.

Student participants will be asked to be involved in the completion of three short surveys. The entire process will take approximately 40 minutes. The contact will be non-intrusive and will not disrupt classroom lessons. The student samples will not be identifiable and confidentiality of all participants will be maintained.

Participation in this study will be beneficial in investigating the classroom environment and attitudes amongst upper primary and junior secondary students towards mathematics in South Australian schools.

Included in this correspondence is a copy of my approval letter from Curtin University's Human Research Ethics Committee (Approval Number SMEC-22-12).

I will be the individual responsible for this research. Should you have any questions, feel free to contact me at (08) 83365315 or via e-mail at dondeieso@yahoo.com.au. Alternatively, you may contact my supervisor, Professor Barry J. Fraser, at B.Fraser@curtin.edu.au.

Yours faithfully,

Don DeIeso, Dip.T, B.Ed, Grad.Dip.Ed, M.Ed, M.Sc.

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Curtin University

Science and Mathematics Education Centre

Letter of Inquiry: School Site Principal

Dear Sir/Madam,

My name is Don DeIeso and I am currently working on my doctoral degree with Curtin University in Perth, Western Australia. I wish to request permission to administer questionnaires to year 7 primary or year 8 secondary school students. The purpose of the research is to investigate the changes in learning environments and students' attitudes and anxiety associated with the transition from primary to secondary school mathematics.

Student participants will be asked to be involved in the completion of three short surveys. Please note that students will **not** be required to solve any mathematics problems. The entire process will take approximately 40 minutes. The contact will be non-intrusive and will not disrupt classroom lessons. The student samples will not be identifiable and confidentiality of all participants will be maintained.

Participation in this study will be beneficial in investigating the classroom environment and attitudes amongst upper primary and junior secondary students towards mathematics in South Australian schools.

Included in this correspondence is a copy of my approval letter from Curtin University's Human Research Ethics Committee (Approval Number SMEC-22-12). Also attached is the **DECD Approval letter**.

I will be the individual responsible for this research. Should you have any questions, feel free to contact me at (08) 83365315 or via e-mail at dondeieso@yahoo.com.au. Alternatively, you may contact my supervisor, Professor Barry J. Fraser, at B.Fraser@curtin.edu.au.

Yours faithfully,

Don DeIeso, Dip.T, B.Ed, Grad.Dip.Ed, M.Ed, M.Sc.

Curtin University
Science and Mathematics Education Centre

Letter of Inquiry: School Site Principal

Dear Sir/Madam,

My name is Don Deleso and I am currently working on my doctoral degree with Curtin University in Perth, Western Australia. I wish to request permission to administer questionnaires to year 7 primary or year 8 secondary school students. The purpose of the research is to investigate the changes in learning environments and students' attitudes and anxiety associated with the transition from primary to secondary school mathematics.

Student participants will be asked to be involved in the completion of three short surveys. The entire process will take approximately 40 minutes. The contact will be non-intrusive and will not disrupt classroom lessons. The student samples will not be identifiable and confidentiality of all participants will be maintained.

Participation in this study will be beneficial in investigating the classroom environment and attitudes amongst upper primary and junior secondary students towards mathematics in South Australian schools.

Included in this correspondence is a copy of my approval letter from Curtin University's Human Research Ethics Committee (Approval Number SMEC-22-12). I have also obtained approval from the Catholic Education Centre to conduct this research.

I will be the individual responsible for this research. Should you have any questions, feel free to contact me at (08) 83365315 or via e-mail at dondeieso@yahoo.com.au. Alternatively, you may contact my supervisor, Professor Barry J. Fraser, at B.Fraser@curtin.edu.au.

Yours faithfully,

Don Deleso, Dip.T, B.Ed, Grad.Dip.Ed, M.Ed, M.Sc.

Appendix D
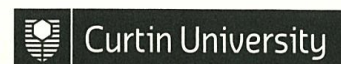
Memorandum

To	Don Deieso, SMEC
From	Pauline Howat, Administrator, Human Research Ethics Science and Mathematics Education Centre
Subject	Protocol Approval **SMEC-22-12**
Date	6 June 2013
Copy	Barry Fraser, SMEC

Office of Research and Development

Human Research Ethics Committee

Telephone   9266 2784
Facsimile   9266 3793
Email   hrec@curtin.edu.au

Thank you for keeping us informed of the progress of your research. The Human Research Ethics Committee acknowledges receipt of your progress report and indication of modifications / changes for the project *"Changes in learning environment and students' attitudes and anxiety associated with the transition from primary to secondary school mathematics"*. Your application has been ***approved***.

Approval for this project is extended to **31 May 2014.**

Your approval has the following conditions:

(i)   Annual progress reports on the project must be submitted to the Ethics Office.

Your approval number remains **SMEC-22-12**. Please quote this number in any further correspondence regarding this project.

Yours sincerely

PAULINE HOWAT
Administrator
Human Research Ethics
Science and Mathematics Education Centre

Please Note: The following standard statement must be included in the information sheet to participants:
This study has been approved under Curtin University's process for lower-risk Studies (Approval Number SMEC-22-12). This process complies with the National Statement on Ethical Conduct in Human Research (Chapter 5.1.7 and Chapters 5.1.18-5.1.21).
For further information on this study contact the researchers named above or the Curtin University Human Research Ethics Committee. c/- Office of Research and Development, Curtin University, GPO Box U1987, Perth 6845 or by telephoning 9266 9223 or by emailing hrec@curtin.edu.au.

Appendix E

Government of South Australia

Department for Education and
Child Development

DECD CS/13/199-3.2

Dear Principal/Director/Site Manager

The research project titled *"Changes in learning environment and students' and anxiety associated with the transition from primary to secondary school mathematics."* *has been reviewed* centrally and granted approval for access to Department for Education and Child Development (DECD) sites. However, the researcher will still need your agreement to proceed with this research at your site.

Once approval has been given at the local level, it is important to ensure that the researchers fulfil their responsibilities in obtaining informed consent as agreed, that individuals' confidentiality is preserved and that safety precautions are in place.

Researchers are encouraged to provide feedback to sites used in their research, and you may wish to make this one of the conditions for accessing your site. To ensure maximum benefit to DECD, researchers are also asked to supply the department with a copy of their final report which will be circulated to interested staff and educators for future reference.

Please contact Allison Cook, Project Officer – Research and Innovation on (08) 8226 4108 for further clarification if required, or to obtain a copy of the final report.

Yours sincerely

Ben Temperly
HEAD OF STRATEGY AND PERFORMANCE

Catholic Education Centre

116 George Street   Thebarton   SA 5031
PO Box 179 Torrensville Plaza   South Australia 5031
Telephone: (08) 8301 6600
Facsimile: (08) 8301 6611
ISD: 61 8 8301 6600
Email: director@cesa.catholic.edu.au
www.cesa.catholic.edu.au

Dear Mr Deleso

Thank you for your recent email correspondence in which you seek permission to approach Catholic schools in connection with the research study *Changes in learning environment and students' attitudes and anxiety associated with the transition from primary to secondary school mathematics.* I understand the study will involve the administration of three short surveys to year 7 and year 8 students.

In the normal course, permission of the Principal of each school in which you wish to conduct research is required. Research in Catholic schools is granted on the basis that individual students, schools and the Catholic sector itself is not specifically identified in published research data and conclusions.

Approval is also contingent upon the following conditions, i.e. that:

- a copy of the surveys has been provided to the Principal

- the permission of parents has been obtained

- the research complies with the ethics proposal of the University

- the research complies with any provisions under the Privacy Act that may require adherence by you as researcher in gathering and reporting data

- no comparison between schooling sectors is made

- the researcher will be carrying out the research within view of the class teacher or authorised school observer

- sector requirements relating to child protection and police checks are met by researchers:

  o where researchers obtain information in relation to a student which suggests or indicates abuse, this information must be immediately conveyed to the Director of Catholic Education SA

  o all researchers and assistants, who in the course of the research interact in any way with students, are required to undertake a police check through the Archdiocese of Adelaide Police Check Unit.

…../2.

Information with regard to obtaining police clearance can be accessed at the website address:
www.cesa.catholic.edu.au

Researchers should forward a certified copy of their National Police Certificate, which has been issued within the last three months, to the Catholic Archdiocese of Adelaide Police Check Unit at the Catholic Education Office, PO Box 179, Torrensville Plaza SA 5031. The Police Check Unit will then post a clearance letter to the researcher. This letter should be provided to the Principal of each school.

Please accept my very best wishes for the research process.

Yours sincerely

HELEN O'BRIEN
DEPUTY DIRECTOR

26 February 2013

**Curtin University
Science and Mathematics Education Centre**

Parent/Guardian/Student Information Sheet

My name is Don DeIeso and I am currently completing a piece of research for my degree of Doctor of Mathematics Education at Curtin University in Perth, Western Australia.

Purpose of Research
I am investigating the changes in learning environments and students' attitudes and anxiety associated with the transition from primary to secondary school mathematics within South Australian schools.

Your Child's Role
Your child will be asked to complete three short surveys that will be administered during one of his/her normal class periods. This entire process will take approximately 40 minutes.

Consent to Participate
Your child's involvement in this research is entirely voluntary. He/she has the right to withdraw at any stage without it affecting his/her rights or my responsibilities. Once you have signed the consent form, I will assume that you have agreed to allow your child to participate in this study and that I have your permission to use the data in this research.

Confidentiality
The information your child provides will be kept separate from his/her personal details, and only my supervisor and I will have access to the completed questionnaires. These questionnaires will be kept in a locked cabinet for five (5) years at which point they will be destroyed.

Further Information
This research has been reviewed and given approval by the Curtin University Human Research Ethics Committee (Approval Number SMEC-22-12). If you would like further information about this study, please feel free to contact me at dondeieso@yahoo.com.au. Alternatively, you may contact my supervisor, Professor Barry J. Fraser, at B.Fraser@curtin.edu.au.

Thank you for your involvement in this research. Your participation is greatly appreciated.

Curtin University
Science and Mathematics Education Centre

Parent/Guardian Consent Form

Dear Parent/Guardian:

Permission is requested for _____ to participate in a research study. The purpose of the research is to investigate the changes in learning environments and students' attitudes and anxiety associated with the transition from primary to secondary school mathematics. Participants will be asked to be involved in the completion of three short surveys. The entire process will take approximately 40 minutes.

The contact will be non-intrusive and will not disrupt classroom lessons. **The student samples will not be identifiable and confidentiality of all participants will be maintained.**

Participation in this study will be beneficial in investigating the classroom environment and attitudes amongst upper primary and junior secondary students towards mathematics in South Australian schools.

Please indicate below whether you give permission for the above named student to participate in this valuable research study. Forms should be returned to the student's teacher.

I will be the individual responsible for this research. Should you have any questions, feel free to contact me by email at dondeieso@yahoo.com.au.

Sincerely,

Don Deieso, Dip.T, B.Ed, Grad.Dip.Ed, M.Ed, M.Sc.

____YES, permission is GRANTED to participate.   ____No, permission is DENIED to participate.

_____
Parent/Guardian Name (Signature)

_____
Parent/Guardian Name (Print)

_____
Date

What is Happening in this Class?

Directions for Students
These questionnaires contain statements about practices which could take place in this class. You will be asked how often each practice takes place.

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

Draw a circle around

1	if the practice takes place	**Almost Never**
2	if the practice takes place	**Seldom**
3	if the practice takes place	**Sometimes**
4	if the practice takes place	**Often**
5	if the practice takes place	**Almost Always**

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

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

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

Your Name: _____

Teacher's Name: _____

School: _____

Grade: _____

Gender: Male ☐   Female ☐

STUDENT COHESIVENESS		Almost Never	Seldom	Some-times	Often	Almost Always
1.	I make friendships among students in this class.	1	2	3	4	5
2.	I know other students in this class.	1	2	3	4	5
3.	I am friendly to members of this class.	1	2	3	4	5
4.	Members of the class are my friends.	1	2	3	4	5
5.	I work well with other class members.	1	2	3	4	5
6.	I help other class members who are having trouble with their work.	1	2	3	4	5
7.	Students in this class like me.	1	2	3	4	5
8.	In this class, I get help from other students.	1	2	3	4	5
TEACHER SUPPORT		Almost Never	Seldom	Some-times	Often	Almost Always
9.	The teacher takes a personal interest in me.	1	2	3	4	5
10.	The teacher goes out of his/her way to help me.	1	2	3	4	5
11.	The teacher considers my feelings.	1	2	3	4	5
12.	The teacher helps me when I have trouble with the work.	1	2	3	4	5
13.	The teacher talks with me.	1	2	3	4	5
14.	The teacher is interested in my problems.	1	2	3	4	5
15.	The teacher moves about the class to talk with me.	1	2	3	4	5
16.	The teacher's questions help me to understand.	1	2	3	4	5
INVOLVEMENT		Almost Never	Seldom	Some-times	Often	Almost Always
17.	I discuss ideas in class.	1	2	3	4	5
18.	I give my opinions during class discussions.	1	2	3	4	5
19.	The teacher asks me questions.	1	2	3	4	5
20.	My ideas and suggestions are used during classroom discussions.	1	2	3	4	5
21.	I ask the teacher questions.	1	2	3	4	5
22.	I explain my ideas to other students.	1	2	3	4	5
23.	Students discuss with me how to go about solving problems.	1	2	3	4	5
24.	I am asked to explain how I solve problems.	1	2	3	4	5

COOPERATION	Almost Never	Seldom	Some-times	Often	Almost Always
25. I cooperate with other students when doing assignment work.	1	2	3	4	5
26. I share my books and resources with other students when doing assignments.	1	2	3	4	5
27. When I work in groups in this class, there is teamwork.	1	2	3	4	5
28. I work with other students on projects in this class.	1	2	3	4	5
29. I learn from other students in this class.	1	2	3	4	5
30. I work with other students in this class.	1	2	3	4	5
31. I cooperate with other students on class activities.	1	2	3	4	5
32. Students work with me to achieve class goals.	1	2	3	4	5

The questionnaire is a modified version of the What is Happening In this Class (WIHIC, Fraser, McRobbie & Fisher, 1996). Used with the permission of the author/s. It is discussed in sections 2.5 and 3.5 of this thesis.

Test of Mathematics Related Attitudes

This survey is used to measure your attitude towards mathematics and mathematics 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. I would prefer to find out why something is true by doing a problem than by being told.
2. Mathematics lessons are fun.
3. Doing problems is not as good as finding out information directly from teachers.
4. I dislike mathematics lessons.
5. I would prefer to do problems than read about them.
6. School should have more mathematics lessons each week.
7. I would rather agree with people than investigate a problem to find out for myself.
8. Mathematics lessons bore me.
9. I would prefer to do my own problems than have a teacher explain them.
10. Mathematics is one of the most interesting school subjects.
11. I would rather find out about things by asking an expert than working on my own.
12. Mathematics lessons are a waste of time.
13. I would rather solve a problem by experimenting than be told the answer.
14. I really enjoy going to mathematics lessons.
15. It is better to ask the teacher the answer than to find out by trying a problem.
16. The material covered in mathematics lessons is uninteresting.
17. I would prefer to do a problem on a topic than to read about it in a textbook.
18. I look forward to mathematics lessons.
19. It is better to be told mathematical facts than to find them out from problem solving.
20. I would enjoy school more if there were no mathematics lessons.

	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	8	SA	A	N	D	SD	15	SA	A	N	D	SD
2	SA	A	N	D	SD	9	SA	A	N	D	SD	16	SA	A	N	D	SD
3	SA	A	N	D	SD	10	SA	A	N	D	SD	17	SA	A	N	D	SD
4	SA	A	N	D	SD	11	SA	A	N	D	SD	18	SA	A	N	D	SD
5	SA	A	N	D	SD	12	SA	A	N	D	SD	19	SA	A	N	D	SD
6	SA	A	N	D	SD	13	SA	A	N	D	SD	20	SA	A	N	D	SD
7	SA	A	N	D	SD	14	SA	A	N	D	SD						

The questionnaire is a modified version of the Test of Mathematics Related Attitudes (TOMRA) based on the Test of Science-Related Attitudes (TOSRA, Fraser, 1981). Used with the permission of the author/s. It is discussed in section 3.5 of this thesis.

MATHEMATICS ANXIETY MEASURE

For the following statements, please rate each item in terms of how anxious you would feel during the event specified. Use the following scale and circle your answer in the space to the left of the item.

1	2	3	4	5
Low Anxiety	Some Anxiety	Moderate Anxiety	Quite a Bit of Anxiety	High Anxiety

1   2   3   4   5   Having to use a calculator or table to solve a problem.

1   2   3   4   5   Thinking about a mathematics test before you take it.

1   2   3   4   5   Being given a difficult homework task which is due the next class meeting.

1   2   3   4   5   Starting a new chapter in a mathematics class.

1   2   3   4   5   Looking through the pages of a mathematics textbook.

1   2   3   4   5   Reading and interpreting graphs and charts.

1   2   3   4   5   Getting ready to study for a mathematics test.

1   2   3   4   5   Listening to another student explain a mathematics formula to you.

The questionnaire is a modified version of the Math Anxiety Rating Scale-Revised (MARS-R, Plake & Parker, 1982) and the Abbreviated Math Anxiety Scale (AMAS, Hopko et al., 2003). It is discussed in section 3.5 of this thesis.

Appendix L

Appendix
A sample bibliotherapy lesson plan featuring *Counting on Frank*

Counting on Frank by Rod Clement depicts the story of a middle school boy's gift of mathematics. He goes through life knowing many things, counting, comparing, and knowing many number facts that all come easily to him. This lesson plan provides a variety of follow-up activities for use during or after reading *Counting on Frank*. Integrating such activities into teaching allows a teacher to address the feelings of their students as they learn mathematics. The book offers a series of questions at the end of the book called *Here's a Chance to Use YOUR Brain!* which many young gifted students may enjoy investigating.

Menu of themes or key concepts

- Everyone has a unique way of looking at the world.
- The mathematically gifted should not be embarrassed because they are good at mathematics.
- Mathematics is used in everyday life events.
- Some gifted and talented students are embarrassed by their mathematics abilities and tend to diminish their skills or talents.
- Mathematics can be easy, fun and rewarding.
- There are many misconceptions about mathematics.

Discussion questions

- Some people say that mathematics is used in everyday life. Can you give some examples?
- How do you feel when adults say mathematics surrounds us?
- Do you think people learn mathematics in different ways? Why? How?
- How do you learn mathematics best?
- How do you feel when an adult tells you to use your brain? Why?
- What do you think is the most frightening thing about mathematics? What is the best thing about mathematics?
- Describe how your mathematics teacher helps you to use your brain. How can you do this on your own?
- Do you share your feelings about mathematics with other people?
- Most people think that the ability to do mathematics in a necessary life skill. How does that belief make you feel about your mathematics ability? Do you agree or disagree?
- Should all smart students be expected to love mathematics? Why or why not?
- What advice would you give to younger students about learning and enjoying mathematics?
- What are some ways you can be proud of your mathematics skills?

Possible activities

- The book concludes with four pages of mathematics problems directly related to the story that give students a chance to use mathematics and numbers in fun ways. The

Source: http://www.harpercollins.com.au/books/Counting-Frank-Rod-Clement/?isbn=9780207173226
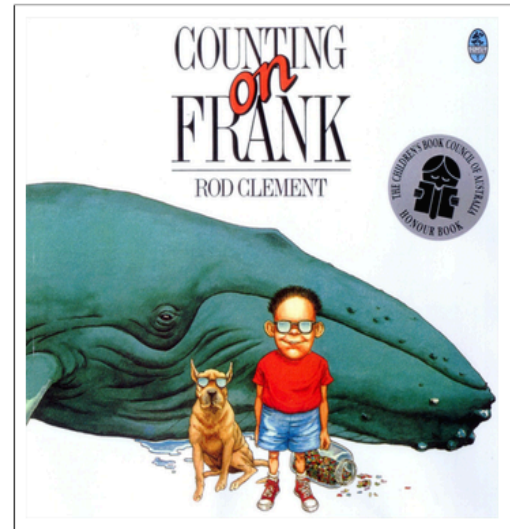
FIGURE 1: Book cover of *Counting on Frank* by Rod Clement.

teacher can encourage the students to explore and solve these problems.
- Students can write their own word problems relating to everyday life events for classmates to solve.
- Students can write a reflective essay about the importance of mathematics in everyday life and how this affects their own beliefs about their mathematics skills and abilities.
- Have students write a poem about their mathematical ability and allow time to share with the class.
- Have students create a picture collage of examples of mathematics use in everyday life.
- Have students keep a mathematics journal to record their feelings about mathematics and share times when others made them feel like a nerd or bad for being good at it.
- Have students create a 'counting' mathematics song and allow them to perform in front of classmates.
- Group students into teams to play Maths Jeopardy. Students have to work collaboratively to solve word problems.
- Invite professional community members to come in to discuss how they use mathematics in their business.
- Allow students to investigate mathematicians through time and identify some who may have been gifted and have them report back their contributions to mathematics.
- Student may want to review the book and notice the character and how he is dressed and portrayed. Does the book portray him as a 'nerd'? How would you change this portrayal?

Interactive mathematics websites that may appeal to the mathematically gifted

www.funbrain.com
www.coolmath4kids.com
www.math.com
www.brainpop.com
http://nrich.maths.org

(Source: Furner & Kenney, 2011)

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A Sample Bibliotherapy Lesson Featuring Math Curse

Scieszka and Smith (1995) published a book titled *Math Curse*, in which they depicted the story of a young child who realizes that everything in life is a mathematical problem that cannot be avoided. The book presents the reader with a variety of math problems in a humorous yet realistic fashion. It has an empathetic tone that assures math anxious readers that they are not alone in their fear of mathematics. Scieszka and Smith have, thereby, provided secondary math teachers with an excellent resource for effective bibliotherapy lessons. The following lesson plan, designed for middle and high school math teachers, provides a variety of follow-up activities for use after reading *Math Curse*. These helpful activities are appropriate for infusing affective instruction into a math curriculum over the course of a semester or an entire academic year. Because secondary math teachers are often under pressure to teach many mathematical concepts and skills in an academic year, they do not have much time to allocate to bibliotherapy lessons using books that may take several days for students to read in class. The use of a highly sophisticated picture book such as *Math Curse*, however, allows a secondary math teacher to effectively address math anxiety with students in much less time. Scheduling such lessons consistently throughout a semester or an academic year allows secondary math teachers to address the anxious feelings of their students as they teach content. The activities become an affective strand incorporated into their math curriculum.

Lesson Plan for Group Bibliotherapy Sessions Using *Math Curse*
Scieszka, J., & Smith, L. (1995). *Math Curse*. NY: Viking Press.
Annotation
   When Mrs. Fibonacci, an elementary school teacher, tells her class members that they can think of almost everything as a math problem, one student becomes overwhelmed by the scope of math. This math anxiety becomes a real curse. However, the student soon realizes that math is everywhere and there is no way of escaping it in daily life. Eventually, the math anxious youngster recognizes math as a means of making one's life easier.

Menu of Possible Themes/Key Concepts
Math surrounds us.
All people can learn math in their own way.
There are many myths and misconceptions about math.
Not all people are confident in their ability to learn mathematics.
Fractions, long division and word problems are frightening to some people.
Drill, practice, and repetition in math may cause boredom.
Poor study habits in math lead to lack of success in math.
Former teachers may have turned students off to math.
Math tests make students feel very nervous.
Math anxiety is a learned behavior and not an inherited trait.
People can learn techniques to overcome math anxiety.
People who are math anxious are not alone in their feelings.

Menu of Possible Introductory Activities
Have the students define the terms "curse" and "anxiety."
Have the students discuss what it means to be a "math whiz kid."
Have the students describe their favorite math teacher.

Menu of Selected Passages from Math Curse *to be Used in Discussion*
"You know, you can think of everything as a math problem."
"I'm getting a little worried. Everything seems to be a problem."
"Mrs. Fibonacci has obviously put a math curse on me. Everything I look at or think about has become a math problem."
"Math is just a total problem."
"I am a raving math lunatic. What if this keeps up for the whole year?"
"I've broken the math curse. I can solve any problem. And life is just great until science class …"

(continued)

Menu of Discussion Questions

1. Some people claim that "math surrounds us." Do you agree?
2. Do you think people learn math in different ways? How do you best learn math? Why?
3. What do you think is the most frightening aspect of math? Why?
4. Have you ever experienced a day similar to the one described in *Math Curse*? How did you feel? What did you do to cope with those feelings?
5. Have you ever had a math teacher place a math curse on you? What happened? What did you do to overcome that feeling of being cursed?
6. Many people think that the ability to do math is a necessary skill for success in life. How does that belief make you feel about your ability in math?
7. Have you ever lost confidence in yourself in a math class? What happened that made you feel less confident? How did it feel? What did you do to deal with your feelings at the time?
8. What do you do to deal with nervousness right before a math exam?
9. What was the most embarrassing experience you've faced in a math class? How did you cope with your embarrassment at the time?
10. Describe what you think math teachers should do to help students remain confident while learning difficult math concepts.
11. Have your friends or family members ever commented on how they've expected you to get straight As in math classes? How did you feel when they made those comments?
12. Have you ever shared your anxious feelings about math with anyone in your family? How did they respond? How did that make you feel?
13. Have you ever tried to discuss your math anxiety with teachers in the past? What happened? How did you feel after the conversation?
14. If you could design a stress-free math class, what would it be like?
15. If you could provide advice to new math teachers working with gifted students, what would you want to tell them? Why?
16. Should all gifted students be expected to love math?
17. If you could elect a math teacher to the "Math Teachers' Hall of Fame," which qualities would you look for in selecting a teacher for this honor? Why?
18. If you could provide some advice to younger brothers or sisters to help them prepare for math classes in middle school or high school, what would you tell them?

Menu of Possible Follow-up Activities

1. Lead students in role playing the following scenarios involving math anxious feelings:
   a. test taking anxiety and how they feel before, during and after a math exam
   b. being called on by the teacher in class
   c. being directed to solve a problem on the classroom chalkboard
   d. doing math homework
2. Have students write letters to the main character in *Math Curse* describing how they felt about the events of the day described in the story.
3. Have the students write a letter to Ann Landers or Dear Abby about their math anxiety.
4. Have students write their math autobiographies describing the events which helped to cause their math anxiety. Provide time for the students to voluntarily share their stories.
5. Have students keep a journal for one day to document how they used math in the course of the day. Have the students report back to the class the following day and conduct a discussion about their findings.
6. Provide students an opportunity to select an artistic medium (ie. magazine photo collage, penciled sketch) to illustrate their math anxiety.
7. Provide students an opportunity to compose songs or raps about their math anxiety or their personal math histories.
8. Lead students in relaxation exercises, training them to incorporate several easy techniques in coping with anxious feelings during exams or any other math distress.

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(continued)

9. Have students compose personal self-affirmation statements to be used in daily math classes and directly before mathematics exams.
10. Have students design anti-math anxiety bumper stickers to be plastered on their school lockers, providing them with a daily self-affirmation statement.
11. Have successful male and female community leaders involved in math related fields visit the class as guest speakers to discuss how they overcame experiences with math anxiety.
12. Provide students an opportunity to create original radio or television advertisements for a national anti-math anxiety campaign.
13. Have students visualize what an anxiety-free, successful day in math would be like and have them write about this day in their math journals.
14. Survey the students about the math problems posed in *Math Curse* to find out which, if any, make them feel anxious. Discuss the results of the survey and why certain problems make them feel anxious.

Along with children's picture books such as *Math Curse*, numerous student self-help books exist that focus on math anxiety. Secondary math teachers should find it easy to locate many effective resources to be used as bibliotherapy reading material. The appendix contains a sampling of books that have been used to help middle and high school math students deal with mathematics anxiety. In selecting these teacher resources, the authors considered the quality of the suggested activities, inclusion of authentic case studies, tips and techniques for coping with math anxiety, user friendliness and the incorporation of guided practice in the remediation of math concepts. All of the books described in the appendix offer many thought-provoking discussion questions appropriate for use in reflective activities with students in bibliotherapy sessions.

(Source: Hebert & Furner, 1997)