Science and Mathematics Education Centre

**Multimedia in High School Mathematics Classes: Students'
Perceptions of the Learning Environment and Engagement**
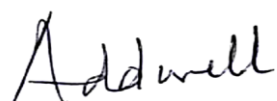
Addwell Tichafa Chipangura

**This thesis is presented for the Degree of
Doctor of Philosophy
of
Curtin University**

November 2014

DECLARATION

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

Addwell Tichafa Chipangura

November 2014

Date

ABSTRACT

The general consensus among psychologists and educators is that students' engagement in mathematics learning is a necessary precondition for improving students' achievement. However, there is less certainty about how to accomplish this.

The study reported in this thesis investigated, first, whether students in classes that were frequently exposed to multimedia (defined as a learning environment that combines hypertext and at least one other media format simultaneously) had different perceptions of the learning environment and engagement (motivation and self-regulation) in mathematics when compared to students who were in classes that were not frequently exposed to multimedia. Second, for students frequently exposed to multimedia, the study examined whether differences existed between males and females in terms of their perceptions of the environment and engagement in mathematics and whether exposure to multimedia was differentially effective for males and females. Finally, the research examined whether relationships exist between the learning environment created in classes exposed to multimedia and student engagement. .

This study involved a sequential, mixed-method design that included two phases. The first phase involved the collection of quantitative data and the second involved the gathering of qualitative information. During the first phase, two instruments were administered to students, one to assess student perceptions of the learning environment and the other to assess students' engagement. During the second phase,

classroom observations and interviews with students and teachers were used to gather information that would provide insights into the quantitative findings.

The sample for the quantitative data collection involved 365 high school students in 16 intact mathematics classes, 191 of whom were males and 174 of whom were females. The ages of the students ranged from 11 to 18 years of age. Of the 16 classes, nine classes were frequently exposed to multimedia and seven classes were not. The sample for the collection of qualitative information included interviews with 10 students, six of whom were from classes that were frequently exposed to multimedia (three male and three female) and four of whom were from classes that were not frequently exposed to multimedia (two male and two female). Interviews were also held with three mathematics teachers, all of whom were teaching classes in both groups. In addition to interviews, classroom observations were conducted in six classes that were frequently exposed to multimedia and six classes that were not frequently exposed to multimedia. Observations were carried out over a six-week period.

To examine differences in students' perceptions of their learning environment and their engagement (for students in classes exposed to multimedia and those in classes that were not) a one-way multivariate analysis of variance (MANOVA) was performed using data collected from the 365 students. The results indicated that there were statistically significant ($p<0.01$) differences for all of the scales on both surveys, with students in classes frequently exposed to multimedia consistently scored higher than students in classes not frequently exposed to multimedia. The effect sizes were large, ranging from 0.57 to 1.56 standard deviations. Analysis of the

qualitative information provided insights into the quantitative findings, suggesting that students who were in classes that were frequently exposed to multimedia were more likely to be autonomous and independent in their learning; had more positive interactions with their peers and the teacher; were more attentive; and engaged during class activities more so than their counterparts in classes that were not frequently exposed to multimedia.

Similarly, a one-way MANOVA was used to examine whether there were differences between males and females who participated in classes that were frequently exposed to multimedia. The results indicated that there were no statistically significant differences in students' perceptions of the environment. However, for engagement, there were statistically significant differences for two of the four scales, these being, Task Value ($p<0.01$, $F= 8.03$, effect size= 0.41 standard deviations, $r_{Y\lambda}= 0.20$) and Self-Efficacy ($p<0.05$, $F= 4.47$, effect size= 0.34 standard deviations, $r_{Y\lambda}= 0.17$). In both cases, males scored higher than their female counterparts.

A two-way MANOVA, with the learning environment and engagement scales as the set of dependent variables and two independent variables based on the type of class (frequently or not frequent exposed to multimedia) and sex (male and female), was used to examine whether the exposure to multimedia was differentially effective for male and female students. The results indicated that there were statistically significant interactions ($p<0.05$) between exposure to multimedia and sex for three environment scales (Involvement, Task Orientation and Equity) and three engagement scales (Learning Goal Orientation, Task Value and Self-efficacy). The

interpretation of the exposure to multimedia-by-sex interaction for the Task Orientation and Equity scales suggested that, in classes that were frequently exposed to multimedia, males and females had similar perceptions. However, in classes that were not frequently exposed to multimedia, females scored higher than their male counterparts. In contrast, for the Involvement, Learning Goal Orientation, Task Value and Self-efficacy scales, in classes that were frequently exposed to multimedia, males scored higher than their female counterparts and in classes that were not frequently exposed to multimedia, females scored higher than their male counterparts.

To examine whether relationships existed between the learning environment and student engagement, simple correlation and multiple regression were used. The results of the simple correlation analysis indicated that the six learning environment scales (Student Cohesiveness, Teacher Support, Involvement, Task Orientation, Cooperation and Equity) correlated significantly and positively with the four motivation and engagement scales (Learning Goal Orientation, Task Value, Self-Efficacy and Self-Regulation) scales at both the individual and class levels, with three exceptions (Learning Goal Orientation with Equity, Self-Regulation with Equity and Self-Regulation with Cooperation) at the individual level of analysis. Interpretation of the standardised regression weights indicated that: Task Orientation was a significant independent predictor of Learning Goal Orientation. Teacher Support, Involvement and Task Orientation were significant independent predictors of Task Value; Involvement and Task Orientation scales were significant independent predictors of Self-Efficacy and Student Cohesiveness; and Involvement and Task Orientation were significant independent predictors of Self-Regulation

(Student Cohesiveness had a negative standardised regression coefficients with Self-Regulation).

The research reported in this thesis is significant because it is one of the first studies within the field of learning environment and mathematics education to examine student exposure to multimedia in mathematics learning. The results offer potentially important insights into how students' exposure to multimedia could promote their engagement in mathematics classes. The interactions between exposure to multimedia and sex with respect to the learning environment and engagement adds to the understanding of how the learning environment, and how each sex perceives it to be, and could be used by schools to guide intervention programmes, which may differ in terms of orientation and application for males and females in order to tackle equity issues.

ACKNOWLEDGEMENTS

My PhD trajectory has been long and loaded with both excitement and disappointments and there were times when I felt like giving up. I am glad that I did not listen to the spirit of defeat as I am now able to reflect on my journey and acknowledge the help and facilitation I received along the way.

Undeniably, the completion of a doctorate takes self-initiative and motivation, however, to complete a task of this magnitude, required people with whom to interact and to work. In this respect, I have been blessed with many individuals and groups in my professional and personal life that have helped to guide, direct and love me along the way. I would like to take this opportunity to extend my thanks to them all.

I am grateful for the support, encouragement, and guidance of the people at Curtin University, especially in the Science and Mathematics Education Centre. I consider myself privileged to have been supervised by Associate Professor Jill Aldridge, without whose help and direction I would not have made it to this point. Jill, for your patience, the great amount of time and effort you have put into the analysis of my data and the expeditious feedback to all of my questions and concerns, I thank you. You are an outstanding supervisor. My thanks are also extended to my associate supervisor, Professor Barry Fraser for his continuous support. This pair worked with me, providing tips when the going got tough, as well as inspiration to encourage me to soldier on.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF ACRONYMS

Acronym	Meaning
AEU	Australian Education Union
AMQ	Academic Motivation Scale
ANOVA	Analysis of Variance
AU	Australia
CEQ	Classroom Environment Questionnaires
CES	Classroom Environment Scale
CLES	Constructivist Learning Environment Survey
COS	Courses of Study
CUCEI	College and University Classroom Environment Inventory
ICEQ	Individualised Classroom Environment Questionnaire
ICT	Information Communication Technology
LASSI	Learning And Study Strategies Inventory
LEI	Learning Environments Inventory
LER	Learning Environments Research
MANOVA	Multivariate Analysis of Variance
MCI	My Class Inventory
MSLQ	Motivated Strategies for Learning Questionnaire
NAPLAN	National Assessment Programme – Literacy and Numeracy
QTI	Questionnaire on Teacher Interaction
SALEM	Students' Adaptive Learning Engagement in Mathematics questionnaire
SALES	Students' Adaptive Learning Engagement in Science questionnaire
SLEI	Science Laboratory Environment Inventory
SMQ	Science Motivation Questionnaire
SMTSL	Students' Motivation Towards Science Learning
TROFLEI	Technology-Rich Outcomes-Focused Learning Environment Inventory
UAE	United Arab Emirates

UK	United Kingdom
US	United States of America
WIHIC	What Is Happening In this Class

CHAPTER 1

RATIONALE AND BACKGROUND

1.1   Introduction

Over the past decade, researchers have highlighted the current crisis of disappointingly low student motivation and interest in mathematics and have, as a result, called for major reforms focused on engaging young people in mathematics learning (Anderson, Hamilton & Hattie, 2004; Osborne & Dillon, 2008; Sjoberg & Schreiner, 2010; Tytler, 2007). On the whole, the crisis has been attributed to the inability of the mathematics curricula and classroom practices to ignite the interest of students to learn mathematics. Whilst this information is important, they provide only minimal insights into the factors that contribute towards high or low student interest in mathematics.

Since the development of the first computers, as multimedia tools, many educators have argued that multimedia could be used to support learning (Bork, 1980; Papert, 1980). Today, multimedia is viewed by many educators as a new and potentially powerful teaching medium. Studies have reported that student exposure to multimedia in the classroom could increase student motivation and interest (Florian, 2004; Mayer, 2001; Squire, 2005; Williams & Jacobs, 2004). They have argued that exposure to multimedia could make available exciting curricula, based on real-world problems, to classrooms and could provide tools that could enhance learning.

Despite the potential benefit of multimedia, there is currently little tangible evidence to support the view that multimedia is bringing about the required shift in the quality of education that it is intended to support. The study reported in this thesis compared the perceptions of students in classes that were exposed frequently to multimedia with those who were not and whether students' self-reports on engagement in mathematics classes differed for these two groups of students. This chapter introduces the study by describing the context (Section 1.2), introducing aims and objectives (Section 1.3), providing a background (Section 1.4) and outlining the significance of the study (Section 1.5). The chapter concludes with an overview of the thesis (Section 1.6).

1.2   Context of the Study

Western Australia is one of six states in Australia, occupying the entire western third of the country. Western Australia is bound by the Indian Ocean to the north and west, the Great Australian Bight and Southern Ocean to the south, the Northern Territory to the north-east and South Australia to the south-east. Western Australia is Australia's largest state with a total land area of 2,529,875 square kilometres, and the second-largest country subdivision in the world. Despite the size of the state, a significant portion of it is sparsely populated. The state has approximately 2.4 million inhabitants (around 11% of the national total), and 92% of the state's population live in the south-west corner of the state, with 75% of the state's population living in the state capital, Perth (Wikipedia, 2013).

Education in Australia is primarily the responsibility of the state. Although some funding for schools comes from the federal government, state governments are largely responsible for the funding of these schools. In Western Australia, the education system follows a three-tier model which includes primary education (primary schools), followed by secondary education (secondary schools/high schools) and tertiary education (universities and technical colleges). Education in Western Australia is compulsory between the ages of 5 and 17.

It is widely recognised that today's young adults (referred to as digital natives by Prensky, 2000) have grown up in a networked environment in which they have become used to interacting with technology and engaging in computer games (Mitchell & Savill-Smith, 2004). For this generation, traditional face-to-face learning would appear to be less favourable to studying in an immersive digital classroom (Prensky, 2000). The Australian Federal Government has acknowledged this shift in students' preferred learning environment by encouraging the use of technology-rich learning environments in all of its classrooms (Jones, 2011). To this end, the Department of Education, Western Australia, has been steering its own information technology revolution since 2001, by creating a vision to bring the education community together, online. Under this vision, Western Australia's Department of Education has invested heavily in information technology. In 2002, all of its public schools were joined up to a telecommunications network (Jones, 2011). High-tech multimedia equipment, including computers, laptops, notebooks, iPads and interactive whiteboards were, at the time of writing this thesis, being added to classrooms. Teachers have undergone professional development in Information and Communication Technology (ICT) and have all been equipped with a laptop (at a

nominal fee). At the time of writing this thesis, there was a computer-to-student ratio that was close to one-to-one in all public schools.

The study reported in this thesis was carried out at a regional high school on the south coast of Western Australia. The school had a population of about 450 and drew many of its students from a low socio-economic area. The Index of Community Socio-Educational Advantage (ICSEA) uses the key attributes of a school's student population to enable meaningful comparisons to be made across schools (ACARA, 2012). The index includes student-level data (including occupation and education level of parents or carers) and/or socio-economic characteristics of areas where students live (for example whether schools are located in a metropolitan, rural or remote area and the proportion of indigenous students.) Most schools have an ICSEA of between 900 and 1100 and, generally, those schools with an ICSEA of less than 1000 are considered to be less advantaged whilst those with an ICSEA above 1000 are considered to be more advantaged (ACARA, 2012). In 2011, the ICSEA value for the school in which the study took place was 926, a figure below the national average value of 1000.

In line with the Department of Education's objectives, this school was striving to use ICT to improve student achievement at all levels. The school's Strategic Numeracy Plan for 2010-2014 was to:

- Increase opportunities for students' engagement in digital age numeracy;
- Expand the use of internet /intranet, online learning and module interface to enhance the teaching and learning of numeracy and literacy;

- Develop a whole school approach that would increase attendance and reduce the achievement gap between girls and boys, and between indigenous and non-indigenous students;

- Strengthen partnerships (through the use of multimedia) with neighbouring schools share effective teaching and learning strategies; and

- Use student literacy and numeracy performance data to inform school and planning.

The school boasts of a range of student facilities, including, well-equipped science laboratories, computer rooms, a learning resource centre, video conferencing rooms, a design and technology centre, photography studio, digital and graphics arts centre, iPads and laptops for general use at the school. The ICT infrastructure built into this school was aimed at facilitating a truly multimedia learning environment that allowed the integration of ICT into the delivery of programs. The computer-to-student ratio at the school was, at the time of writing this thesis, one-to-one. High school students who were enrolled at the school had the option of choosing to study in either classroom settings (face-to-face) or in an external mode (such as e-learning).

1.3   Objectives of the Study

To date there is a dearth of literature that examines whether the use of multimedia in mathematics classes has resulted in any improvements in student perceptions of their learning environment and whether such shifts have impacted on students' engagement. Therefore, this study took up this challenge and sought to assess whether the learning environment perceptions and engagement of students in classes

that were exposed frequently to multimedia differed from those who were in classes that were not exposed. This section details the specific research objectives that guided this study.

To ensure that the results of the study were based on solid foundations, it was necessary to first examine the reliability and validity of the questionnaires when applied to this sample. Therefore, the first research objective was:

Research Objective # 1

To investigate whether the instrument used to assess students' perceptions of the learning environment and self-reports of adaptive learning engagement in mathematics were valid and reliable for use in a school located in regional Western Australia.

Most schools in Western Australia, including the one in which this study was carried out, have been connected online to enable the teachers and students to use up-to-date technologies in their classrooms. At the school at which the study was undertaken, many of the mathematics classes were exposed to a truly multimedia learning environment and students in these classes spent between one quarter and more than four-fifths of their scheduled learning time in mathematics, under the directions of a teacher, in these environments. As elucidated before and reiterated here, it is not clear whether this exposure to multimedia has brought with it shifts in students' perceptions of their environment and improvements in their engagement in mathematics classes. Given the Department of Education's financial investment in

ICT in its schools and the amount of time students spent in multimedia learning environments (coupled with lack of evidence as to the effectiveness of such an environment) it was considered important to determine whether exposure to multimedia impacted on students' perceptions of their learning environment and engagement in mathematics. Further, if this was the case, then, to determine causal explanations of the differences and establish whether these were linked to students' exposure to multimedia. To this end, the second research objective was:

Research Objective # 2

To examine whether differences exist for students who were frequently exposed to multimedia in mathematics classes and those who were not (in terms of perceptions of the learning environment and engagement in mathematics) and, if so, investigate why.

Gender gap issues in mathematics education have been well documented over many years and continue to persist today (Baker, 2002; Britner, 2008; Meece, Glienke & Burg, 2006). Recent literature reviews suggest that sex differences continue to exist for student achievement, selection of mathematics courses and career choices (Forgasz & Rivera, 2012; Forgasz & Tan, 2010). Given these distinct variations, coupled with the differences in the way in which students learn mathematics, it is important for mathematics educators to be aware of and respond to them appropriately (Osborne & Dillon, 2008). In line with this challenge, this study explored the role of student sex in multimedia learning environments and students' engagement, and sought:

Research Objective # 3

To examine whether differences exist for male and female students who were frequently exposed to multimedia in mathematics classes in terms of: a) perceptions of the learning environment; and b) engagement in mathematics.

Researchers have claimed that student exposure to multimedia in classrooms could increase student motivation and interest (Florian, 2004; Mayer, 2001; Squire, 2005; Williams & Jacobs, 2004). Given this theoretical background, the present study examined whether student exposure to multimedia influenced students' perceptions of the environment and their engagement and whether these influences differed for male and female students. Therefore, the fourth research objective was:

Research Objective # 4

To examine whether exposure to multimedia in mathematics classes was differentially effective for male and female students in terms of: a) perceptions of the learning environment; and b) student engagement in mathematics.

Much past research has sought to examine environment outcomes relationships. This study hypothesised that the learning environment created during exposure to multimedia would influence student engagement. To examine these relationships, the fifth research objective sought:

Research Objective # 5

To investigate whether, for students who were frequently exposed to multimedia, there was a relationship between students' perception of the learning environment and their engagement in mathematics.

1.4   Background to the Study

This section provides a brief theoretical understanding upon which the present study was built, including an overview of: multimedia learning (Section 1.4.1); the field of learning environments (Section 1.4.2); engagement (Section 1.4.3); and, gender issues in mathematics (Section 1.4.4).

1.4.1   Multimedia Learning

To put this study into context, it is necessary to provide a common understanding of the key concept to be investigated, multimedia. Mayer (2001) defined multimedia, in an educational context, as a learning environment where more than one media format was used to help to create mental models that meaningfully interconnect verbal and pictorial communication, thereby promoting learning. It is more than just technology but, rather, the application of technology to the presentation of information in a single medium that includes many formats, including animation, video, graphics, print (text) and audio. In the context of this study, multimedia was considered to be the combination of hypertext and at least one other media format used simultaneously (including audio, video, images, animations, data and diagrams) to

assist in creating mental models. In this study, gadgets (including computers and other web-enabled portable devices) that were able to interface with other media equipment, were considered to be multimedia machines.

Aldridge, Fraser and Fisher (2003) assert that there is considerable optimism that the integration of information communication technology (ICT) into the learning environment will provide teachers with the means to effectively manage the diverse educational provisions needed to optimise individual student's outcomes. Whereas conventional classroom instruction often fails to expose students to examples and problems that make knowledge relevant to them, the effective use of multimedia technology has the potential to enable the visualisation of concepts and a better understanding of mathematics (Collins, Brown, & Holum, 1991).

It is widely recognised that tailor-made, well-designed multimedia supported lessons have the potential to offer a number of benefits over traditional, lecture based teaching. As such, exposure to multimedia could potentially raise learners' motivation (Aldrich, 2005; Michael & Chen, 2006; Prensky, 2000), enable learners to engage in interactive learning environments (Amory, 2001; Gee, 2003), intensify learners' information retention (Randel, Morris, Wetzel, & Whitehill, 1992) and improve learners' problem solving skills (Gros, 2007; Mayer, Moutone & Prothero, 2002; Squire, 2005). Such learning environments also serve as virtual worlds which cultivate peer groups with the social competence to share knowledge, skills and resources, as well as to solve problems in a collaborative manner and to increase their self-regulatory skills (Gee, 2003; Gros, 2007).

Squire (2005) and Williams and Jacobs (2004) noted that, by using multimedia technologies, teachers could provide opportunities for students to learn, think critically and have discussions with their peers in ways that were supported by ICT. Bitter and Pierson (2002) argue that technology is an agent of change and that appropriate use of multimedia can make learning for students more interesting and enriching and prepare them for the demands of the workplace. Sharp and Byrne (2002) argued that, with multimedia, not only are teachers likely to be 'teaching' less, but would also have the responsibility to inspire, motivate, and excite students about the use of technology for learning.

Despite the perceived benefits of multimedia, research has failed to provide hard evidence as to whether, with the introduction of multimedia in the classrooms, there has been a shift in students' perceptions of their learning environment and whether multimedia has improved students' engagement in their school work, particularly in mathematics. This study examined whether, with exposure to multimedia in the classrooms, students' perceptions of the environment and their engagement in mathematics would improve and whether this improvement differed for males and females.

1.4.2   The Field of Learning Environment

The first formal studies relevant to the field of learning environments go back nearly 80 years when Lewin (1936) proposed the formula, $B = f(P,E)$ in which Behaviour (B) is a function of both the Person (P) and the Environment (E). Lewin (1936) distinguished between beta press (a description of the environment as perceived by

11

people themselves in an environment) and alpha press (a description of the environment as observed by a detached observer). Murray (1938) applied Lewin's concepts to his 'needs-press' model in which 'needs' refers to an individual's motivation to achieve goals, and 'press' describes how the environment either helps or hinders a person to meet their goals.

Murray distinguished between two types of environmental 'press', one being 'alpha' press, which referred to the environment as it actually exists (according to an external observer), and the other, 'beta' press, describes the environment as perceived by the individual. Stern, Stein and Bloom (1956) in applying this idea, further distinguished between the two terms by clarifying that the 'alpha press' could be better understood as being a 'consensual' or group view of the environment while the 'beta press', referred to the personal view of the environment held by an individual. Like Lewin (1936, 1951), Murray's (1938, 1951) work was influential in person-environment fit research and helped to describe needs but did not attempt to explain the nature and effects of the needs-press match (Edwards, 2008; Pace & Stern, 1958).

The modern era of learning environment research commenced when Rudolf Moos (1974) and Herbert Walberg (1968) began independent lines of research on the conceptualisation and assessment of psychosocial environments using specially-developed instruments. The learning environment instruments that followed were, by and large, modelled on Moos' (1979) three basic categories for describing human environments, based on a social ecological perspective, these being, Relationship, Personal Development, and System Maintenance and Change dimensions (described

later in Chapter 2). Moos' influence can still be seen in the modification of existing instruments (Fraser, 2012), and in the creation of new ones that reflect current educational trends.

Learning environment research has involved the investigation of associations between students' outcomes (both affective and cognitive outcomes) and the learning environment, the evaluation of educational innovations, determinants of classroom environment, teacher action research and links and transitions between different levels of schooling (Fraser, 2012). Numerous studies have shown that student perceptions account for appreciable amounts of variance in learning outcomes, often beyond that attributable to background student characteristics (Martin-Dunlop & Fraser, 2008; Opolot-Okurut, 2010; Wei, den Brok & Zhou, 2009). My study is distinct in that it extends the field of learning environments, concerned with the evaluation of an educational innovation, by examining whether exposure to multimedia is indeed effective in terms of improving students' perceptions of the learning environment.

Whereas early research on classroom learning environments has used predominantly quantitative methods, combining quantitative and qualitative methods is a distinctive thrust of current research (Tobin & Fraser, 1998). Researchers in recent times have complemented their large scale questionnaire surveys with focused classroom observations and interviews in order to provide contextual understandings of learning environments (see for example, Afari, Aldridge, Fraser & Khine, 2013; Aldridge, Fraser & Huang, 1999; Tobin & Fraser, 1998).

My study is focused on the human aspect of classroom environments. It was grounded in the field of learning environments and incorporated the collection of quantitative data (using pre-established perceptual measures) and qualitative data (using observations and interviews). A comprehensive review of literature for the field of learning environments is provided in Chapter 2.

1.4.3 Engagement

While the field of learning environment research focuses on classroom life, usually from the students' perspective (Fraser, 2007), contemporary research in educational psychology draws attention to the importance of developing self-belief and self-regulatory capabilities in students in order to promote engagement in the classroom (Zimmerman, 2008). Student engagement refers to the degree of attention, curiosity, interest, optimism and passion that students show when they are learning or being taught. The consensus amongst theorists is that students' successful learning engagement in mathematics is primarily determined by their level of motivation and self-regulation in mathematics learning (Boekaerts & Cascallar, 2006; Hanrahan, 2002; Velayutham & Aldridge, 2012; Zimmerman, 2000).

Motivation, according to Schunk (2004), is the internal circumstance that instigates and focuses goal-oriented behaviour. Research has indicated that motivated students are the key to successful learning engagement in classrooms (Pajares, 2001, 2002; Pajares & Schunk, 2001). Students' motivation plays a pivotal role in their conceptual change processes, critical thinking, learning strategies, and mathematics achievement (Glynn, Taasoobshirazi & Brickman, 2007; Kuyper, van der Werf &

Lubbers, 2000). Three components of motivation that have been consistently researched are learning goal orientation, task value, and self-efficacy, each of which is integral to self-regulated learning (Velayutham & Aldridge, 2013; Zimmerman, 2002).

Students' self-regulation has been described by Pintrich (2000) as the active, constructive process whereby learners set goals for their learning and then attempt to monitor, regulate, and control their cognition, motivation, and behaviour, guided and constrained by their goals and the contextual features in the environment. Self-regulation in mathematics has also been identified as a pivotal construct that influences students' engagement in learning and their achievement in school (Boekaerts & Cascallar, 2006).

Zimmerman (2000) argues, however, that self-regulatory skills are of little value to students if they cannot motivate themselves to use them. In order to facilitate self-regulated learning in mathematics, educators should, first, focus on understanding students' motivational beliefs (Kaplan, Lichtinger & Gorodetsky, 2009). According to Hanrahan (2002), an essential key to successful mathematics learning is a positive motivational belief that mobilises otherwise inert knowledge. Urdan and Schoenfelder (2006) propose that enhancing student motivation requires attention to the key features of the classroom learning environment that are likely to influence student motivation. This thesis considered these suggestions and specifically investigated psychosocial aspects of a multimedia learning environment and their influence on students' engagement in mathematics learning. As a result, one of the aims of this research was to inform practitioners and policy makers about which

factors within a multimedia learning environment are likely to enhance students' engagement in mathematics learning.

The study reported in this thesis investigated whether students' self-reports on engagement and their perceptions of a learning environment that integrated multimedia into the learning process differed from those students who were not exposed to multimedia, and whether this learning environment was differentially effective for male and female students in mathematics classrooms.

1.4.4   Gender Issues in Mathematics

Concern about gender and educational attainment has focused largely on the extent to which female and male students perform differently in different subjects. Before the feminist theory of the 1970s, it was not thought unusual that more males than females would study mathematics and that female achievement levels might not equal those of their male counterparts. Since then, in Australia, there have been policies and intervention programmes aimed at achieving gender equity. That is, the elimination of discrimination not just to ensure equal treatment between sexes, but that gender is recognised and appropriate and possibly differing responses are taken to ensure equity of outcomes and achievement for both sexes. Despite this initiative, gender differences in mathematics learning continue to persist (Forgasz & Rivera, 2012). Australian statistics continue to reveal that a greater proportion of male as opposed to female students choose to study the most demanding mathematics courses especially when they become optional (Forgasz & Rivera, 2012).

Current research indicates that, although girls begin to develop negative perceptions of mathematics before the age of nine, the differences between primary school male and female students in terms of motivation towards and perception of mathematics are not significant (Alexakos & Antoine, 2003). Gender differences tend to be more marked, and manifest themselves more clearly, in the secondary school years with males consistently maintaining a higher intrinsic value for mathematics than females. Wolf and Fraser (2008) echoed the same findings when they reported that students' views of mathematics generally became less positive as they progressed through the schooling system and that this trend was more magnified amongst females.

Sex differences in students' perceptions of their learning environment have been reported by various researchers. Numerous past studies have reported that boys and girls have different perceptions of their classroom learning environment (Fraser, 2012). In 2004, Wahyudi and Treagust explored sex differences in students' perceptions of their classroom learning environment and found that female students generally held slightly more positive perceptions of both actual and preferred learning environments than their male counterparts. Waxman and Huang (1998) reported that female students generally had more favourable perceptions of their classroom learning environment than did male students. Another study by Aldridge and Fraser (2008) indicated that females perceived more positive classroom environments than did their male counterparts.

Despite the extensive research on gender issues, there is a dearth of literature that examines the impact of exposure to multimedia, especially with respect to the learning environment perceptions and engagement of different sex in a multimedia

learning environment. This study fills this gap in literature and is distinct in that it sought to understand whether sex differences exist, improving our understanding of the impact of multimedia on males and females.

1.5   Significance of the Study

This section outlines the significance of the current study, which is later expanded on in Section 5.6. The present research is significant because it is the first study within the field of learning environment and mathematics education that has examined student exposure to multimedia in mathematics learning as perceived by students themselves. This study is distinctive because it used multiple research methods (from the students' view point) to examine the learning environment created in classes exposed to multimedia to better understand the effect that this had on students' engagement in mathematics. The findings from the present research offer potentially important insights into how exposing students to multimedia learning environments could promote secondary students' engagement towards mathematics learning and, in turn, encourage them to proactively regulate their own learning progress.

With regards to student exposure to multimedia, the results of the study provide insights into how students of different sex perceive the learning environment and engagement. This contribution has the potential to increase the understanding of what drives student engagement in males and females, and the aspects of the learning environment that each sex prefers. This information could be used to design intervention programmes that may differ in terms of orientation and application for

girls and boys and tackle equity issues. Schools with similar characteristics could take stock and implement similar remedial actions.

The present study adds to the literature related to the field of learning environments. The research gap, related to the examination of the influence of students' perceptions of the learning environment on engagement in mathematics in classes that were exposed to multimedia, was bridged through this study. These findings add to the literature on secondary school students who undergo a critical developmental period during the transition from primary to secondary school when significant shifts in engagement demands and expectations occur.

1.6   Thesis Overview

My study examined whether students in classes that were frequently exposed to multimedia in mathematics lessons perceived their learning environment differently and reported different levels of engagement from their counterparts who were not exposed to multimedia. The study is reported in five chapters.

The first chapter has stated the purpose and rationale for this research. It described the context and background of the thesis by highlighting the current crisis in students' engagement in mathematics learning. This chapter identified and detailed the importance of investigating multimedia environments as a learning environment as a means of alleviating the current crisis in student engagement in mathematics. The chapter went on to provide an explanation of the need to examine sex differences in order to address equity concerns. These discussions led to the

formation of five pertinent research objectives, centred on investigating the influence of a multimedia learning environment on students' engagement in mathematics learning. Finally, the chapter concluded by highlighting the significance of the present study.

Chapter 2 reviews literature related to the objectives of my study and the benefits of using multimedia in the classroom. Given that the present study drew on and extended the field of learning environment, Chapter 2 provides a brief history of the field and related research (including learning environment instruments) that has been conducted within the field of learning environments. A major focus of this study was to examine whether students' exposure to multimedia impacted on student engagement and whether there was a relationship between students' engagement and their perceptions of the learning environment. Therefore, literature related to student engagement, including a review of past instruments that have been used to assess students' engagement (motivation and self-regulation) was reviewed. Because my study investigated whether exposure to multimedia was differentially effective for male and female students in mathematics, a review of literature on gender issues in mathematics concluded Chapter 2.

Chapter 3 details the research methods and the sampling procedures used in the current study. The research questions are restated and the samples used for the collection of data are detailed. The chapter describes the instruments used for the collection of the quantitative and qualitative data. The chapter provides details related to the analyses of the data and concludes by describing ethical concerns that were related to the study and how these were addressed.

Chapter 4 reports the results of the study. The chapter begins by reporting the results of the analyses of the quantitative data, including validity and reliability of the instruments used in this study, differences between students frequently exposed to multimedia and those who were not, differences between male and female students frequently exposed to multimedia, differential effectiveness of exposure to multimedia in mathematics classrooms for male and female students and associations between students' perceptions of the learning environment and student engagement in mathematics. Qualitative results, derived from observations and interviews, were, to contextualise the findings, presented as narratives that described the classroom life of students.

Chapter 5 concludes the thesis by providing a detailed discussion of the study's findings. The chapter outlines the limitations of the study and provides recommendations based on the results of the study. Finally the significance of the study to research, policy and practice in the wider education arena are detailed.

CHAPTER 2

REVIEW OF LITERATURE

2.1   Introduction

This chapter provides a review of literature related to the objectives of my study, including the use of multimedia in the classroom, the field of learning environments, student engagement and gender issues in mathematics. The chapter is organised under the following headings:

- Multimedia and Classroom Learning (Section 2.2);
- Field of Learning Environments (Section 2.3);
- Engagement (Motivation and Self-regulation) (Section 2.4);
- Gender Issues in Mathematics (Section 2.5); and,
- Chapter Summary (Section 2.6).

2.2   Multimedia and Classroom Learning

As the focus of this study was to investigate the impact of exposing students to multimedia in mathematics classrooms, this section starts by defining multimedia for the purpose of this study (Section 2.2.1). The chapter goes on to review literature related to multimedia including, the advantages of using multimedia in classrooms (Section 2.2.2) and past research related to multimedia environments (Section 2.2.3).

2.2.1   Defining Multimedia

The term, multimedia, can be used as a noun (a medium with multiple content forms) or as an adjective describing a medium as having multiple content forms. When the term multimedia is employed within an educational context, reference is often made to the principle (underpinning the cognitive theory of learning) that a human brain is capable of processing and encoding simultaneous auditory and visual stimuli (Paivio, 1971). Research has indicated that text and speech are better remembered if accompanied by visual information (Paivio, 1971).

Darragh (1996) considers multimedia to be a delivery and environment system which integrates text, graphics, animation, data, video and audio from various sources. Fetterman (1997) and Beckman (1996), on the other hand, define multimedia as instructional materials that include one or more forms of media in addition to textual information. More recently, Mayer (2001) defined multimedia, in an educational context, as a learning environment where more than one media format is used to help to create mental models that meaningfully interconnect verbal and pictorial communication, thereby promoting learning. Multimedia is more than simply technology but, rather, the application of technology to the presentation of information in a single medium that coordinates a combination of formats (such as animation, video, graphics, print / text and audio). It is the coordinated combination of video, sound, hypertext, animation, and graphics. As such, and within the context of this thesis, multimedia is considered to be the combination of hypertext and at least one other media format that is used simultaneously in an educational setting to

assist in creating mental models that promote and engage students in the learning process.

Computers, web-enabled or 'smart' phones, portable devices (such as laptops, netbooks, iPods and iPads) are all considered to be self-contained, multimedia machines which include hypertext, buttons, video, and audio in the working environment (Darragh, 1996). These gadgets are able to interface with other media equipment, making it possible to design a mathematical learning environment with high levels of interactivity, structure and the use of effective navigation tools.

2.2.2   *Advantages of Multimedia*

Since the development of the first computers as multimedia tools, many educators have argued that computers in schools should be used to support learning (Bork, 1980; Carnegie Commission on Higher Education, 1977; Papert, 1980). These arguments have amplified as computers have evolved into the more powerful, relatively low cost, multimedia machines that are available today. Multimedia allows teachers to address various learning styles in the classroom. By incorporating multimedia in their instruction, teachers can capture students' attention, engage learners, explain difficult concepts and inspire creativity (Mayer, 2001). Multimedia gives teachers the means to provide differentiated instruction to students with different abilities giving teachers the potential to meet the needs of all students.

With multimedia technology, students have the opportunity to use different senses and thinking skills (Florian, 2004). Learning materials can be presented using

auditory and visual styles simultaneously. Students can see, hear and model concepts in their environment because multimedia has the capacity to bring a concept to life. Multimedia provides the potential for students to extend their experiences and to have immediate feedback provided through their explorations and results (Snyder & Vaughan, 1998). Multimedia provides students with opportunities to work at their own pace, making it easier for teachers to individualise the needs of specific students and to implement individual educational programmes (Williams & Jacobs, 2004). Further, with multimedia, students are able to stop and explore, or repeat a process as often as they wish or go to another part of a program that offers a different kind of explanation, example, or function without limiting the progress of other students (Squire, 2005).

The combination of video, text, sound, animation and graphics addresses many different learning styles simultaneously and, as such, allows differentiation in instruction in order to meet the needs of students of different backgrounds and learning styles (Papastergiou, 2009). A major benefit of the use of multimedia in mathematics is the high interactivity of the student and the concepts, as well as the practical application of the skills learned (Darragh, 1996). Past research has indicated that using multimedia technology in education is consistent with the principles of constructivism and holds promise for improving education (Bransford, Brown, & Cocking, 2000).

Multimedia offers learners with learning disabilities a means by which they can reach their potential (Banes & Walter, 2002). For example, multimedia might provide students with hearing problems the opportunity to listen to instructions while

seeing a picture that relates to the words. For students who have fine motor challenges or poor typing skills, multimedia could provide access to the curriculum through tools such as speech-to-text that can be used to help them to write their essays and short stories (Mayer, 2001).

Multimedia offers opportunities for problem solving in collaborative groups and the comparison of results, both of which have potential to assist students in the development of communication and team skills (Schellens & Valcke, 2005). Through the use of multimedia, it is possible to show accountability for learning during collaborative activities as students are required to contribute to their group's results (Kuo, Hwang, & Lee, 2012). Such activities cultivate fertile ground for active learning for all students. Multimedia allows students to relate connections of concepts through collaborative constructions and discussions of concept maps and diagrams (Lipponen, 2002). Such collaborative discussions permit and promote real time feedback through the use of multimedia tools that support conversations and comments. Learning collaboratively not only has the potential to help students to learn the spirit of respecting others, but also to facilitate their learning performance (Kuo, Hwang, & Lee, 2012; Schellens & Valcke, 2005). Through the process of collaboration and brainstorming in collaborative learning groups, students are able to efficiently receive a large amount of information, which is helpful to them in generating new ideas for completing learning tasks (Lipponen, 2002).

Multimedia enables visualisation of difficult concepts and procedures more easily by using static and/or dynamic multimedia through modelling. Afari, Aldridge, Fraser and Khine (2013) noted that, not only do students relate positively to visual

interactions (especially if there is a game-like atmosphere to the presentation) but they also become more engaged in their tasks. Traditional methods do not seem not to take advantage of the fact that, as visual learners, we form a picture in our minds to assist with the comprehension of concepts (Papastergiou, 2009).

Another benefit of using multimedia is the accessibility to limitless resources for teaching and learning (Abbott & Cribb, 2001). Teachers are no longer limited to textbooks; as vast amounts of knowledge and teaching ideas may be explored on the web. The exposure of students to the Internet in schools makes multimedia a convenient tool to obtain information and to keep updated since it can be streamed from an educational web site maintained by a publisher or content expert (Kerr, Neale, & Cobb, 2002). The use of web-based multimedia also provides a means by which students can access a lesson from anywhere in the world.

Discussions on the effectiveness of multimedia in the classroom, however, have varied. Although learning with multimedia is more versatile than most traditional methods, some researchers have identified problems associated with using it in the classroom. Clark (1983) argues that there is little solid evidence to support the conclusion that any specific medium has a distinct advantage over others in terms of learning benefits. He takes the position that some of the reported benefits of multimedia are artificial and may be the result of novelty in the classroom. That is, students may be responding to a change in the presentation of material itself and not the multimedia. He concludes that research has not always demonstrated that the use of multimedia is a benefit.

Forman (1998) suggested that multimedia may discourage students from thinking deeply and using language effectively. Forman (1998) expressed concern that children's imagination and the use of words for expression is not promoted well through the use of multimedia, noting that too little of their imagery comes from their own imaginations. Wiburg (1995) shared Forman's hesitancy to jump onto the 'multimedia wagon' and suggested that teachers need to become critical users of multimedia. Reeves and Harmon (1994) also warned that blind acceptance of multimedia may not lead to beneficial outcomes. He warned that developers of multimedia programs must not assume that, since multimedia *ought* to be effective for instruction, then they *are* effective for instruction. Yelland (1999) warned against teachers using the glamour of games to squeeze a bit more information into the heads of children in the name of productivity. She purports that multimedia and educational technologies in general had simply amplified the activity of teachers and the passivity of children.

Standards for mathematics education, as written in the Curriculum Framework (a statement by Western Australian government that sets up an outcomes-based approach to education with a developmental-constructivist view of learning), stress the need to change the emphasis from traditional 'chalk and talk' methods to using concrete and visual multimedia technologies (Curriculum Council, 2006). Fundamental to the outcomes-focus in education is a shift in focus from an emphasis on teaching and holding teachers accountable for what they teach, to an emphasis on learning and holding teachers accountable for what and how students learn. The Curriculum Framework emphasises that all students have a better chance of becoming effective problem solvers and develop mathematical skills if abstract

concepts and principles are modelled and presented visually (Curriculum Council, 2006). Multimedia, supported by Information and Communications Technologies (ICT), can model real-world problems in classrooms and hence provide tools to enhance learning.

Despite the overwhelming support for multimedia in literature, there is little research that examines whether students' exposure to multimedia increases their engagement in mathematics. The study reported in this thesis took up this imperative and filled the research gap in terms of investigating whether students' exposure to multimedia impacted on their engagement and whether students' exposure to multimedia was differentially effective for male and female students.

2.2.3   Past Research on Multimedia

The field of educational technology has conducted assessments of trends in usage and capital expenditure outlays in the field of multimedia. Today, schools and universities, combined, are spending billions of dollars on computer-related technology. While many indications suggest that the educational application of this methodology is still in its infancy, student exposure to multimedia has been increasing geometrically and, in comparison, studies related to student perceptions of their exposure to multimedia and engagement have been minimal (Kuehn, 1994).

Snyder and Vaughan (1998) explored the role of exposure to multimedia in shaping students' perceptions of an ideal learning environment and their expectations of multimedia usage in their classes. The analyses of data collected from 714 college

students at a university in the US, indicated that those students who had been exposed to multimedia techniques were more likely to include multimedia in their visions of an optimal classroom.

Past studies have reported that the use of computers in the classroom increases student motivation and interest (Lajoie, 1993). In a series of case studies at 17 English primary and secondary schools, Passey, Rogers, Machell, McHugh and Allaway (2003) examined the impact of multimedia on student motivation, learning outcomes, behaviour and school attendance. Their study concluded that, with the inclusion of ICT, students, rather than just completing tasks, were more committed to learn. The study also suggested that ICT impacted on students' motivation positively, their attitude towards their school work and their behaviour in class.

Using a national database, Lee, Brescia and Kissinger (2009) examined whether students' behaviour and achievement scores in mathematics and reading were related to computer use for school work or other than school work. They found that those students who used a computer for one hour per day, displayed more positive school behaviours and had higher test scores in reading and mathematics.

Dorman and Fraser (2009) investigated relationships between perceptions of the classroom environment, home computer use, Internet access and students' attitudes to computer use. This study, involving 4,146 high-school students from Western Australia and Tasmania, found that improving the classroom environment had the potential to improve students' attitudes towards computers; whereas home computer

and Internet access did not. Further, academic efficacy mediated the effect of classroom environment dimensions on students' attitude to computer use.

Muir-Herzig (2004) examined the overall use of multimedia in the classroom by teachers and students, at a high school in the US, to determine the effect that the level of multimedia use had on at-risk students' achievement and attendance. The results indicated that teachers' and students' use of multimedia had no significant positive effect on either the achievement or the attendance of at-risk students.

What is of interest to teachers is the 'audience' of multimedia. As would be expected, each audience has its own mix of personalities, backgrounds, desires, and culture of expectations which affect their perception of being exposed to multimedia. Unfortunately, students' perceptions of their exposure to multimedia have not been fully addressed in literature. Although research supports the idea that multimedia can stimulate students' interest and engagement (Owen, 2005), there is a dearth of research related to the effect and impact of exposure to multimedia on students' engagement in school work, particularly in mathematics in Western Australia. Therefore, this study sought to fill this research gap by investigating whether exposing students to multimedia in mathematics classes improved students' active learning engagement.

2.3   Field of Learning Environment

Given that the present study drew on and extended the field of learning environment, this section provides a brief history of the field and related research that has been

conducted within the field. The concept of a classroom environment is a subtle one that teachers have been aware of anecdotally (Fraser, 2001). Different classes have different characteristics arising from the ways in which students interact with each other, with the teacher, and with their environment. Fraser (2007; 2012) refers to learning environments as the shared perceptions of the students and sometimes the teacher. It is this aspect of the classroom environment that the study reported in this thesis is interested in examining. Throughout this study and from now onwards, the terms classroom environment and learning environment are used interchangeably, with both terms referring to the psychosocial climate of the classroom.

Researchers and educators in science and mathematics education have relied heavily, and sometimes exclusively, on the assessment of academic achievement and other learning outcomes (Fraser, 2012). However, these measures alone cannot give a complete picture of the educational process. Fraser (2012) argues that students spend up to 20,000 hours in classrooms at school by the time they finish university. Students, therefore, have a large stake in what happens in their classrooms and their reactions to and perceptions of their classroom experiences are significant (Fraser, 2012).

There are two types of learning environments in education, namely, school-level environments and classroom environments. While school-level environments are considered to be more global than classroom ones, and involve organisational aspects of the school as a whole, classroom environments are concerned with the psychosocial aspects of classrooms (Anderson, 1982). The interpersonal relationships involved in a school-level environment differs to those involved in a

classroom, in that, in the former, they are between teachers, heads of departments/learning areas and principals, whereas in the latter, they are between the teacher and his or her students, and among students. The study reported in this thesis focused on classroom environments.

Broadly, there are two aspects of the classroom environment that have featured in past research, namely, the physical environment and the human environment. The physical environment includes the material setting of the classroom, such as furniture, lighting and the layout of the objects in the classroom. The human environment, on the other hand, includes the psychosocial dimensions of the classroom, the students and the teacher in that classroom and their interaction with each other. It is the human aspect of the classroom environment that is the focus of the study reported in this thesis.

This section reviews literature related to the field of learning environments, including: the history of the field of learning environments (Section 2.3.1); classroom learning environment instruments and studies in which the instruments were used (Section 2.3.2); and past learning environments research (Section 2.3.3).

2.3.1   *History of the Field of Learning Environments*

The history of learning environments research has its origins in the social sciences. According to Kurt Lewin (1936), the dynamics of an event can be traced back to the relationship between the individual and the environment. Lewin believed that all behaviour and experiences are a function of the person and his/her environment and

that every kind of behaviour is dependent upon the psychological field. Lewin proposed the formula, B = *f* (P, E) where behaviour (B) is a function of both the person (P) and the environment (E). Lewin recognised that both the environment and its interaction with characteristics of the individual are potent determinants of human behaviour.

In 1938, Murray extended Lewin's theory with his needs-press model in which 'needs' refers to an individual's motivation to achieve goals and 'press' describes how the environment either helps or hinders a person to attain those goals. Murray (1938) later applied and differentiated the concepts of *alpha press* (a description of the environment as observed by an outside observer) and *beta* press (a description of the environment as perceived by people themselves in that same environment).

Stern, Stein, and Bloom, (1956) built on Murray's discrimination between *alpha press* and *beta press*. They suggested that *beta press* could further be discriminated by the individual view and experience of the environment that each student has of the learning environment versus the communal view that the students have as a group of participants in the learning environment. They used private *beta press* to represent the distinct view an individual student may have of the classroom environment and *consensual beta press* for the collective view of the students' perceptions.

According to Fraser (2012), the benefits of considering *beta press* in schools and classrooms are many. For example, an outside observer might miss important events and interactions that occur in a particular environment over time. Students observe more of a teacher's typical behaviour than what an outside observer would and are

more familiar with their teacher's idiosyncrasies (which may be interpreted differently by an outside observer). Further, students are in a better position to judge certain aspects of a teacher's behaviour, such as clarity of expression and may observe aspects of a teacher's behaviour that an external observer may not.

The main weakness concerned with the use of *alpha press* is that: first, outside observers must make judgements about the observations, based on experiences external to the learning environment; second their mere presence could change the classroom climate; third, training external observers can be expensive and time-consuming; and, finally, the findings can be more difficult to analyse than the use of questionnaires administered to students in that environment would be. The study reported in this thesis relies, for the most part, on descriptions of the environment as perceived by the students within that environment.

A great stride in the historical development of the field of learning environment occurred nearly half a century ago when Walberg and Moos began seminal independent programs of research (Fraser, 1986; Fraser & Walberg, 1991; Moos, 1974). In their work on the Harvard Project Physics, Walberg and Anderson (1968) developed the Learning Environment Inventory (LEI, Walberg & Anderson, 1968; see Section 2.3.2.1). Independently, but at around the same time, Moos developed the Classroom Environment Scale (CES, Moos & Trickett 1974; Moos 1979; see Section 2.3.2.2) as part of his work in a range of human environments including prisons and psychiatric hospitals. Moos (1974) later developed a scheme for classifying human environments into three categories or dimensions these being, relationship, personal development and system maintenance and change. The

relationship dimension involves the nature and intensity of personal relationships within the environment and the extent to which people are involved with and supportive of each other. The personal development/personal growth or goal orientation dimensions are indicative of the underlying goals of the particular settings. The system maintenance and system change dimensions involves the degree of structure, clarity of expectations and openness to change. These dimensions co-exist in all human environments and have been used extensively by researchers in the construction of learning environment instruments (Fraser, 2007; 2012) and the classification of individual scales.

From its genesis in the United States, with the pioneering work of Walberg (1979) and Moos (1979), the field of learning environments research spread to Australia and The Netherlands and later to Asia. Researchers around the world have not only successfully cross validated several questionnaires in English-speaking countries (Singapore and Brunei), but have also completed the task of translating, back-translating and validating these instruments into Spanish, Mandarin, Indonesian, Korean, and Malay languages (Fraser, 2012). Researchers have also replicated Western research in establishing consistent associations between the learning environment and student outcomes, in using learning environment assessments in the evaluation of education programmes and in identifying determinants of learning environments (Fraser, 2012).

2.3.2   *Classroom Learning Environment Instruments*

The most widely-used method of investigating the learning environment has been through the utilisation of perceptual measures. A striking feature of the field of learning environments is the availability of a variety of economical, valid and widely-applicable questionnaires. Spanning a period of nearly half a century, researchers have developed numerous questionnaires designed to assess students' perceptions of a range of dimensions pertinent to the learning environment (Fraser, 2007, 2012). These questionnaires have been used at different educational levels and in different countries. In this section, a brief description of nine historically-significant and contemporary instruments is provided, including: Learning Environments Inventory (Section 2.3.2.1); Classroom Environment Scale (Section 2.3.2.2); Individualised Classroom Environment Questionnaire (Section 2.3.2.3); My Class Inventory (Section 2.3.2.4); College and University Classroom Environment Inventory (Section 2.3.2.5); Questionnaire on Teacher Interaction (Section 2.3.2.6); Science Laboratory Environment Inventory (Section 2.3.2.7); Constructivist Learning Environment Survey (Section 2.3.2.8) and What Is Happening In this Class questionnaire (Section 2.3.2.9).

An overview of each of the nine instruments, listed above, including the education level for which the instrument was intended to be used (primary, secondary or higher education), the number of items in each scale and the classification of each scale according to Moos' (1974) scheme for classifying human environments (described previously in Section 2.3.1) is provided below in Table 2.1.

Table 2.1   Overview of Nine Historically Important and Contemporary Learning Environment Questionnaires

Instrument	Level	Items per Scale	Scales Classified According to Moos' Scheme			Reference
			Relationship Dimension	Personal Development Dimension	System Maintenance and Change Dimension	
Learning Environment Inventory	Secondary	7	Cohesiveness Friction Apathy Favouritism Cliqueness Satisfaction	Speed Difficulty Competitiveness	Diversity Formality Material Environment Goal Direction Disorganisation	Fraser, Anderson & Walberg (1982)
Classroom Environment Scale	Secondary	10	Involvement Affiliation Teacher Support	Task Orientation Competition	Order and Organisation Rule Clarity Teacher Control Innovation	Moos & Trickett (1987)
Individualised Classroom Environment Questionnaire	Secondary	10	Personalisation Participation	Independence Investigation	Differentiation	Fraser (1990)
My Class Inventory	Elementary	6-9	Cohesiveness Friction Satisfaction	Difficulty Competitiveness		Fisher & Fraser (1981)
College and University Classroom Environment Inventory	Higher Education	7	Personalisation Involvement Student Cohesiveness Satisfaction	Task Orientation	Innovation Individualisation	Fraser & Treagust (1986)
Questionnaire on Teacher Interaction	Secondary/ Primary	8-10	Understanding Helping/Friendly Dissatisfied Admonishing		Leadership Freedom and Responsibility Uncertain Strict	Wubbels & Levy (1993)
Science Laboratory Environment Inventory	Upper Secondary Higher Education	7	Student Cohesiveness	Open-Endedness Integration	Rule Clarity Material Environment	Fraser, Giddings & McRobbie (1995)
Constructivist Learning Environment Survey	Secondary	7	Personal Relevance Uncertainty	Critical Voice Shared Control	Student Negotiation	Taylor, Fraser & Fisher (1997)
What Is Happening In this Class?	Secondary	8	Student Cohesiveness Teacher Support Involvement	Investigation Task Orientation Cooperation	Equity	Aldridge & Fraser (2000)

*Adapted from Fraser (2012) with permission

2.3.2.1   *Learning Environment Inventory (LEI)*

As mentioned in the previous section, the first learning environment questionnaires for use in educational settings were developed in the United States during the late 1960s and early 1970s. The Learning Environment Inventory (LEI; Walberg & Anderson, 1968) was developed to evaluate the well-known Harvard Project Physics in terms of students' perceptions of their physics classrooms. The LEI consists of 105 items, divided evenly (seven items in each scale) into 15 scales, namely, Cohesiveness, Friction, Favouritism, Cliqueness, Satisfaction, Apathy, Speed, Difficulty, Competitiveness, Diversity, Formality, Material Environment, Goal Direction, Democracy and Disorganisation. The items are presented in a cyclic order and are responded to using the alternatives of Strongly Disagree, Disagree, Agree and Strongly Agree. For some items, the scoring direction (or polarity) is reversed. While many scales were intended to assess more traditional, teacher-centred classrooms, some are still useful today (as with the scale Cohesiveness and Goal Orientation, both of which were used in this study).

The internal consistency reliability and discriminant validity of the LEI were reported by Fraser et al. (1982) but the factor structure of the LEI has not been established. Despite this shortcoming, the survey has been widely used by past researchers in investigating associations between students' perceptions of their learning environment and a range of outcomes (Fraser, 1979; Hirata & Sako, 1998; Hofstein, Gluzman, Ben Zvi & Samuel, 1979; Lawrenz, 1976; Walberg, 1968).

2.3.2.2   Classroom Environment Scale (CES)

As a result of extensive research involving a variety of human environments, including psychiatric hospitals, conventional work sites, prisons, school environments and university residences at Stanford University, Moos developed the Classroom Environment Scale (CES; Moos, 1974, 1979; Moos & Trickett, 1974). This instrument has 90 items with 10 items in each of the nine scales of Involvement, Affiliation, Teacher Support, Task Orientation, Competition, Order and Organisation, Rule Clarity, Teacher Control and Innovation. While the majority of scales are intended to examine traditional classrooms, some scales have been modified and used in more recent learning environment instruments.

The items are responded to using a True/False format. The validity and reliability of the CES, when used in classroom settings, have been reported by numerous researchers (Fisher & Fraser, 1983; Humphrey, 1984; Moos & Moos, 1978; Trickett & Moos, 1973). The scales from the CES that are pertinent to this study were the Teacher Support and Involvement scales from the relationship dimension and the Task Orientation scale from the personal development dimension.

2.3.2.3   My Class Inventory (MCI)

The My Class Inventory (MCI), a simplified version of the LEI, was developed for use with students aged 8-12 years (Fisher & Fraser, 1981; Fraser, Anderson & Walberg, 1982; Fraser & O'Brien, 1985). The MCI differs from the LEI in a number of ways. First, to minimise fatigue among younger children, the MCI contains only

five of the LEI's original 15 scales. Second, the item wording was simplified to enhance readability. Third, the LEI's five-point response format was reduced to a two-point (Yes–No) response format (which was later increased to a three-point response format by Goh and Fraser, 1998). Finally, students respond to items of the MCI on the survey itself rather than on a separate response sheet, thereby reducing the risk of errors when transferring responses from one place to another.

The final version of the MCI has a 38-item (long form) or 25-item (short form) version, both of which involve the five scales of Cohesiveness, Friction, Satisfaction, Difficulty and Competitiveness. Although originally, the MCI made use of a Yes–No response format, more recently a three-point response format, consisting of, Seldom, Sometimes, and Most of the Time has been used (Goh, Young & Fraser, 1995). The MCI has been utilised and validated in various classroom settings by past researchers (Majeed, Fraser & Aldridge, 2002; Sink & Spencer, 2005; Scott Houston, Fraser & Ledbetter, 2008). The Student Cohesiveness scale has been incorporated in this study.

2.3.2.4   *Individualized Classroom Environment Questionnaire (ICEQ)*

The Individualised Classroom Environment Questionnaire (ICEQ) was developed by Rentoul and Fraser (1979) to assess dimensions of the learning environment pertaining to individualised and inquiry-based classrooms as opposed to those of traditional classrooms. The ICEQ is significant because it marks the departure from instruments that measure traditional classrooms to one that measures more contemporary classrooms. The ICEQ also included both an actual version (which

measures students' perceptions of practices which are happening in the classroom learning environment) and a preferred version (which is concerned with goals and value orientations and assesses the students' perceptions of the 'ideal' state of the classroom learning environment). Further, versions also were developed to allow either students or teachers to respond to it. The ICEQ included both a short form and a long form. The final version of the ICEQ is comprised of 50 items evenly distributed in five scales namely: Personalisation, Participation, Independence, Investigation, and Differentiation (Fraser, 1990). Each of the items is responded to on a five-point frequency scale with the response alternatives of Almost Never, Seldom, Sometimes, Often and Very Often. The scoring direction is reversed for some of the items. The ICEQ has been utilised and validated in various classroom settings by past researchers (Ashgar & Fraser, 1995; Fraser & Butts, 1982).

2.3.2.5   The College and University Classroom Environment Inventory (CUCEI)

The College and University Classroom Environment Inventory (CUCEI) was developed for use in small classes (sometimes referred to as seminars) of up to 30 students at the college or university level (Fraser & Treagust, 1986; Fraser, Treagust & Dennis, 1986). There are seven items in each of the seven scales, namely Personalisation, Involvement, Student Cohesiveness, Satisfaction, Task Orientation, Innovation and Individualisation. Each of the items is responded to using a Likert-type frequency scale with four response alternatives of Strongly Agree, Agree, Disagree and Strongly Disagree. The scoring direction for half of the items is reversed.

Despite the CUCEI having been utilised and validated by past researchers (Fraser, 1991; Joiner, Malone & Haimes, 2002; Nair & Fisher, 2000; Yarrow, Millwater & Fraser, 1997; Fraser, Williamson & Tobin, 1987), Logan, Crump and Rennie (2006) found that the psychometric properties of the CUCEI were not ideal when used in computing classrooms in New Zealand.

2.3.2.6   *Questionnaire on Teacher Interaction (QTI)*

In the Netherlands, Wubbels, Creton and Hooymayers (1992) developed the Questionnaire on Teacher Interaction (QTI). The QTI is based on the work of Leary (1957) and was designed to examine the interpersonal relationships between teachers and students (Creton, Hermans & Wubbels, 1990; Wubbels, Brekelmans & Hooymayers, 1991; Wubbels & Levy, 1993). Wubbles' theoretical model maps interpersonal behaviour using an *influence* dimension (Dominance – Submission) and a *proximity* dimension (Cooperation – Opposition) (Wubbels & Brekelmans, 2005; Wubbels & Levy, 1993). These dimensions are represented in a coordinated system divided into eight equal sectors each of which corresponds to a scale in the QTI, namely, Leadership, Helping/Friendly, Understanding, Student Responsibility/ Freedom, Uncertain, Dissatisfied, Admonishing and Strict behaviour.

Although the original version of the QTI had 77 items, following cross-validation and comparative work in different countries, a more economical 48-item version was developed and validated in Singapore and Australia (Goh & Fraser, 1996; Fisher, Henderson & Fraser, 1995), and a 64-item version was validated in the US (Wubbels & Levy, 1993). The items are responded to using a five-point frequency scale

ranging from Never to Always. The QTI was not selected for use in this study as it would have limited the scope of the research because of the QTI only focuses on teacher-student interpersonal relationships.

2.3.2.7   Science Laboratory Environment Inventory (SLEI)

The Science Laboratory Environment Inventory (SLEI) was developed by Fraser, Giddings and McRobbie (1995) to measure the learning environment of science laboratory classrooms at the senior high school and higher education levels. The SLEI has 35 items that are evenly distributed between the five scales, which are, Student Cohesiveness, Open-Endedness, Integration, Rule Clarity and Material Environment. The SLEI was developed as both a class form (which seeks to obtain the perceptions of the students in the entire class) and a personal form (which seeks to obtain the student's perceptions of their own role within that classroom environment) and has separate actual and preferred versions. Items are responded to using a five-point frequency response format of Almost Never, Seldom, Sometimes, Often and Very Often.

The SLEI was field-tested and validated simultaneously with a sample of 5,447 students in 269 classes in six countries, namely, the US, Canada, England, Israel, Australia and Nigeria (Fraser, Giddings, & McRobbie, 1995; Fraser & McRobbie, 1995). The SLEI was also shown to be psychometrically sound in other countries, including Australia (Fisher, Henderson, & Fraser, 1997; Fraser & McRobbie, 1995), Singapore (Wong & Fraser, 1995), Korea (Fraser & Lee, 2009) and the US (Lightburn & Fraser, 2007). Since the focus of this research was on the effectiveness

of exposing students to multimedia in science laboratories, rather than mathematics classrooms, this instrument was not considered to be suitable for use in the present study.

2.3.2.8   *Constructivist Learning Environment Survey (CLES)*

The Constructivist Learning Environment Survey (CLES) was developed by Taylor, Fraser and Fisher (1997) to measure the extent to which a classroom environment conforms to the constructivist philosophy and to help teachers in their reflections and fine-tuning of their teaching strategies. The CLES consists of 30 items evenly distributed in the five scales of Personal Relevance, Uncertainty, Critical Voice, Shared Control and Student Negotiation. Items are responded to using a five-point frequency format of Almost Never, Seldom, Sometimes, Often and Almost Always. The CLES was the first learning environment instrument to order the items in scales rather than cyclically to provide students with contextual cues, thereby improving the reliability of the instrument (Taylor et al., 1997).

The CLES has been validated in different countries around the world including South Africa (Aldridge, Fraser & Sebela, 2004), the US (Nix, Fraser & Ledbetter, 2005; Ogbuehi & Fraser, 2007; Peiro & Fraser, 2009; Spinner & Fraser, 2005), Korea (Kim, Fisher & Fraser, 1999, 2000), Australia and Taiwan (Aldridge, Fraser, Taylor & Chen, 2000). As my study did not seek to assess the extent to which a multimedia environment conformed to a constructivist philosophy or to help teachers in their reflections in fine-tuning their teaching strategies, the CLES was not considered to be a suitable choice for this study.

2.3.2.9   *What Is Happening In this Class? Questionnaire (WIHIC)*

In learning environment research, it is not unusual to develop an instrument using scales derived from pre-existing instruments. The What Is Happening In this Class? questionnaire (WIHIC, Fraser, Fisher & McRobbie, 1996) combines modified versions of salient scales from a range of existing questionnaires, that were shown in past studies to be good predictors of student outcomes, along with additional scales that were developed to accommodate contemporary educational concerns. The development of the WIHIC has been considered to be a significant milestone in the field of learning environments.

The original version of the WIHIC had 90 items which was later refined by Aldridge, Fraser and Huang (1999) to include 56 items that were evenly distributed in seven scales, namely, Student Cohesiveness, Teacher Support, Involvement, Task Orientation, Investigation, Cooperation and Equity. The WIHIC is available in both a class form (which assesses a student's perceptions of the class as a whole) and a personal form (which assesses a student's personal perceptions of his or her role in a classroom) (Fraser, 2012). This study used the personal form because it sought to elicit the students' individual role within the classroom learning environment and to facilitate differentiating between the perceptions of male and female students. The items of the WIHIC are responded to using a five-point frequency-response format ranging from Almost Never to Almost Always that requires the respondent to indicate how often a practice occurs.

The WIHIC has been validated and used successfully in different countries by many researchers. For example, a cross-national sample of 3,980 high-school students from Australia, the UK and Canada, Dorman (2003) conducted a comprehensive validation of the WIHIC. Confirmatory factor analysis supported the seven-scale *a priori* structure, with the statistics indicating a good fit of the model to the data. In a second study, Dorman (2008) used both the actual and preferred forms of the WIHIC with a sample of 978 secondary-school students from Australia, and a separate confirmatory factor analyses, for the actual and preferred forms, supported the seven-scale a priori structure, with fit statistics indicating a good fit of the model to the data. The use of multitrait–multimethod modelling, with the seven scales as traits and the two forms (actual and preferred) of the instrument as methods, supported the WIHIC's construct validity.

Aldridge et al. (1999) cross validated the WIHIC with a sample of 1879 high school students in 50 classes in Taiwan and 1081 high school students in 50 classes in Australia. The WIHIC has also been validated and used to examine classroom learning environments in studies carried out in Australia (Dorman, Fisher & Waldrip, 2006; Dorman, 2008; Velayutham & Aldridge, 2013), Singapore (Chionh & Fraser, 2009; Khoo & Fraser, 2008), India (Koul & Fisher, 2005, 2006), South Africa (Aldridge, Fraser & Ntuli, 2009), Indonesia (Fraser, Aldridge & Aldophe, 2010; Wahyudi & Treagust, 2004), Korea (Kim et al., 2000), US (Allen & Fraser, 2007; den Brok, Fisher, Rickards & Bull, 2006; Helding & Fraser, 2013; MacLeod & Fraser, 2010; Martin-Dunlop & Fraser, 2008; Ogbeuhi & Fraser, 2007; Pickett & Fraser, 2009; Wolf & Fraser, 2008), Uganda (Opolot-Okurut, 2010), Canada

(Zandvleit & Fraser, 2004, 2005), Australia, Canada and the UK (Dorman, 2003) and the United Arab Emirates (Afari, Aldridge, Fraser & Khine, 2013).

An overview of studies that have used the WIHIC in investigating classroom learning environment and various student outcomes is provided in Table 2.2. For each study, the nature and size of sample is provided along with the country and language involved. The findings from the studies indicate that the psychosocial classroom learning environment scales from the WIHIC are associated with a range of student outcomes including; attitudes, satisfaction, enjoyment, academic efficacy, achievement, motivation and self-regulation.

Given the reliability and validity of the WIHIC and its applicability to different classroom learning environments, this instrument was considered to be a suitable choice and was modified to assess the students' perceptions of their multimedia learning environment in mathematics classes in Western Australia. Section 3.5.1.1 reports how the WIHIC was modified for the purpose of this study.

2.3.3   *Past Research in Learning Environments*

For nearly half a century, learning environment research has contributed significantly to the field of education. This study drew on the rich resource of diverse, valid, economical and widely-applicable assessment instruments that are available in the field of learning environments to examine the impact that exposure to multimedia has on students' perceptions of the learning environment and their engagement in mathematics classes.

Table 2.2   Studies that Have Used the WIHIC in Investigating Environment–Outcome Associations

Reference(s)	Country(ies)	Language(s)	Sample(s)	Outcome variable
Aldridge, Fraser & Huang (1999); Aldridge & Fraser (2000)	Australia Taiwan	English Mandarin	1,081 (Australia) & 1,879 (Taiwan) in 50 science classes	Enjoyment
Fraser, Aldridge & Adolphe (2010)	Australia Indonesia	English Bahasa Indonesia	567 students (Australia) and 594 students (Indonesia)	Several attitude scales
Zandvliet & Fraser (2004, 2005)	Australia Canada	English	1,404 students 81 networked classes	Satisfaction
Chionh & Fraser (2009)	Singapore	English	2,310 grade 10 geography & mathematics students	Achievement Attitudes Self-esteem
Khoo & Fisher (2008)	Singapore	English	250 working adults attending computer education courses	Satisfaction
Velayutham, Aldridge & Fraser (2011, 2013)	Australia	English	1360 grade 8,9 & 10 science students in 78 classes	Motivation Self-regulation
Afari, Aldridge, Fraser & Khine (2013)	UAE	Arabic	352 college students in 33 classes	Enjoyment Academic efficacy
Martin-Dunlop & Fraser (2008)	California, US	English	525 female university science students in 27 classes	Attitude
Ogbuehi & Fraser (2007)	California, US	English	661 middle-school mathematics students	Attitude Achievement
Wolf & Fraser (2008)	New York, USA	English	1,434 middle school science students in 71 classes	Attitude Achievement
Allen & Fraser (2007)	Florida, US	English Spanish	120 parents and 520 grade 4 & 5 students	Attitude Achievement
Robinson & Fraser (2013)	Florida, US	English Spanish	78 parents and 172 kindergarten science students	Attitude Achievement
Helding & Fraser (2012)	Florida, US	English Spanish	924 students in 38 grade 8 & 10 science classes	Attitude Achievement

Fraser (2012) delineated ten distinct categories or lines of research within the field of learning environments, these being, research on associations between student outcomes and the environment (Aldridge & Fraser, 2008; Fraser, 2007; Ogbuehi & Fraser, 2007; Telli, den Brok & Cakiroglu, 2010), programme evaluation of educational innovations (Martin-Dunlop & Fraser, 2008; Nix et al., 2005; Wolf &

Fraser, 2008), teacher action research (Aldridge & Fraser, 2008; Aldridge, Fraser & Ntuli, 2009; Aldridge, Fraser & Sebela, 2004; Aldridge, Fraser, Bell & Dorman, 2012; Bell & Aldridge, 2014), differences between students' and teachers' perceptions of actual and preferred environment (Fisher & Fraser, 1983; Fraser & McRobbie 1995), combining quantitative and qualitative methods (Aldridge, Fraser & Huang, 1999), school psychology (Sink & Spencer, 2005), links between educational environments (Aldridge, Fraser & Laugksch, 2011; Fraser & Kahle, 2007; Jegede, Fraser & Okebukola, 1994; Moos, 1991), cross-national studies (Aldridge, Fraser & Huang, 1999; Fraser, Aldridge & Soerjaningsih., 2010; Fraser, Aldridge & Adolphe, 2010), transition between different levels of schooling (Ferguson & Fraser, 1998) and determinants of classroom environment (Moos, 1978, 1979; den Brok, Telli, Cakiroglu, Taconis & Tekkaya, 2010; Dorman, Aldridge & Fraser, 2006; Rickards, den brok & Fisher, 2005). Table 2.3 summarises these lines of research with an explanation of the focal point of each.

Of particular relevance to my study was past research related to the following three lines of research; associations between the learning environment and student outcomes (discussed in Section 2.3.3.1); the use of environment dimensions as criterion variables in the evaluation of educational innovations (discussed in Section 2.3.3.2); and the combined use of quantitative and qualitative research methods (discussed in Section 2.3.3.3).

Table 2.3   Lines of Past Research and their Emphasis

Research area	Main emphasis of research
Environment-Outcome Associations	Investigation of associations between perceptions of psychosocial characteristics of a classroom environment and students' cognitive and affective learning outcomes.
Evaluations of educational innovations	Process criteria used in the evaluation of educational innovations.
Differences between student-teacher perceptions	Investigation of differences between students and teachers in their perceptions of the same classroom situation.
Determinants of classroom environment	Classroom environment dimensions used as criterion variables in research aimed at identifying how classroom environment varies with different class-level and school-level factors.
Use of quantitative qualitative research methods	Research involving the use of both quantitative and qualitative methods in the same study in order to identify salient features of the learning environment.
Cross-national studies	Research that crosses national boundaries.
Teacher action research	Research involving educational environments to help teachers to improve their own classroom or school environments.
Links between educational environments	Research involving links between and the joint influence of, two or more environments (eg. school, home and parents' work environments).
Transition between different levels of schooling	Research involving early adolescents' transition from primary school to the larger, less personal secondary school environment.
School psychology	Research involving the evaluation of the efficacy of school counselling programmes in terms of improved classroom environment.

2.3.3.1   Associations between the Learning Environment and Student Outcomes

The strongest tradition in past learning environment research has involved the

investigation of associations between students' perceptions of psychosocial

environmental characteristics and a range of outcomes (both affective and cognitive outcomes, Aldridge & Fraser, 2008; Fraser, 2012). Numerous studies have reported that student perceptions account for appreciable amounts of variance in learning outcomes, often beyond that attributable to background student characteristics (Dorman, 2001; Dorman & Fraser, 2009; Fraser, 2007, 2012). (This range of studies is summarised in Table 2.4.)

In Western Australia, Velayutham and Aldridge (2013) used the WIHIC and the Students' Adaptive Learning Engagement in Science questionnaire (SALES) to collect data from a sample of 1360 students. Their findings suggested positive associations between the learning environment (Student Cohesiveness, Investigation and Task Orientation scales) and students' affective outcomes (motivation and self-regulation). In addition, motivation (Learning Goal Orientation, Task Value and Self-efficacy) influenced students' self-regulation in science.

In California, Ogbuehi and Fraser (2007) used the WIHIC and the CLES with a sample of 661 middle-school students in 22 classes. Their findings indicated positive associations between students' perceptions of classroom learning environment and students' attitudes to mathematics and conceptual development. Similarly, in Turkey, Telli, Cakiroglu and den Brok (2006) found positive associations between the scales of the WIHIC and students' attitude to biology. Telli, den Brok and Cakiroglu (2010) investigated the associations between teacher-student interpersonal behaviour and students' attitudes to science using the QTI with an attitude questionnaire for a sample of 7,484 grade 9–11 with students from 278 classes in 55 public schools in 13 major Turkish cities. Their results revealed that the influence dimension of the QTI

was related to student enjoyment, whilst the proximity dimension was associated with attitudes to inquiry. Fisher et al. (1995) used the QTI to establish associations between student outcomes and perceived patterns of teacher-student interaction for samples of 489 senior high-school biology students in Australia.

Associations between students' cognitive and affective outcomes have also been established, using the WIHIC, for samples of: 525 female university science students in California, US (Martin-Dunlop & Fraser, 2008); 352 college students in 33 classes in UAE (Afari et al., 2013); and 1434 middle-school science students in 71 classes in New York, US (Wolf & Fraser, 2008). In Florida, US, Allen and Fraser (2007) established associations between classroom environment, achievement and attitudes among a sample of 120 parents and 520 grade 4 and 5 students while Helding and Fraser (2012) also established associations between classroom environment, achievement and attitudes among a sample of 924 students in 38 grade 8 and 10 science classes in the same state. Wong, Young and Fraser (1997) investigated associations between three student attitude measures and a modified version of the SLEI involving 1,592 grade 10 students in 56 chemistry classes in Singapore.

Using a modified WIHIC in Uganda, Africa, Opolot-Okurut (2010) established associations between students' perceptions of their mathematics classroom learning environment and motivation among a sample of 81 secondary school students in two schools.

Table 2.4   Studies of Associations between Outcomes and Learning Environment

Study	Outcome Measures	Sample
Studies Involving QTI		
Wei, den Brok & Zhou (2009)	Achievement	160 grade 8 students (4 classes) of secondary school in southwest China.
Haladyna, Olsen & Shaughnessy (1982)	Attitudes	5,804 science, mathematics and social studies students in 277 Grade 4, 7 and 9 classes in the US.
Studies Involving CES		
Fisher & Fraser (1983)	Inquiry skills Attitudes	116 grade 8 and 9 science classes in Tasmania, Australia.
Studies Involving MCI		
Fraser & Fisher (1982)	Attitude Nature of science	2,305 grade 7 science students in 100 classes in Tasmania, Australia.
Goh, Young, & Fraser (1995)	Attitudes	1,512 primary school students in Singapore.
Majeed et al. (2002)	Attitudes	1,565 mathematics students in 81 classes in Brunei Darussalam.
Studies Involving WIHIC		
Okan (2008)	Attitudes	152 university students in Turkey.
Wolf & Fraser (2008)	Attitudes Achievement	1434 students in 71 classes in the US.
Zandvliet & Fraser (2005)	Attitudes	1,404 students in 81 classes in Australia and Canada.
Opolot-Okurut (2010)	Motivation	81 secondary school students in Uganda.
Velayutham & Aldridge (2013)	Motivation Self-regulation	1360 grade 8, 9 & 10 students in Perth, Australia.
Ogbuehi & Fraser (2007)	Attitudes	661 middle-school mathematics students in 22 classes in California, US.
Afari et al. (2013)	Enjoyment Academic efficacy	352 college students in 33 classes in the UAE.
Studies Involving CLES		
Aldridge et al. (2004)	Attitudes	1,843 grade 4–9 students in 29 mathematics classes in South Africa.
Nix et al. (2005)	Attitudes	1,079 high school students in 59 classes in Texas, US.
Studies Involving SLEI		
Fisher et al. (1997)	Attitudes	489 senior high school biology students in Australia.
Fraser & McRobbie (1995)	Attitudes	80 senior high school chemistry classes in Australia.
Wong & Fraser (1996)	Attitudes	1,592 Grade 10 chemistry students in Singapore.

*Adapted from Fraser (1998) with permission

This range of studies, summarised in Table 2.4, have been conducted in a variety of subjects (mathematics, science, English, geography, computing), at various grade levels (elementary, secondary, higher education), using different outcome measures and different learning environment questionnaires throughout the world. There is no doubt that, given this range of studies, mentioned above, in addition to those summarised in Table 2.4, student perceptions of the learning environment account (in addition to background student characteristics) for variance in learning outcomes. However, there is a lack of evidence in the literature as to whether there are any associations between students' exposure to a multimedia learning environment and their engagement (motivation and self-regulation). The present study extends past research in the field of learning environments by investigating whether associations exist between students' perception of their exposure to a multimedia learning environment and their engagement in mathematics.

2.3.3.2   *Evaluating Educational Innovations*

The evaluation of educational innovations examines the impact of innovations in terms of changes in the classroom learning environments (Fraser, 2012). A growing number of studies, some of which are described below, have successfully used learning environment instruments to evaluate the effectiveness of educational innovations. For example, Nix, Fraser and Ledbetter, (2005) used the CLES in their evaluation of an innovative science teacher development programme (based on the Integrated Science Learning Environment model). Programmes were evaluated in terms of the types of school classroom environments created by these teachers as perceived by their students (N= 445 students in 25 classes). For this evaluation, Nix

et al. (2005) used an innovative side-by-side response format for the CLES so that students could provide their perceptions of 'THIS' classroom (the students' current class with the teacher who had experienced the professional development) and 'OTHER' classrooms (other classes at the same school taught by different teachers who had not experienced the professional development). Students of teachers who had experienced the professional development perceived their classrooms as having appreciably higher scores for each of the CLES scales of Personal Relevance and Uncertainty, relative to the comparison classes.

In Australia, Aldridge and Fraser (2008, 2011) used the Technology-Rich Outcomes-Focused Learning Environment Inventory (TROFLEI) in monitoring and evaluating the success of an innovative new senior high school in Western Australia in promoting outcomes-focused education. The sample included 449 students in 2001, 626 students in 2002, 471 students in 2003 and 372 students in 2004. Changes in student perceptions of the classroom environments over the four years supported the efficacy of the school's educational programmes in that changes were statistically significant and of moderate magnitude for seven of the ten TROFLEI scales. However, the degree of change in the learning environment differed for different learning areas. Subsequent interviews with administrative staff provided explanations for differences in results between learning areas in terms of whether teachers were proactive in using outcomes-focused learning/teaching principles.

An innovative science course for prospective elementary teachers in a large urban university in California was evaluated by Martin-Dunlop and Fraser (2008). Selected scales of the WIHIC and SLEI were administered to 525 females in 27 classes and

large differences were found on all scales between students' perceptions of the innovative course and their previous courses. The largest gains were observed for Open-Endedness and Material Environment.

Wolf and Fraser (2008) evaluated the effectiveness of using inquiry-based laboratory activities in terms of learning environment, attitudes and achievement. The WIHIC was administered to 1,434 middle-school science students in 71 classes. The results revealed that inquiry instruction promoted more Student Cohesiveness than non-inquiry instruction (effect size of one-third of a standard deviation). Also, inquiry-based instruction was found to be differentially effective for male and female students.

In California, US, Ogbuehi and Fraser (2007) evaluated the effectiveness of using an innovative teaching method for the topic of systems of linear equations involving a numerical method (Cramer's method) in terms of learning environment, students' attitudes and students' conceptual development. Using a sample of 661 middle-school mathematics students in 22 classes, they found that students in the experimental group perceived more Shared Control, Shared Negotiations and Investigation than their counterparts in the control group.

In Singapore, classroom environment measures were used as dependent variables in evaluations of computer-assisted learning by Teh and Fraser (1994) and computer application courses for adults by Khoo and Fraser (2008). In an evaluation of adult computer application courses, Khoo and Fraser (2008) adapted the WIHIC to use with the 250 working adults attending five computer education centres in Singapore.

The results indicated that students perceived their classroom environments positively, with this pattern varying only a little for students of different sexes and ages. However, males perceived statistically significantly more of the involvement component, whereas females perceived more of the equity component.

My review of literature indicated that, to date, there have been no studies undertaken in Western Australia to examine the effectiveness of exposing students to multimedia. This study fills this gap in literature and extends research in the field of learning environments concerned with the evaluation of educational innovations by examining whether exposure to multimedia is indeed effective in terms of improved perceptions of the learning environment and whether exposure to multimedia is equally effective for males and females.

2.3.3.3   *Use of Quantitative and Qualitative Research Methods*

Traditionally, educational research utilised empirical or quantitative methodologies (Eisner, 1981). Around 1985, however, qualitative techniques, which sought to provide a greater depth of understandings of specific situations, rather than predictions of outcomes, have been used (Kember, Lai, Murphy, Siaw, Wong & Yuen, 1990; Merriam, 1988). According to Denzin and Lincoln (2000), distinctions between quantitative and qualitative methods are justified by the researchers' philosophical outlook about what is being researched.

Modern educational research techniques, however, encourage the use of a wide range of data types and analysis methods in order to gain a clearer understanding of the

dynamics and impact of the situation being studied (Fraser, 2012). Today, one of the more powerful trends in educational research is the combining of qualitative and quantitative research methods to obtain a clearer picture of the data and those subjects involved in the study (Fraser & Tobin, 1991; Tobin & Fraser, 1998).

Studies within the field of learning environments that involve a combination of qualitative and quantitative methods have become more prevalent in recent years (Tobin & Fraser, 1998). Fraser (1999), in his review of qualitative learning environment studies, concluded that findings from the quantitative component of the research were generally in accordance with the observations gathered from the qualitative methods.

In many studies, quantitative data has been used to provide a broad overview of the trends and generalisations while qualitative information has been gathered to provide explanations and depth to the findings. For example, Aldridge et al. (1999), in their cross-national study, analysed data collected from 1,081 grade 8 and 9 science students in Western Australia and 1,879 grade 7 to 9 students in Taiwan. The findings of the large-scale quantitative overview, using the WIHIC, provided a starting point from which qualitative methods (such as observations, interviews, and narrative stories) could be used to gain a more in-depth understanding of the classroom environments in each country.

Afari, Aldridge and Fraser (2013) investigated the effectiveness of games when used in tertiary-level mathematics classes in the United Arab Emirates. In addition to using quantitative information (from a sample of 352 students), interviews,

classroom observations and narrative stories were used to provide insights into games in action in mathematics classrooms. The information obtained from interviews with students and teachers was used to help to explain the pre–post differences in students' perceptions of the learning environment and their attitudes towards mathematics.

The study reported in this thesis used both quantitative and qualitative methods to determine whether students frequently exposed to multimedia in mathematics classes perceived the learning environment differently to their counterparts who were not exposed to multimedia in their mathematics classes. As with previous studies, this study involved the collection of quantitative data to provide a general picture of the research problem; whereas qualitative data were used to extend and explain this general picture.

2.4   Student Engagement

A major focus of this study was to examine whether students in classes exposed to multimedia were more engaged than those who were in classes not exposed to multimedia. It was considered pertinent, therefore, to review literature related to student engagement. In particular, this section focuses on relevant theory and research related to motivation and self-regulation, as constructs that were used to assess student engagement in this study (Section 2.4.1). Section 2.4.2 reviews past instruments that have been used to assess students' engagement (motivation and self-regulation) including the Students' Adaptive Learning Engagement in Science questionnaire (SALES), that was modified for use in this study.

2.4.1   *Motivation and Self-Regulation*

Failure at school is a concern to teachers, psychologists and parents (Anderson, Hamilton & Hattie, 2004) and is generally associated with a number of adverse life outcomes (Blechman, 1996; Lichtenstein & Blackorby, 1995). Engaging students at school becomes paramount because it fosters the development of creative, informed and resilient citizens who are able to fully participate in a dynamic and globalised world. Engagement at school also leads to many benefits for individuals and society, including higher levels of employment and earnings, better health, longevity, tolerance and social cohesion (Gonski, Boston, Greiner, Lawrence, Scales & Tannock, 2011).

Theobald (2006) noted that students' lack of interest in learning is an issue that needs to be addressed. Further, Theobald (2006) stressed that stimulating students' engagement to learn remains one of the greatest challenges for teachers. While researchers generally agree that improving student engagement in school work is a high priority, and a necessary precondition for boosting student achievement, there is less certainty about how to accomplish this (Theobald, 2006).

Students who are engaged show sustained behavioural involvement in learning activities accompanied by positive emotional tone (Pintrich, 2003). They select tasks at the edge of their competencies (Bandura, 1986), initiate action when given the opportunity (Schunk & Pajares, 2005) and exert sustained intense effort and concentration in the implementation of learning tasks (Boekaerts & Cascallar, 2006; Boekaerts & Corno, 2005; Corno, 1994). Engaged students in general are likely to

show positive emotions during ongoing action, including enthusiasm, curiosity, and interest. At the opposite end of the continuum to engagement is disaffection. Students who are disaffected are passive, do not try hard and give up easily in the face of challenges. Disaffected students can be bored, depressed, anxious, or even angry about their presence in the classroom. They tend to be withdrawn from learning opportunities or even rebellious toward teachers and classmates (Neo & Neo, 2009).

Anderson, Hamilton and Hattie (2004) assert that it is distressing when students, who are not less able than others, fail because they simply do not sufficiently engage in academic activities in order to pass. This lack of engagement in tasks has been commonly described and conceptualised as a deficit in or lack of motivation and self-regulation. Therefore it would appear that an essential key to successful science and mathematics learning is a positive motivational belief that mobilises otherwise inert knowledge (Hanrahan, 2002). When students have higher motivation, their satisfaction with their learning is greater which, in turn, can lead to better learning outcomes (Fraser, 2012; Fraser & Walberg, 1991).

The construct of motivation has been examined from a number of theoretical perspectives, including cognitive, behavioural and social learning approaches (Anderson, Hamilton, & Hatie, 2004; Bandura & Schunk, 1981; Murphy & Alexander, 2000; Schunk, Pintrich & Meece, 2008). The most common is the cognitive approach, in which motivation is a rather broad and sometimes ill-defined construct (Murphy & Alexander, 2000) with some researchers appearing to view it as a personal attribute (Bandura & Schunk, 1981). On the other hand, the behavioural

approach focuses on the effect of the immediate environment on motivation, which is seen as a function of the consequences of a person's behaviour. The social learning approach to the study of motivation is based on field-theoretical conceptualisations of action (Lewin, 1952), which stresses the importance of considering the person and the interaction with his or her environment. This approach lends itself to the study of motivation within an ecological paradigm.

Research indicates that students' successful learning engagement in mathematics is primarily determined by their level of motivation and self-regulation in mathematics learning (Boekaerts & Cascallar, 2006; Hanrahan, 2002; Kaplan et al., 2009; Velayutham, Aldridge & Fraser, 2011; Zimmerman, 2000). The interactions between behavioural, environmental and personal determinants that are proposed in the social cognitive theory suggest that relevant aspects of the learning environment will affect both students' motivational beliefs and their self-regulation.

There are two types of motivation; intrinsic and extrinsic motivation (Al Hmouz, Wilma & Rose, 2010). While intrinsic motivation is perceived as the doing of an activity for its inherent satisfaction, for example, the enjoyment of school learning is characterised by an orientation toward mastery, curiosity, and the learning of challenging and novel tasks (Gottfried, Cook & Morris, 2005; McInerney, 2002; Phillips & Lindsay, 2006), extrinsic motivation is related to doing something that leads to a separate outcome. Extrinsic motivation is generally associated with winning; therefore students tend to concentrate more on the prize than on the satisfaction derived from learning (Phillips & Lindsay, 2006; Ryan & Deci, 2000).

Research has revealed that students' motivation in mathematics learning is a crucial affective component because it plays a pivotal role in their conceptual change processes, critical thinking, learning strategies, and achievement in mathematics (Kuyper, van der Werf, & Lubbers, 2000; Lee & Brophy, 1996; Pintrich, Marx & Boyle, 1993; Wolters, 1999). Psychologists have spent considerable effort trying to construct theories of motivation, particularly in the academic context. Currently, there are a number of prominent theories which are prominent in contemporary educational psychology including the self-efficacy theory, attribution theory, self-worth theory, achievement goal theory and task value theory.

Ultimately though, the critical factor in the learning process may be related to how students react to their environment. Environments which are perceived as being nurturing, supportive and helpful will develop, in students, a sense of confidence and self-determination which will be translated into the learning-oriented behaviours of the intrinsically motivated student (Seifert, 2004; Seifert & O'Keefe, 2001).

This theoretical basis, coupled with the lack of research on the impact exposure to multimedia has on student engagement (motivation and self-regulation), provided the impetus for this research. Therefore, one aim of this study was to investigate the elements in the multimedia learning environment which impacted on students' engagement in mathematics learning.

Four components of engagement have been shown to consistently promote students' engagement in learning and adaptive self-regulated beliefs, these being, Learning Goal Orientation (described in Section 2.4.1.1), Task Value (described in Section

2.4.1.2), Self-Efficacy (described in Section 2.4.1.3), and Self-Regulation (described in Section 2.4.1.4). Each of these components is integral to successful engagement in learning and is described below.

2.4.1.1   *Learning Goal Orientation*

Achievement goal theory has emerged as one of the most prominent theories of student motivation (Midgley, 2002). Achievement goal theory posits that students' academic motivation can be understood as attempts to achieve goals (Dweck, 1986; Dweck & Leggett, 1988; Nicholls et al., 1990). The assumptions of goal theory is that students' behaviours are a function of desires to achieve particular goals. As such, research has focused primarily upon the two dominant goals of learning, namely, learning goal orientation (which refers to the purpose of developing competence and focuses on learning, understanding, and mastering tasks) and performance goal orientation (which refers to the purpose of demonstrating competence, especially in managing the impressions of others) (Ames, 1992). Students pursuing learning goal orientations have been described as self-regulating and self-determining (Seifert, 1997) and their dispositions foster cognitive development. They strive to acquire new information to improve their competence and believe that effort (some internal, controllable factor) is the cause of success or failure and that intelligence is malleable (Dweck & Leggett, 1988).

In contrast, students pursuing performance goals tend to be preoccupied with ability concerns (Dweck & Leggett, 1988). They are more concerned about how well they perform relative to others and how others will perceive them, therefore, they are

likely to engage in less sophisticated strategy use (Nolen, 1988; Seifert, 1995), make more negative self-statements and attribute success to uncontrollable factors (Seifert, 1995). They are motivated mainly by a strong desire to outperform others and to document their superior ability. Midgley, Kaplan and Middleton (2001) suggested that the performance goal approach had the potential to turn into a performance avoidance goal when students undergo changes in their perceived competence.

Evidence from past research has indicated that students' learning goal orientation is likely to influence a range of positive learning outcomes including student achievement and problem solving strategies (Brookhart, Walsh & Zientarski, 2006; Kaplan & Maehr, 1999, 2007), positive emotions and persistence (Elliott & Dweck, 1988), positive social attitude towards others (Kaplan, 2004), choice of subjects (Cury, Elliot, Da Fonseca & Moller, 2006), effort and persistence (Elliot, McGregor & Gable, 1999), employment of deep learning strategies (Elliot et al., 1999; Kaplan & Midgley, 1997), retention of information (Elliot & McGregor, 1999) and self-efficacy (Kaplan & Maehr, 1999). Students who perceive the teacher as emphasising learning goals are more inclined to use adaptive cognitive, emotional and behavioural regulatory strategies (Ames & Archer, 1988; Kaplan & Midgley, 1999; Newman, 1998; Ryan, Gheen & Midgley, 1998; Urdan & Midgley, 2003).

According to Kaplan and Maehr (2007), learning goal orientation is an adaptive motivational orientation. In their review of goal orientations, Wigfield and Cambria (2010), concluded that motivational theorists agreed upon the benefits of learning goal orientation to students and strongly recommended that this goal orientation be focused on in schools. Based on this theoretical and research evidence, learning goal

orientation can be considered to be a key component of students' motivation in mathematics learning and was, therefore, included as a motivational construct in this study.

Ames (1992) contends that the primary source of their goals orientation is not children's inherent characteristics but is, rather, a result of their classroom learning environment experiences. Both theory and research evidence suggest that teachers' instructional practices and procedures influence the goals that students pursue (Anderman & Young, 1994). In particular, for mathematics education, goal orientation theory implies that changes in classroom goal structures could enhance or inhibit the motivation of all students who participate in that classroom (Anderman & Young, 1994). The implication is that goal orientations are more a product of context rather than the person (Wigfield & Cambria, 2010). Based on this premise, this study examined whether the learning environment, created in classrooms exposed to multimedia influenced students' learning goal orientation.

2.4.1.2   Task Value

According to Eccles (1983), Pintrich (2000) and Pintrich and De Groot (1990), task-value theory emphasises the critical role of academic task value beliefs in directing students' motivation to learn. There are four major aspects of task value, these being, attainment value (importance of the task), intrinsic value (enjoyment one gains from doing the task), utility value (usefulness of the task) and cost (what one has to give up to do the task) (Eccles & Wigfield, 2002). In their version of the modern expectancy-value theory, Eccles and Wigfield, (2002) emphasised the integral role of

the value of the tasks for students' expectation of success, achievement-related choices and performance. Students who were convinced that their learning activity was important, interesting and useful were more inclined to spend more effort and persist longer towards completing an activity (Wolters and Rosenthal, 2000). Schunk and Zimmerman (2007) reported that even when students lacked self-confidence, they were still likely to initiate and maintain their efforts if they valued the learning activity.

Research has consistently supported claims about the association between the value a student holds for the task and his or her choice to participate and sustain effort in that academic task. Pintrich and De Groot (1990) and Wolters, Yu and Pintrich (1996) reported that task value was strongly associated with cognitive and self-regulatory strategies. These studies concluded that students who believed that their learning activity was interesting and important were more cognitively engaged in trying to learn and comprehend the materials presented to them. Tuan, Chin and Shieh (2005) concluded that task value significantly influenced students' attitudes towards mathematics and mathematics achievement. Research carried out in a range of subject areas has reported that task value influences students' academic choices, persistence, performance and achievement (Bong, 2001; Denissen, Zarrett & Eccles, 2007; Durik, Vida & Eccles, 2006; Eccles, 1993; Marsh, Köller, Trautwein, Lüdtke & Baumert, 2005; Meece, Wigfield & Eccles, 1990; Pekrun, 1993, 2009; Simpkins, Davis-Kean & Eccles, 2006; Xiang, McBride & Bruene, 2004).

When students value the task given to them, they are more likely to engage in learning and, in turn, improve their achievement (Schunk & Zimmerman, 2007).

Therefore, task value was considered to be an important construct when examining students' motivation in multimedia learning environments. Wigfield and Cambria (2010), in their review of task value, acknowledged that there was a lack of research on how classroom environment factors influenced the development of task values. This study took up the challenge and investigated whether exposure to multimedia influenced students' task value, there by filling this research gap.

2.4.1.3   Self-Efficacy

Self-efficacy is a construct synonymous with confidence and refers to a person's judgement about his or her capability to complete a task at a specified level of performance. It is the person's belief that he or she is able (or unable) to perform the task at hand and is correlated with achievement-related behaviours, including cognitive processing, achievement performance, motivation, self-worth and choice of activities (Bandura, 1977, 1993). Students who are efficacious (perceive themselves as capable) are more likely to be self-regulating, strategic and metacognitive. Further, efficacious students tend to be more willing to face difficult or challenging problems (Schunk, 1984, 1985) and exercise control over stress that could provoke anxiety (Bandura, 1993).

A strong notion of self-efficacy creates feelings of tranquility and challenge in the face of difficult tasks. According to Pajares (1996), students with high self-efficacy regard difficult tasks as challenges that need to be mastered. Students who see themselves as capable are more likely to display adaptive, mastery behaviours, while those who are less efficacious are likely to behave in an ego, performance-oriented

manner (Dweck, 1986). Individuals with a weak notion of self-efficacy are inclined to think that tasks are more difficult than they are. As such, these thoughts are a breeding ground for feelings of failure and depression, tension and helplessness (Bandura, 1997). Hence, self-efficacy beliefs are considered to be powerful predictors of the choices that students make, the effort that they expend and their persistence in facing difficulties (Bandura, 1997; Britner & Pajares, 2001; Zeldin & Pajares, 2000).

A significant number of researchers have examined the influence of students' self-efficacy on motivation and learning (Bouffard-Bouchard, 1990; Bouffard-Bouchard, Parent, & Larivée, 1991; Lent, Brown, & Hackett, 2002; Pintrich & De Groot, 1990; Schunk, 2003; Zimmerman, Bandura, & Martinez-Pons, 1992). Their findings suggest that self-efficacy influences students' motivation and cognition by affecting their task interest, task persistence, the goals they set, the choices they make and their use of cognitive, meta-cognitive and self-regulatory strategies. Studies carried out at various levels of education (e.g., primary, secondary, and tertiary), in different subject areas (reading, writing, mathematics and computing science) and targeting different ability levels (average, talented, below average) have consistently found positive relationships between students' self-efficacy and their achievement. (Bouffard-Bouchard, 1990; Carmichael & Taylor, 2005; Lane, Lane & Kyprianou, 2004; Pajares & Miller, 1994; Schunk, 2003).

A student's self-efficacy has been found to mediate between the several determinants of competence (e.g., skill, knowledge, ability, or former achievements) and their subsequent performances (Bandura, 2006; Schunk & Pajares, 2001). At the

secondary school level, research has indicated that self-efficacy is a stronger predictor of achievement and engagement in mathematics-related activities than either the students' sex or their parental background (Kupermintz, 2002; Lau & Roeser, 2002). Among middle school students, mathematics self-efficacy is a predictor of mathematics achievement, with girls having higher maths grades and stronger self-efficacy than boys (Britner & Pajares, 2001; Pajares, Britner & Valiante, 2000).

Research on the influence of classroom environment on academic efficacy was initially brought to the attention of learning environment researchers by Lorsbach and Jinks (1999) who called for the convergence of these two fields. Dorman (2001) and Dorman and Adams (2004) have since found that the learning environment of mathematics classes was likely to influence students' academic efficacy. Velayutham, Aldridge and Fraser (2013) also found strong positive relationships between the learning environment in science classrooms and student self-efficacy.

Given that self-efficacy can be considered to be a pivotal construct that could influence students' engagement in mathematics learning and that the learning environment is likely to influence students' self-efficacy beliefs, the present research sought to examine whether students exposed to multimedia had a greater sense of self-efficacy than those who were not.

2.4.1.4   *Self-Regulation*

Pintrich and Schrauben (1992) defined self-regulation as the student's choice to engage in a particular learning activity and the degree of intensity of effort and persistence in that activity. Zimmerman (2008) refers to self-regulated learning as the degree to which students meta-cognitively, motivationally and behaviourally participate in the learning process. Self-regulated learning steers and directs students' cognitive and motivation processes to achieve learning goals (Boekaerts & Cascallar, 2006). Pintrich and De Groot (1990) identified three components of self-regulated learning that are relevant for classroom performance, namely, students' meta-cognitive strategies in planning, monitoring and modifying their cognition, use of cognitive strategies, and management and control of effort in academic tasks.

Researchers agree that learning goal orientation, task value and self-efficacy, without self-regulation, are of limited value to students in stimulating their engagement (Pintrich, 2000; Velayutham, Aldridge & Fraser, 2011; Velayutham & Aldridge, 2013). Boekaerts and Cascallar (2006), in their review of self-regulation theory, reiterate that the key conjecture in most models of self-regulation is that students' motivational beliefs play a vital function in ensuring students' successful engagement in self-regulated learning. While Dweck (1986) reported that students' motivational beliefs promote the establishment, maintenance, and attainment of personally challenging and valued achievement goals, Pintrich (2000) and Velayutham, Aldridge and Fraser (2011) emphasised that both adaptive motivational beliefs and adaptive self-regulated learning are integral to students' engagement in classroom tasks.

The core requirements of the self-regulated learner are personal initiative, perseverance and adaptive skills (Zimmerman, 2008). Boekaerts and Cascallar (2006) contend that students must not only be motivated through assigning goals and values to the learning activity, but also to sustain effort until the completion of the task. Effort regulation is the key element required for building students' learning skills as well as helping them stay focused and be able to handle the numerous distractions that they face in and out of the classroom (Alderman, 1999).

Self-regulation in learning has been established as both an important outcome of the schooling process and as a key determinant of students' academic success (Wolters, 2010). Research has provided consistent evidence to suggest that students who are self-regulated gain greater academic achievement (Baker, Chard, Kettlerlin-Geller, Apichatabutra & Doabler, 2009; Dignath, Buettner & Langfeldt, 2008; Guthrie, McRae & Klauda, 2007). In a study by Wolters and Pintrich (1998), the self-regulatory strategies, utilised by junior high school students, predicted their semester grades in mathematics, social studies and English. Research by Pintrich and DeGroot (1990) involving year seven students suggested that motivational, cognitive and meta-cognitive aspects of self-regulated learning predicted students' performance on homework, classwork, quizzes and overall grades. Van der Stoep, Pintrich and Fagerlin (1996) and Zimmerman and Martinez-Pons (1990) emphasised that higher achieving students show greater engagement in different components of self-regulated learning when compared to lower achieving students.

Studies of interventions aimed at improving students' self-regulated learning have shown promising results, including the transfer of skills beyond the context of

training such as improving students' self-efficacy beliefs and achievement scores (Perels, Gurtler & Schmitz, 2005; Schunk, 2005; Schunk & Ertmer, 2000; Taboada, Tonks, Wigfield & Guthrie, 2009; Wigfield, Guthrie, Perencevich, Taboada, Klauda, McRae & Barbosa, 2008). Perels et al. (2005) examined the effects of self-regulation and problem solving strategies training on 249 students, and confirmed that it is possible to improve and sustain students' self-regulation and mathematical problem-solving competence through even relatively short interventions. A mixed-method study by Cleary, Platten and Nelson (2008), involving year nine students, found that those students who had been given instructions in self-regulated learning showed improvement in biology achievement when compared to those who had not received the instruction.

Boekaerts and Cascallar (2006) purport that student' perceptions of the classroom learning environment affect their conscious and unconscious choices in completing learning activities in the classroom. Boekaerts and Cascallar (2006) further recommended that researchers and teachers focus simultaneously on the students' self-regulation of the learning and motivation process as well as on the environmental triggers that affect these processes. Zimmerman (2008) also asserts that the effects of learning environment on students' self-regulated learning should be studied further.

To date, no research has examined students in classes exposed to multimedia and whether they have increased self-regulation when compared to students in classes not exposed to multimedia. Therefore, this study filled this research gap by comparing the self-regulation of students in these two groups.

2.4.2   *Instruments Used to Assess Motivation and Self-Regulation*

A number of instruments have been used to assess student motivation and self-regulation. Although some of these instruments were developed for use in science classrooms, they are reviewed here because the underpinning theory upon which the surveys were developed are also relevant to students in mathematics classes. This section provides a brief review of seven instruments, these being: Science Motivation Questionnaire (described in Section 2.4.2.1); Students' Motivation Towards Science Learning (described in Section 2.4.2.2); Academic Motivation Scale (described in Section 2.4.2.3); Learning and Study Strategies Inventory (described in Section 2.4.2.4); Motivated Strategies for Learning Questionnaire (described in Section 2.4.2.5); and Students' Adaptive Learning Engagement in Science questionnaire (described in Section 2.4.2.6).

2.4.2.1   *Science Motivation Questionnaire (SMQ)*

The Science Motivation Questionnaire (SMQ) was developed by Glynn, Taasoobshirazi and Brickman (2009) to assess students' science motivation at the university level. Glynn et al (2009) incorporated six motivational components that can be linked to learning science (intrinsic motivation, extrinsic motivation, personal relevance, assessment anxiety, self-determination and self-efficacy). After exploratory factor analysis, the resulting questionnaire, SMQ was reduced to five scales; intrinsic motivation and personal development, self-efficacy and assessment anxiety, self-determination, career motivation and grade motivation. The scales and

number of items in each scale in the SMQ together with the Cronbach alpha coefficient for each scale are shown in Table 2.5.

Table 2.5   Number of Items and Cronbach Alpha Reliability for Scales of the SMQ

Scale	Number of item	Cronbach's alpha
Intrinsic motivation and personal relevance	10	0.91
Self-efficacy and assessment anxiety	9	0.88
Self-determination	4	0.74
Career motivation	2	0.88
Grade motivation	5	0.55

Source: Glynn, Taasoobshirazi & Brickman (2009)

Although there are merits to this questionnaire, Glynn et al. (2009) reported that items in the career motivation scale, which had only two items, and the grade motivation scale, which had a relatively low reliability of 0.55, required revision to represent the constructs more effectively.

2.4.2.2   *Students' Motivation Towards Science Learning (SMTSL)*

Tuan, Chin & Shieh (2005) developed the Students' Motivation Towards Science Learning (SMTSL) to assess students' motivation in science classes. This questionnaire has six motivational constructs, namely, self-efficacy, active learning strategies, science learning value, performance value, achievement goal and learning environment stimulation. Table 2.6 provides information about the number of items in each scale and each scale's alpha reliability according to Tuan et al (2005).

Close scrutiny of this survey indicates that some of the constructs (active learning strategies and learning environment stimulation scales), theoretically, might not be

directly related to students' motivational beliefs in science learning. In addition to long sentences and words that could potentially be confusing for secondary school students, the SMTSL has a number of negatively worded items with the self-efficacy scale having five of the items being negatively worded. As such, the face validity of the instrument was compromised. The achievement goal theory categorises students' goal orientation as either learning goal orientation or performance goal orientation but, according to the achievement goal theory, learning goal orientation refers to students' purpose of developing competence and focuses on learning, understanding, and mastering tasks. Therefore, with reference to achievement goal theory, the conceptualisation and measurement of this construct could be considered ambiguous and theoretically unsound. Further, the SMTSL included a four-item scale, all of which are reverse scored, to represent performance goal. Based on these findings, which cast doubt on the content validity of the SMTSL, this survey was not selected for use in this study.

Table 2.6 Number of Items and Cronbach Alpha Reliability for Scales of the SMTSL

Scale	Number of item	Cronbach's alpha
Self-efficacy	7	0.91
Active learning strategies	8	0.82
Science learning value	5	0.70
Performance goal	4	0.81
Achievement goal	5	0.80
Learning environment stimulation	6	0.75

Source: Tuan, Chin & Shieh, (2005)

2.4.2.3   *Academic Motivation Scale (AMQ)*

The Academic Motivation Scale (AMQ) was developed by Vallerand, Pelletier, Blais, Briére, Senècal and Valliéres (1992) to assess students' general motivation toward education. The AMQ consists of seven scales that assessed three types of intrinsic motivation (intrinsic motivation to know, intrinsic motivation toward accomplishment, and intrinsic motivation to experience stimulation), three types of extrinsic motivation (external regulation, introverted regulation, and identified regulation) and amotivation (lack of both extrinsic and intrinsic motivation). The AMQ has 28 items equally divided among the seven scales (4 items per scale). The AMQ was not developed for a particular subject or specific type of student. Because the purpose of this study was not to determine students' general motivation towards mathematics (but to determine the impact exposure to multimedia had on students' motivation), the use of the AMQ was considered unsuitable for this study

2.4.2.4   *Learning and Study Strategies Inventory (LASSI)*

The Learning and Study Strategies Inventory (LASSI) was developed to assess university students' self-regulated learning (use of learning and study strategies) (Weinstein, Schulte & Palmer, 2002). This ten-scale 80-item survey measures attitude, motivation, time management, information processing, test taking strategies, anxiety management, concentration, ability to select main ideas, use of study aids, and implementation of self-testing strategies. Due to its complex scales and length, this survey is not considered suitable for use at the lower secondary level, despite its

applicability in assessing self-regulation at university level. For this reason, this instrument was considered unsuitable for this study.

2.4.2.5   *Motivated Strategies for Learning Questionnaire (MSLQ)*

The Motivated Strategies for Learning Questionnaire (MSLQ) was developed to assess self-regulation in high school students (Duncan & McKeachie, 2005). The MSLQ is comprised of two parts, a motivation section (consisting of six scales that assess intrinsic goal orientation, extrinsic goal orientation, task value, control of learning beliefs, self-efficacy for learning and performance and text anxiety) and a learning strategies section (consisting of three general types of scales, namely, cognitive strategies, metacognitive strategies and resource management). Four scales assess students' use of different cognitive strategies, namely, rehearsal, elaboration, organisation and critical thinking. Students' use of metacognitive strategies is assessed using a 12-item scale. The final four scales in the learning strategies section (time and study environment management, effort regulation, peer learning and help-seeking) assess students' management of different resources. Table 2.7 provides information about the number of items in each scale and each scale's Cronbach alpha reliability, according to Duncan & McKeachie (2005).

The MSLQ was originally designed for use with university students, therefore, some of the words were considered to be beyond the comprehension of lower secondary students (the target population for the present study). Close scrutiny of the MSLQ also indicated that many of the items were negatively worded and, moreover, some of the items were considered to be long and complex, increasing the possibility of

confusion among lower secondary school students. As indicated in Table 2.7, the reliability of some of the scales (Help Seeking and Extrinsic Goal Orientation) was relatively low. Further, the cognitive and meta-cognitive strategy scales (rehearsal, elaboration, organisation, critical thinking and meta-cognitive) each assess complex self-regulatory strategies that may be beyond the comprehension of secondary students. Based on this premise, the MSLQ was not considered to be a suitable instrument for secondary students and was not selected for use in this study.

Table 2.7   Number of Items and Cronbach Alpha Coefficient for Scales of the MSLQ

Section	Scale	Number of items	Cronbach's alpha
Motivation	Intrinsic goal orientation	4	0.74
	Extrinsic goal orientation	4	0.62
	Task value	6	0.90
	Control of learning beliefs	4	0.68
	Self-efficacy for learning	8	0.93
	Text anxiety	5	0.80
Learning Strategies	Rehearsal	4	0.69
	Elaboration	6	0.75
	Organisation	4	0.64
	Critical thinking	5	0.81
	Meta-cognitive	12	0.79
	Time and study	8	0.76
	Effort regulation	4	0.69
	Peer learning	3	0.76
	Help seeking	4	0.52

Source: Duncan & McKeachie (2005)

2.4.2.6   Students' Adaptive Learning Engagement in Science Questionnaire

(SALES)

The Students' Adaptive Learning Engagement in Science questionnaire (SALES) was developed by Velayutham, Aldridge and Fraser (2011) to assess students' engagement in science learning in lower secondary science classrooms. The SALES includes three sales to assess motivation all of which have been consistently associated with motivational beliefs, these being, learning goal orientation, task value and self-efficacy. The survey also includes a scale to assess self-regulation (the degree to which students meta-cognitively, motivationally and behaviourally participate in their own learning). The SALES is made up of 32 items with eight items in each of the four scales. Some of the items were adapted from existing motivation and self-regulation questionnaires (MSLQ, Pintrich, Smith, Garcia & McKeeachie, 1991; PALS, Midgley et al., 1996; SMTSL, Tuan et al., 2005 and SMQ, Glynn et al., 2009) whilst the others were new. Items of the SALES are responded to using a five-point Likert scale of Strongly Disagree, Disagree, Not Sure, Agree and Strongly Agree. The number of and Cronbach alpha coefficient for each scale (Velayutham, Aldridge & Fraser, 2011) are shown in Table 2.8.

Table 2.8   Number of Items and Cronbach Alpha Reliability for Scales of the SALES

Scale	Number of item	Cronbach's alpha
Learning goal orientation	8	0.91
Task value	8	0.92
Self-efficacy	8	0.92
Self-regulation	8	0.91

Source: Velayutham (2012)

For the purposes of this study, the SALES questionnaire was selected to assess students' engagement (motivation towards and self-regulation) in mathematics because of the pertinence of the scales and the high reliability and validity when used with students in Western Australia (Velayutham & Aldridge, 2013). Section 3.5.1.2 reports, in detail, how the SALES was modified to suit this study, and describes the SALES' four, eight-item scales that were incorporated into the study.

2.5   Gender Issues

Given that the present study examined whether exposure to multimedia in mathematics classes was differentially effective for male and female students in terms of their perceptions of the learning environment and engagement in mathematics, this section reviews literature related to gender issues. Concern about student gender and educational attainment focuses mainly on the extent to which female and male students perform differently in different subjects. Gender differences in mathematics learning outcomes are not a new phenomenon (Forgasz & Rivera, 2012; Ritchie, 2013).

Before the feminist theories of the 1970s, it was not thought unusual that more males than females would study mathematics and other related subjects and that female achievement levels might not equal to those of their male counterparts. Since the 1970s, voices have been raised in Australia and elsewhere with respect to gender inequities in education and, since then, there has been considerable research in the field of gender in education (Leder, 1992, 1993). In Australia, there has been much activity aimed at addressing gender inequities, including reports (Ritchie, 2013),

education policies (see for example Australian Education Union's, 2008, Policy on Sex Equity) and intervention programs (see for example Vos, Astbury, Piers, Magnus, Heenan, & Stanley, 2006). Despite this activity, gender differences in mathematics learning continues to persist (Forgasz & Rivera, 2012). Australian statistics continue to reveal that a greater proportion of male rather than female students choose to study the most demanding mathematics courses when they become optional (Forgasz & Rivera, 2012).

Joyce and Farenga (1999) noted that, although girls begin developing negative perceptions of mathematics before the age of nine, the differences between primary school males and females in terms of motivation towards and perception of mathematics are not significant (Alexakos & Antoine, 2003). Gender differences tend to be more marked, and manifest themselves, in the secondary school years. Watt (2004, 2008), in a longitudinal study involving 1,323 students spanning from grades seven to 11, reported that, even when students' intrinsic value of mathematics declined during adolescence, male students consistently maintained a higher intrinsic value for mathematics than female students. The same study concluded that gender differences in intrinsic value for English favoured females, which is consistent with existing gender stereotypes. The National Centre for Education Statistics (2000) in the US found that gender gaps in motivation and academic performance in mathematics increased throughout secondary school. In later secondary school years, very few females go on to enrol in subjects that require rigorous mathematics or pursue careers that involve mathematics. Further, Watt (2006, 2010) used a sample of 442 students in grades nine to 11 to investigate the role of motivation in students' mathematics-related occupational intentions. The results of this study indicated that,

although males who had mid-to high-utility values planned to pursue mathematics-related careers, only those females who had the highest utility value planned to pursue mathematics-related careers.

Research related to the reasons why females are not pursuing careers in mathematics suggested that the educational process is a factor that influences women's career choices (Rosser, 1997). Firstly, teachers may inadvertently favour boys, especially in areas considered to be the male domain, by providing them with more and better instruction. Teachers have been found to give males more praise and more criticism (Drudy & Chathain, 2002), call on males more often, accept more call-outs from males, and follow up more often and at greater length on male responses (Duffy, Warren & Walsh, 2001; Einarsson & Granstrom, 2002; Martin & Newcomer, 2002). Teachers sometimes help females by doing things for them, whereas, with males, they tend to explain but expect the males to do it themselves (Sadker & Sadker, 1994). A number of studies reported that males were asked higher-level questions more frequently than their female counterparts (Drudy & Chathain, 2002; Jones, 1989; Martin & Newcomer, 2002).

Secondly, findings suggest that gender bias may occur in mathematics classrooms if boys and girls differ in terms of interests and attitudes, prior experience, achievement, self-confidence, preferred ways of learning (such as cooperative versus competitive goal structure) work rate or single-sex classes (Anderman & Young, 1994; Pajares, 1996; Pintrich & DeGroot, 1990; Zimmerman & Martinez Pons, 1990). Further, typical school instruction has been found to favour the learning of boys. Seymour and Hewitt's (1997) study of the reasons why highly competent

women drop out of college mathematics, reinforces the findings that males, and not females, held stereotypical views of mathematics as a male domain. The women in Seymour and Hewitt's (1997) study reported that many men considered mathematics to be a male domain and, in various ways, belittled and even harassed women who chose to study mathematical subjects. Further, Eisenberg, Martin and Fabes (1996) acknowledged that students perceive mathematics, science and technology as male domains.

Margolis, Fisher and Miller (2000) reported that the self-confidence of girls and boys in mathematics begins to drop in early adolescence, but drops more precipitously for girls than for boys. Margolis, Fisher and Miller (2000) also reported that female students' loss of confidence in mathematics precedes a decrease in interest. Another perspective on the influence of self-confidence is the finding that female students had lower self-confidence in their mathematical skills even when they were actually more successful and accomplished more than the male students in their classes (Gurer & Camp, 2002). Wolf and Fraser (2008) echoed the same findings when they reported that students' views of mathematics generally became less positive as they progressed through the schooling system and that this trend was more magnified amongst girls. In their review, Gurer and Camp (2002) found that the gender gap for liking mathematics increased with age.

In Eisenhart and Finkel's (1998) study, the females claimed that they had better things to do with their time and that interpersonal relationships and face-to-face conversation were activities that they valued. Eisenhart and Finkel (1998) reported that, for females, especially as they grow older, it is relationships rather than abstract

problem solving that confer social status. Although a number of researchers in the field of gender in education have suggested that collaboration rather than competition promotes learning for females (D'Amico, Baron & Sissons, 1995; Oakes, 1990; Pryor, 1995; Sanders et al., 1997), some researchers have indicated that cooperative learning may not be as beneficial for males. Peterson and Fennema (1985) reported that females' achievement on both product and process mathematics questions were greatest in those classes that used more cooperative learning, whereas males' achievement on product questions was greater with competitive instructional games.

Forgasz and Leder (1995, 1997), purport that girls in single-sex mathematics classes develop higher levels of confidence in mathematics, which is reflected in their subsequent choice of more challenging mathematics. Forgasz and Leder (1995) present an analysis of the outcomes of a programme in another Australian school, which implemented single-sex mathematics classes for Year 10 students. They found that females did, indeed, enrol in larger numbers than usual in higher level upper secondary school mathematics and that the programme as a whole appeared to have benefited both males and females.

Further to this argument, D'Amico et al. (1995) found that, although females benefited from learning in groups of any size, groups larger than pairs were detrimental to males' learning. Further, Lansford and Parker (1999), in a study of same-sex triads of third through to fifth grade students, identified a subset of males who they characterised as more aggressive and as exchanging less information among group members.

In Dreyden and Gallagher's (1989) study of gender differences on the mathematics section of the UK's Standard Assessment Tests (SAT), a work-rate difference among gender, was identified. They found that, with no time limit on tasks, the sex difference was insignificant suggesting that time limiting on tasks affected boys and girls differently. Karp and Shakeshaft (1997) also suggested that reducing the emphasis on speediness was one way to make mathematics more girl-friendly.

Past studies have indicated that males and females have different perceptions of their classroom learning environment (Henderson & Fisher, 2008; Majeed et al., 2002; Wong & Fraser, 1995). For example, Kim et al.'s (2000) study involving 543 Korean science students' attitudes towards science and the use of the WIHIC and QTI revealed that males perceived their learning environments and interpersonal behaviour more favourably than females. In 2004, Wahyudi and Treagust explored sex differences in students' perceptions of their classroom learning environment and found that female students generally held slightly more positive perceptions of both actual and preferred learning environments than their male counterparts.

Telli, den Brok, Tekkaya and Cakiroglu (2009) explored the effects of grade level and sex on students' perceptions of their learning environment in classes in Turkey with 1474 high school using the WIHIC. Their results indicated that females scored significantly higher than males on three out of seven scales. Females perceived their classrooms as more task oriented, with greater teacher support and equity than the males did.

Using a sample of 13,000 students from urban elementary, middle and high school students in the US, Waxman and Huang (1998) reported that female students generally had more favourable perceptions of their classroom learning environment than male students. In a study in Taiwan, Huang (2003) investigated whether school, subject and several academic background variables varied with sex in middle school students. The results of this study supported previous findings that reported that females perceived their classroom learning environments more positively than males did (den Brok, Fisher, Rickards & Bull, 2006; Goh & Fraser, 1998; Kaya, Ozay & Sezek, 2008).

Sex differences in student perceptions of their learning environment have been reported by various researchers. The picture portrayed by past research is that female students, in general, perceive a more positive classroom environment than male students. For example, Henderson, Fisher and Fraser (2000) reported that females perceived greater levels of student cohesiveness, integration, task orientation, involvement and a more favourable material environment than did their male counterparts. A study by Aldridge and Fraser (2008) indicated that female students perceived a more positive classroom environment than male students in terms of student cohesiveness, cooperation, equity and young adult ethos. Margianti, Fraser, and Aldridge (2004) investigated male and female perceptions of the actual classroom learning environment in computing courses and reported that female students had significantly higher perceptions than male students on three scales, namely, Order and Organization, Task Orientation, and Cooperation. In 2002, Raaflaub and Fraser found that female students perceived greater levels of teacher support, cooperation, and equity than their male counterparts.

However, despite all of this research related to gender issues, there is a dearth of literature that examines whether students' exposure to multimedia in mathematics classes is differentially effective for male and female students. Little is known about the impact of exposure to multimedia on students' perceptions of the environment and their engagement. This study is, therefore, distinct in that it filled this gap in the literature.

2.6   Chapter Summary

My study sought to examine whether students' exposed to multimedia in mathematics classes had more favourable perceptions of the learning environment and a greater sense of engagement in mathematics when compared to students in classes that were not exposed to multimedia. This study also investigated whether exposure to multimedia was differentially effective for male and female students in terms of their perception of the learning environment. Finally, for those students who were exposed to multimedia, the study investigated whether linear relationships existed between their perceptions of the learning environment and their engagement in mathematics.

Bearing in mind the foci of my research, this chapter reviewed the literature relevant to multimedia and classroom learning, the field of learning environments, engagement (motivation and self-regulation) and gender issues in mathematics. In brief, Section 2.2 defined multimedia as the coordinated combination of hypertext and at least one other media format that is used simultaneously (including audio,

video, images, animations, data and diagrams) in an educational setting to assist in creating mental models that promote and engage students in the learning process.

This section outlined the possible advantages of using multimedia in classrooms. By incorporating multimedia in their instruction, teachers have the potential to capture students' attention, engage learners, explain difficult concepts and inspire creativity. Multimedia gives teachers the means to provide differentiated instruction to students with varying abilities, giving teachers the potential to meet the needs of all students. A major benefit of the use of multimedia in mathematics is the high degree of interactivity between the student and the concepts, as well as the practical application of the skills learned. Another benefit of using multimedia is its potential for students to extend their experiences and to have immediate feedback provided through their explorations and results. Multimedia provides the ability for students to work at their own pace, making it easier for teachers to individualise the needs of specific students and to implement individual educational programmes. Multimedia also offers opportunities for problem solving in collaborative groups and the comparison of results, both of which assist students in the development of communication and team skills.

Many studies have reported that the use of multimedia in the classroom promotes positive outcomes (Dorman & Fraser, 2009; Lajoie, 1993; Lee, Brescia & Kissinger, 2009; Muir-Herzig, 2004; Passey, et. al., 2003; Snyder & Vaughan, 1998). Although multimedia can stimulate/arouse students' interest and engagement (Owens, 2005), there would appear to be a dearth of research related to the effect and impact of exposure to multimedia on students' engagement in school work particularly in

mathematics classes in Western Australia. Therefore, this study sought to fill this research gap by investigating whether exposing students to multimedia in mathematics classes improved students' active learning engagement.

Given that the present study drew on and extended the field of learning environments, Section 2.3 provided a brief history of the field and related research that have been conducted within the field. The term learning environment (used interchangeably with classroom environment) refers to the psychosocial climate of the classroom. The history of learning environments research has its origins in the social sciences. According to Kurt Lewin (1936), all behaviour and experiences are a function of the person and his/her environment and that every kind of behaviour is dependent upon the psychological field. Lewin proposed the formula, B = f (P, E) where behaviour (B) is a function of both the person (P) and the environment (E). In 1938, Murray extended Lewin's theory with his needs-press model and later applied and differentiated the concepts of *alpha press* and *beta press*. Stern, Stein, and Bloom, (1956) further discriminated *beta press* into private *beta press* and consensual *beta press.* Walberg and Anderson (1968) developed the Learning Environment Inventory. Independently, but at around the same time, Moos (1979) developed the Classroom Environment Scale and, later, developed a scheme for classifying human environments which involved three categories or dimensions, these being, relationship, personal development and system maintenance and change.

From its genesis in the United States, the field of learning environments research spread to Australia, The Netherlands, and later to Asia and the US. A striking feature of the field of learning environments is the availability of a variety of economical,

valid and widely-applicable questionnaires. These questionnaires have been used at different educational levels and in different countries. A brief description of nine historically-significant and contemporary instruments is provided for: Learning Environments Inventory; Classroom Environment Scale; Individualised Classroom Environment Questionnaire; My Class Inventory; College and University Classroom Environment Inventory; Questionnaire on Teacher Interaction; Science Laboratory Environment Inventory; Constructivist Learning Environment Survey and What Is Happening In this Class questionnaire.

Section 2.3.3 goes on to provide a review of past learning environment research related to the three lines of research that were pertinent to my study, these being; associations between the learning environment and student outcomes; the use of environment dimensions as criterion variables in the evaluation of educational innovations; and the combined use of quantitative and qualitative research methods.

Given that the major focus of this study was to examine whether students' exposure to multimedia impacted student engagement, Section 2.4 reviewed literature related to student engagement. Research indicates that students' successful learning engagement in mathematics is primarily determined by their level of motivation and self-regulation in mathematics learning. Four components of engagement that have been consistently associated to students' adaptive (characteristics that promote students' engagement in learning) motivated and adaptive self-regulated beliefs are learning goal orientation, task value, self-efficacy and self-regulation. Literature related to each of these components are reviewed below.

Section 2.4 concludes with a review of past instruments that have been used to assess students' engagement (motivation and self-regulation). A brief description of past instruments that were used to assess motivation and self-regulation is provided, these being, Science Motivation Questionnaire, Students' Motivation Towards Science Learning, Academic Motivation Scale, Learning and Study Strategies Inventory, Motivated Strategies for Learning Questionnaire and Students' Adaptive Learning Engagement in Science questionnaire.

Because my study investigated whether exposure to multimedia was differentially effective for male and female students in mathematics, a review of literature on gender differences concluded Chapter 2. My review indicated that a gender gap in mathematics still exists. Past research suggests that girls begin to develop negative perceptions towards mathematics at the age of nine. Although nonsignificant at this age, gender differences became more marked during secondary school. Past research has found that females are less likely to pursue careers in mathematics and that the educational process could be a factor that influences women's career choices. Other factors that have been found to influence females include the lower self-confidence of goals, the use of competitive learning strategies, work rate (during which girls were less likely to succeed on tasks with time limits) and the value they placed on the utility of mathematics.

In conclusion, this literature review highlighted existing gaps in extant research and established the significance of the present study in bridging these gaps. The next chapter presents the research methodology that has been employed in this study.

CHAPTER 3

RESEARCH METHODS

3.1   Introduction

Whereas the previous chapter reviewed literature pertinent to the present study, this chapter describes and reports the research methods used in this study. The research methods are presented using the following headings:

- Research objectives (Section 3.2);

- Design of the study (Section 3.3);

- Sample (Section 3.4);

- Data collection (Section 3.5);

- Data analyses (Section 3.6);

- Ethical consideration (Section 3.7); and

- Chapter summary (Section 3.8).

3.2   Research Objectives

The specific research questions, introduced in Chapter 1, are reiterated below:

Research Objective # 1

   To investigate whether the instrument used to assess students' perceptions

   of the learning environment and self-reports of adaptive learning

engagement in mathematics were valid and reliable for use in a school located in regional Western Australia.

Research Objective # 2

To examine whether differences exist for students who are frequently exposed to multimedia in mathematics classes and those who are not (in terms of perceptions of the learning environment and engagement in mathematics) and, if so, investigate why.

Research Objective # 3

To examine whether differences exist for male and female students who were frequently exposed to multimedia in mathematics classes in terms of: a) perceptions of the learning environment; and b) engagement in mathematics.

Research Objective # 4

To examine whether exposure to multimedia in mathematics classes was differentially effective for male and female students in terms of: a) perceptions of the learning environment; and b) student engagement in mathematics.

Research Objective # 5

To investigate whether, for students who were frequently exposed to multimedia, there was a relationship between students' perceptions of the learning environment and their engagement in mathematics.

3.3   Design of the Study

There has been continuing debate, since the late 1960s, about the relative attributes of qualitative and quantitative research approaches. Depending on the research problem, either quantitative methods, qualitative methods or a combination of both has been used (Creswell, 2008).

There has been concern as to whether combining of approaches brings into question the 'compatibility' between the worldviews and the method used (Tashakkori & Teddlie, 1998). Those who argue for 'incompatibility' conclude that mixing methods is untenable because a single worldview does not exist for the enquiry. However, the view of pragmatists holds that, philosophically, it is important to use procedures that 'work' for the research problem under study and that it may be advantageous to use more than one method to thoroughly understand a research problem (Tashakkori & Teddlie, 1998). Creswell, Goodchild and Turner (1996) and Walker and Evers (1988) assert that the idea of worldview is mistaken and incoherent, thus opening the possibility for using mixed-methods without substantial concern for philosophical underpinnings. However, Greene and Caracelli (1997) recommend that researchers report the worldviews that they hold while collecting both quantitative and

qualitative data – thus honouring worldviews as important but encouraging researchers to collect both types of data.

Given that qualitative and quantitative methods of inquiry each address particular questions and not others (Nolan & Short, 1985); the view of the pragmatist has been to collect data suited to the particular question that is to be answered. Modern educational research techniques encourage the use of a wide range of data types and analysis methods in order to more clearly understand the dynamics and impact of the situation being studied (Fraser, 2012). Today, one of the more powerful trends in educational research is to combine qualitative and quantitative research methods to obtain a clearer picture of the data and those subjects involved in the study (Fraser & Tobin, 1991; Tobin & Fraser, 1998).

In my research, I used a mixed-method approach to enable me to address the research objectives more effectively. In this study, it was felt that the use of both quantitative and qualitative methods, in combination, would provide a better understanding (than either method would have by itself) of the effect of exposing students to multimedia environments and the impact this had on their engagement in mathematics.

Creswell and Plano Clark (2007) refer to the mixed-method approach as a procedure for collecting, analysing, and 'mixing' both quantitative and qualitative methods in a single study to better understand a research problem. Creswell (2008) identified four types of mixed method designs, namely: the triangulation design (the simultaneous collection and merging of equally weighted quantitative and qualitative data to understand a research problem); the embedded design (the collection of quantitative

and qualitative data simultaneously with one form of data playing a supportive role to the other form of data); the exploratory design (the collection of qualitative data first then collecting quantitative data second in order to generalise the findings); and the explanatory design (the collecting and analysing of quantitative data and then qualitative data sequentially).

The present study involved an explanatory design that involved two phases. An explanatory mixed-method design consists of first collecting and analysing quantitative data and then collecting and analysing qualitative data sequentially. The qualitative data (which followed the collection and analysis of the quantitative data) was used to help to explain or elaborate on the quantitative results. By using an explanatory mixed-method approach (with quantitative data being collected first and analysed before gathering qualitative data) I was able to explain and elaborate on the quantitative results (as described by Creswell & Plano Clark, 2007).

My study was driven by a post-positivistic view - a belief that there is reality to be 'captured' and that this reality can never be fully understood but can only be approximated (Lovat & Smith, 1991). A post-positivistic view relies on multiple methods of research in order to 'capture' as much as possible the reality surrounding a phenomenon. As such, this method and, in particular, this study involved moving between different paradigms.

The theoretical drive for the first phase, involving the collection of data using surveys, was deductive with a positivist worldview (Lovat & Smith, 1991). Priority was given to the gathering and analysis of quantitative data using quantitative

research methods. The purpose of the first phase was to provide a global picture of the differences, if any, in students' perceptions of their learning environment and engagement in mathematics for students in classes exposed to multimedia (when compared to those who were not) as well as to provide the study with a snap shot of whether relationships exist between the learning environment and engagement.

In contrast, the second phase, which involved the collection of data using observations and interviews, was inductive, drawing on interpretivist and constructivist worldviews (Morse, 2003). In the second phase, the quantitative results obtained during the first phase were used as a springboard for the collection of qualitative data. This second phase sought to 'capture' and elaborate on the quantitative findings and, as much as possible, provide causal explanations. Essentially, the quantitative data served to provide the study with a general picture of the learning environment and, the second phase, served to provide more in-depth insights and causal explanations for the general quantitative results.

This general method of combining research methods has been used successfully in previous learning environment research. For example, Aldridge, Fraser and Huang (1999) used multiple research methods, including interviews, to investigate the environment in Taiwanese and Australian schools. Other studies that reflect this change towards a multiple-method approach include studies by Allen and Fraser (2007), Dorman, Fraser and McRobbie (1994) and Maor and Fraser (1996).

An overview of the mixed method design used in my study is provided in Figure 3.1. The diagram shows that data, collected used pre-established questionnaires from a

sample of 365 students in 16 classes, was analysed to provide information regarding the reliability and validity of the questionnaires, similarities and differences and relationships between students' perceptions of their learning environment and their engagement in mathematics classes. These results and interpretations were then used to guide the collection of qualitative data in order to provide more in-depth information about the results. The results from phase 1 and phase 2 of this study were merged to answer the research objectives. The sample and research methods for each of the two phases are described below.

Research Program
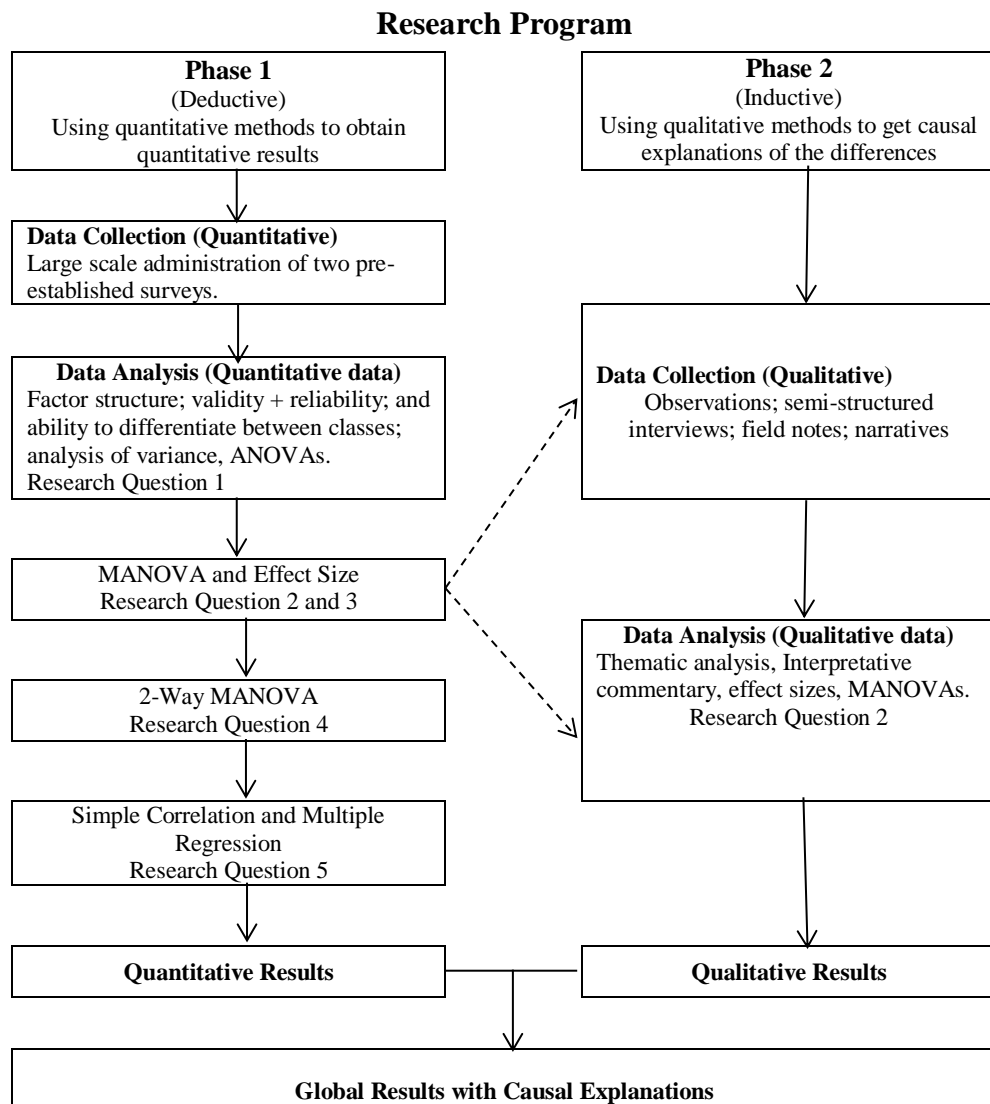
Figure 3.1   Illustrative overview of the Design of the Study

3.4   Sample

This section describes the sample and its selection used for the present study, with respect to: the school site (Section 3.4.1); the quantitative sample (Section 3.4.2); and the qualitative sample (Section 3.4.3.

3.4.1   School Site

The site selected for the present study was a 30-year old regional senior high school (catering for Years 8 to 12) located in the Great Southern Region of Western Australia. This site was selected for my research as I was a teaching member of the staff and, as such, I was keen to improve student engagement in my classes. As a staff member, selecting this research site also provided access to those participants who had volunteered to be involved in the study (both in and outside of their classrooms) over a period. Being a staff member at the school also provided opportunities for prolonged engagement for the collection of qualitative data. My role at the school and the possible power-relationships involved and how these were overcome are described later in Section 3.7.

This particular school was also considered a suitable site because, as described in Chapter 1, it has a unique ICT infrastructure that allows the integration of ICT into the delivery of programs to facilitate a true multimedia learning environment. Since this school had recently taken a lead over other schools within the district in the introduction of e-learning, with video conferencing support, in an effort to make the

teaching-learning process more effective, this site was considered ideal for the purpose of this study.

At the school, all mathematics classes were streamed according to student ability. Year 8 students (first year high school) were streamed according to their Year 7 National Assessment Programme–Literacy and Numeracy results. Year 9 and 10 mathematics classes were streamed according to the overall student's performance in Year 8 and the Year 9 National Assessment Programme – Literacy and Numeracy results, respectively. The purpose of the streaming in Years 9 and 10 was to differentiate between those students who were destined for job-related courses after Year 12 and those who intended to go on to study mathematics at university level.

The upper school classes (Years 11 and 12) catered for mathematics courses that ranged from foundations in mathematics (for those students enrolled in job-related courses) to specialist mathematics (for students classed as gifted and talented). Because of the low enrolment numbers in senior school mathematics courses, the classes for the different mathematics courses were often combined to form classes with approximately 20 to 30 students. As a result, all mathematics classes in the upper school included both Year 11 and 12 students. All of the mathematics classes at this school participated in the study.

3.4.2   *Student Sample for Quantitative Data Collection*

At the time of data collection, the school had a population of approximately 430 students enrolled in Years 8 to 12. To increase the internal validity of my findings,

the study involved the entire school population, as this would represent the opinions of the whole school. Intact groups of students (that is, whole classes rather than a sample population of each group) were used, providing a sample of 365 students (191 of whom were males and 174 of whom were females), in 16 mathematics classes. The students' ages ranged from 11 to 17 years. Only those students whose parents had provided consent for them to be involved in the study were included in the study. Those students who were absent on the days that the data were collected were not included.

Each student at the school was entitled to four class hours of mathematics instruction per week. Of the 16 mathematics classes, nine of the classes had an interactive whiteboard in their classrooms and/or more than two class hours of mathematics instruction in the computer laboratory. These classes (n=197 students) were considered to be frequently exposed to multimedia. The remaining seven classes did not have interactive whiteboards or computers in their classrooms and had less than two periods in the computer laboratory each week. These classes were considered not to be frequently exposed to a multimedia learning environment. Using this criteria, a sample of nine mathematics classes that were frequently exposed to multimedia (n=197 students, 107 of whom were males and 90 of whom were females) and seven classes that were considered not to be frequently exposed to multimedia (n=168 students, 84 of whom were males and 84 of whom were females) was used. Table 3.1 provides an overview of this sample.

All six of the mathematics teachers who were teaching at the school at the time of this study, agreed to have the surveys administered to the students in their

classrooms. In all cases, the teachers who taught students in classes that were frequently exposed to multimedia also taught the students who were in classes that were not frequently exposed to multimedia.

Table 3.1   Overview of the Quantitative Sample

Sex	Number of Students		
	Frequently Exposed to Multimedia	Infrequently Exposed to Multimedia	Total
Male	107 (29%)	84 (23%)	191 (52%)
Female	90 (25%)	84 (23%)	174 (48%)
Total	197 (54%)	168 (46%)	365 (100%)

3.4.3   Qualitative Sample

The qualitative data were gathered using classroom observations and interviews with teachers and students (described in Section 3.5.3). This section describes the sample for each.

Of the six mathematics teachers at the school (all of whom allowed administration of the surveys to students in their class) three of them were willing to have their classes observed. Two classroom observations per week (all of which were carried out during 60 minute lessons) were made over a six-week period. To allow meaningful comparisons, each week, one pair of classes, from the same grade level and taught by the same teacher was selected. Therefore, each pair of classes (observed in one week) were selected to be comparative in terms of year level, number of males and females and student ability and, importantly, both classes were taught by the same teacher. This provided a total of 12 classroom observations, of which 4 observations were made in the classes of each of the three teachers (two of which were frequently

exposed to multimedia and two which were not). Over the six-week period classes from each grade level were observed.

Ten students (five males and five females), based on their willingness, participated in the interviews. The students were all selected from year 10 classes to provide a cohort that was likely to be, generally, representative of both junior and senior students. To ensure that the views of both groups were represented, six students were selected from classes that were frequently exposed to multimedia (three male and three female students) and four students were selected from classes that were not frequently exposed to multimedia (two males and two females).

The three mathematics teachers, all of whom expressed a willingness for me to observe their classes, were also prepared to be interviewed and were included in the sample. All three of the teachers had more than ten years of teaching experience.

3.5   Data Collection

This section details the data collection methods used in the present study. Section 3.5.1 describes the surveys used to collect the quantitative data and Section 3.5.2 describes the methods used to gather the qualitative information.

3.5.1   Instruments

Two surveys were used to collect the quantitative data in this study, one to assess students' perceptions of the learning environment and the other to assess students'

sense of engagement (motivation and self-regulation) in mathematics lessons. A number of considerations were made with respect to deciding on the most appropriate instruments. First, a review of literature, described in Chapter 2, was carried out to ensure that the instruments were suitable and had been shown to be reliable and valid in past studies. Second, scales and individual items were scrutinised to ensure that the wording was suitable or could be adapted for use in mathematics classes. After reviewing a number of instruments, the What Is Happening in This Class? (WIHIC) questionnaire (described in Section 3.5.1.1) was selected to assess students' perceptions of the learning environment and the Students' Adaptive Learning Engagement in Science (SALES) questionnaire (described in Section 3.5.1.2) was used to assess students' engagement (motivation and self-regulation) in mathematics classrooms. Each of these is described below.

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

The What Is Happening In This Class? (WIHIC) questionnaire was developed by Fraser, Fisher and McRobbie (1996) to bring parsimony to the field of learning environments by combining the most salient scales from existing questionnaires with new dimensions of contemporary relevance. The original 90-item nine-scale version was refined by both statistical analyses of data from 355 junior high school science students and extensive interviewing of students about their views of their classroom environments in general, the wording and salience of individual items and their questionnaire responses (Fraser et al., 1996). The present study involved a more recent version of the WIHIC that had been further refined by Aldridge, Fraser and Huang (1999), which had 56 items in seven scales.

In addition to its relevance to the present study, the WIHIC was also selected because of its validity and reliability when used with secondary school students. Numerous studies around the world have found this questionnaire to be valid and reliable (Aldridge & Fraser, 2000; Allen & Fraser, 2007; Lightburn & Fraser, 2002; Margianti, Aldridge, & Fraser, 2004; Riah & Fraser, 1998; Pickett & Fraser, 2009). In particular, the WIHIC has been found to be reliable when used with high school students in Australia in a range of studies, with samples of: 355 junior high school science students (Fraser et al, 1996); 1433 students (Dorman, 2003); 1404 students in 81 senior high schools (Zandvliet & Fraser, 2004, 2005); 1081 junior high school students in 50 science classes (Aldridge & Fraser, 2000; Aldridge, Fraser & Huang, 1999); 978 students (Dorman, 2008), and more recently 1360 students in 78 science classes in Western Australia (Velayutham, Aldridge & Fraser, 2013).

In addition to the Australian studies, discussed above, the validity and reliability for the original, modified, and/or translated versions of the WIHIC have been established in other countries, including, Indonesia, which involved 422 students enrolled in 12 university level classes (Soerjaningsih, Fraser, & Aldridge, 2001); Singapore, with 250 adult learners in 23 computer classes (Khoo & Fraser, 2008); Brunei, with 644 Year 10 Chemistry students (Riah & Fraser, 1998); California, with 1720 mathematics students (Rickards, den Brok & Fisher, 2005); Korea, with 543 Year 8 students in 12 schools (Kim et al., 2000); and South Africa, with 2638 Year 8 science students (Aldridge, Laugksch, Seopa & Fraser, 2006).

These studies, particularly those carried out in Australia provide strong support for the reliability and validity of the WIHIC. Given this overwhelming evidence for the validity of the WIHIC, it was considered suitable for the present study. The following paragraphs provide the basis for choosing the WIHIC scales to measure students' perceptions of their multimedia psychosocial learning environment.

Student Cohesiveness was selected because it was felt that social acceptance by peers and the need to have friends are integral facets of the learning environment that can have an effect on students' learning. According to Aldridge, Fraser, Bell and Dorman (2012), students are more likely to do well in their learning if they do not experience harassment or prejudice from their peers. A cohesive learning environment also helps students to feel that they are accepted and supported by their peers and allows them to make mistakes without running the risk of being ridiculed.

Teacher Support was selected because the teachers' relationship with students was considered to be a critical aspect of any learning environment that could determine whether the students were inspired or turned away from learning the subject. When the students consider the teacher to be approachable and interested in them, they are more likely to seek the teacher's help if there is a problem with their work. Hijzen, Boekaerts and Vedder (2007) emphasised that the teacher's supportive role is a pivotal key in determining the student's learning.

Involvement was selected to assess the extent to which the students had attentive interest, participated in discussions, did additional work and enjoyed the class. Taylor and Campbell-Williams (1993) argue that a key factor in students' learning

process is participation in classroom discussions and the negotiation of ideas and understandings with peers. Students should be encouraged to think of learning as an active process on their part, involving a conscious intention to make sense of new ideas or experiences and improve their own knowledge and capabilities, rather than simply to reproduce or remember concepts (Velayutham et al, 2013).

Task Orientation was considered to be important because, according to Spady (1994), students need to have goals, both short-term and long-term. If the goals or learning objectives are clear and meaningful, then the students are more likely to be engaged in their learning. In addition, to ensure students optimise their time-on-task, Aldridge et. al (2012) states that the teacher has to demonstrate clear expectations and provide frequent feedback and reinforcement. It was necessary to check whether a multimedia learning environment provided these attributes.

Cooperation was selected because the extent to which students cooperated rather than competed with one another on learning tasks in a multimedia learning environment was considered to be important. According to Johnson, Johnson and Smith (2007) and Tan, Sharan and Lee (2007), in a collaborative learning environment, the students work together to find solutions to given problems. A cooperative learning environment, therefore, would ensure students relate positively to each other and learn from each other.

Equity was incorporated into the study to assess the extent to which students perceive that the teacher treats them in a way that encourages and includes them as frequently as their peers in a multimedia learning environment. This scale gives an indication of

whether students perceive that they are treated fairly or unfairly by their teacher. Dorman, Aldridge and Fraser (2006) contended that this element of the learning environment was important because it would ensure that the teacher provided equal and unbiased opportunities for all the students in the class.

The Investigation scale although included in the original WIHIC, was not selected for use in the present study. This scale assesses the extent to which skills and processes of inquiry and their use in investigations are emphasised in the learning environment. Close scrutiny of individual items, indicated that this scale, was not appropriate for this study as there were few, if any, investigations carried out in mathematics classes. As a result, this scale was omitted.

Based on the above discussions on the important contributions of each scale in the WIHIC towards the conception of the multimedia psychosocial learning environment, six of the seven scales (Student Cohesiveness, Teacher Support, Involvement, Task Orientation, Cooperation and Equity) were included in the present study. Each of the scales had eight items.

There are two forms of the WIHIC questionnaire - a class form and a personal form. The class form seeks to obtain the perceptions of the whole class, whereas the personal form focuses on the student's perception of their own role within that classroom environment (Fraser, Giddings & McRobbie, 1995). The present study used the personal form for three reasons. First, the personal form provides a conventional way whereby students, as individuals, are invited to be the 'eyes' and to report on the general 'health' of the environment from an individual perspective.

Second, the personal form was suitable for this study as the students were required to respond to items which would elicit their personal role within the classroom, as it would not have been in the case of the class form (Fraser, Giddings & McRobbie, 1995; Fraser, McRobbie & Fisher, 1996). Finally, because this study examined male and female groups of students, the personal form solicited each individual student's role, thereby facilitating differentiation between male and female roles within that classroom environment (Fraser, Giddings & McRobbie, 1995). Table 3.3 provides, for each scale, a description and a sample item.

The items of the WIHIC were considered to be non-threatening to the students. The questionnaire did not require them to provide their identity and the items did not directly assess performance, personality or character. Students' responses were recorded on the questionnaire itself to avoid errors that could arise in transferring the responses to a separate answer sheet. The items were arranged in cyclic order, in blocks of six (the number of scales contained in the questionnaire) to avoid passive responses. For each block, the first item assessed Student Cohesiveness, the second item assessed Teacher Support, the third item assessed Involvement, the fourth item assessed Task Orientation, the fifth item assessed Cooperation and the sixth item assessed Equity.

The items of the WIHIC were arranged in a cyclic order to guard against passive responses. Each item was responded to using a five-point frequency-response format of Almost Always, Often, Sometimes, Seldom and Almost Never, that required respondents to indicate how often the statement occurred. A copy of the modified WIHIC that was used in my study can be found in Appendix A.

Table 3.2   Description, Sample Items and Moos Classification for Each WIHIC Scale.

Scale Name	Scale Description	Sample item	Moos' scheme
Student Cohesiveness	The extent to which student know, help and are supportive of one another.	I know other students in this class.	R
Teacher Support	The extent to which the teacher helps, befriends trusts and is interested in students.	The teacher goes out of his/her way to help me.	R
Involvement	The extent to which students have attentive interest, participate in discussions, do additional work and enjoy the class.	I explain my ideas to other students.	R
Task Orientation	The extent to which it is important to complete activities planned and stays on the subject matter.	I know what I am trying to accomplish in this class.	P
Cooperation	The extent to which students cooperate rather than compete with one another on learning tasks.	I work with other students in this class.	P
Equity	The extent to which students are treated equally by the teacher.	I am treated the same as other students in this class.	S

Note. R = Relationship, P = Personal Development, S = System Maintenance and System Change.
Response alternatives: Almost Never, Seldom, Sometimes, Often and Almost Always
Source: Aldridge, Fraser & Huang (1999), with permission.

3.5.1.2 *Students' Adaptive Learning Engagement in Mathematics (SALEM)*

To assess students' engagement (motivation and self-regulation) in mathematics learning, the Students' Adaptive Learning Engagement in Science (SALES) questionnaire (developed by Velayutham, Aldridge and Fraser, 2011) was modified for use in mathematics classes. The SALES questionnaire consists of four scales with eight items in each scale, namely, Learning Goal Orientation, Task Value, Self-Efficacy and Self-Regulation.

The SALES was validated using a sample of 1360 Western Australian students from 78 science classes across Grade 8, 9 and 10 (Velayutham, Aldridge & Fraser, 2011, 2013). In their study, the eigenvalue for all factors were greater than 1, ranging from 1.44 to 15.01 whilst the cumulative variance for all four factors was high at 63.2%. All of the items were retained as they loaded above 0.50 on their respective factors and did not load on any other factor. The Cronbach alpha coefficient for each scale was above 0.90, hence attesting a high reliability of the constructs. The factor loadings and internal consistency measures confirmed the reliability and validity of the questionnaire. The component correlation matrix obtained from oblique rotation showed that the requirement of discriminant validity was also met. Each scale in the SALES survey differentiated significantly between classes.

This questionnaire was selected because, in addition to the strong support for reliability and validity when used with high school students in Western Australia, it can be easily understood and completed by secondary school students. To adapt the SALES to suit mathematics classes, the term 'science' was replaced with the term 'mathematics' throughout. For example, a statement that read "In this science class, one of my goals is to learn new science content." was changed to "In this mathematics class, one of my goals is to learn new mathematics content." The structure, design and format of the original SALES were kept; but this new version was referred to as the Students' Adaptive Learning Engagement in Mathematics (SALEM).

The four SALEM scales (Learning Goal Orientation, Task Value, Self-Efficacy and Self-Regulation) each had eight items that were responded to using a five-point Likert-type scale ranging from Strongly Agree to Strongly Disagree. As with the WIHIC, the items of the SALEM were arranged in cyclic order to guard against passive responses. For each SALEM scale, Table 3.3 provides a description and a sample item. A copy of the SALEM used in the present study can be found in Appendix B

Table 3.3   Descriptions and Sample Items for Each Scale of the SALEM

Scale Name	Scale Description	Sample item
Learning goal Orientation	The drive/desire to develop skills and competences by mastering tasks.	One of my goals is to master new mathematics skills.
Task Value	The extent to which students value the tasks given to them.	What I learn can be used in my daily life.
Self-Efficacy	The beliefs/judgements students hold about their capabilities to perform a task.	I can figure out how to do difficult work.
Self-Regulation	The degree to which students meta-cognitively, and motivationally participate in their own learning.	I keep working until I finish what I am supposed to do.

Both the WIHIC and SALEM were administered to classes during a single mathematics lesson. To allow time for a stable learning environment to be established, the surveys were administered during the second term of the school year. Classroom teachers, with support from the researcher, administered the surveys. The researcher was present throughout administration to assist students with queries or reading difficulties. The questionnaires took approximately 25 minutes to complete.

3.5.2 Gathering Qualitative Information

Whereas Section 3.5.1 reported the collection of data using quantitative methods, this section reports the methods used to gather qualitative information, including observations (Section 3.5.2.1), narratives (Section 3.5.2.2) and interviews (Section 3.5.2.3).

3.5.2.1 Observation

Creswell (2008) defined observation as the process of gathering open-ended, first hand, information by observing research participants. Observing in a school setting, as was the case here, requires good listening skills and careful attention to visual detail (Hammersley & Atkinson, 1995). The purpose of my observations was to look for reasons and explanations to the quantitative results.

Observations were considered to be a suitable form of data collection for the present study as it allowed me to examine the behaviours of the students in the two groups. As a member of the teaching staff at the research site, I had unlimited access to the participants and observed the students over a prolonged period.

Although, in the literature, there are many observational roles that researchers can choose from, the three popular ones are participant observer, non-participant observer and changing observational roles. Given that my role changed, depending on the observation that I was making, the third option, changing observation roles, was considered to be most appropriate. No one role was considered to be suitable for

all of the situations that I encountered and, as a result, it changed depending on both my rapport with the participants (both teachers and students) and how I could best understand and answer the research objective.

The purpose of changing observational roles throughout the period of this study was to enable me to be subjectively involved in the setting as well as to view the setting objectively. For those observations that I made during the course of my day-to-day teaching activities at the site, I assumed the role of participant observer and used field notes to record my observations. This offered the study opportunities to view the experiences of the participants as the teacher. During these observations I recorded the interactions (between students and between students and myself) and recorded comments related to how much interest students had in their mathematics classes.

During my more formal observations (carried out twice a week for six weeks), I assumed a non-participatory observer role. For these observations (which generally lasted 60 minutes), I sat at the back of the classroom and observed the lesson. I used field notes to record my observations during the lesson, which included the teaching style, interactions between the teacher and students, peer-to-peer interactions and the accomplishment of tasks by the students.

3.5.2.2 Narratives

To portray what was happening in the classroom, it was considered appropriate to represent my observations through narrative stories (Denzin & Lincoln, 1994;

Clandinin & Connelly, 2000). Narratives provided a means by which I could reflect and represent the observations that I had made over a period of time rather than just one lesson. As a researcher-participant in this study with room to 'see' students' views of their daily experiences from their own perspective, the stories were particularly useful for representing knowledge and understanding of the learning environment at this school.

Clandinin and Connelly (2000) define narrative study as the study of the ways in which humans experience the world around them. Clandinin and Connelly (2000) view education and educational research as the construction and reconstruction of personal and social stories; learners, teachers, and researchers are story tellers and characters in their own and other's stories.

During the writing of the narratives, I was aware of the need to represent research participants in a socially-honest manner. However, despite the desire to engage in egalitarian research, there was a contradiction in the power relationship, between the subjects and I that posed a risk of betrayal and manipulation (Stacey, 1988). To address any issues of representation and legitimisation, any quotations that were included in the narrative stories were, in fact, spoken by the people portrayed. It is acknowledged, also, that the narratives and subsequent commentaries are my interpretation of the situation, experiences and interviews. I also attempted to represent those who were studied and their classroom environment using verisimilitude (i.e., to resemble truth or reality) and asked members of the groups involved to read the stories to verify the authenticity of each.

Following the approach recommended by Clandinin and Connelly (2000) and used in other learning environment studies (see for example, Aldridge et al., 1999, 2009), qualitative data as reflected in narrative stories were interpreted using the method of constant comparison (Kolb, 2012) provided in an interpretative commentary.

3.5.2.3   Interviews

Interviews with students and teachers were used, in conjunction with other data collection methods, to provide explanations of the quantitative results so that meaningful interpretations could be made (Cohen, Manion & Morrison, 2000). Interviews were also used to follow-up unexpected observations and to probe into the reasons behind the teachers' and students' responses to the surveys (Kerlinger, 1986). Interviews with teachers were used to examine whether they supported the views of their students and why they did so.

In-depth semi structured interviews were carried out with the students and the teachers. Focus and attention was given to listening and understanding what was said. In line with Gaskell's (2000) recommendation, respondents were given enough time to think and pauses were not unnecessarily filled with further questions. Based on suggestions by Patton (1990), an interview guide was developed to guide the process. Open-ended interview questions, largely based on survey items included in the different scales of WIHIC and SALEM (to which the students had earlier responded), were used to guide the interviews. The last questions on the interview protocol were used to solicit other views that the interviewees may have wanted to say with respect to the students' learning environment and the impact it had on

student engagement in mathematics. The interview protocol used in the present study is provided in Appendix C.

All interviews were audio-taped and transcribed verbatim, after which a thematic analysis was undertaken to collate and condense the data into succinct themes. The analysis of the interview data is described in Section 3.6.

3.6   Data Analyses

As discussed earlier, the data collection was carried out in two phases. The data collected, using questionnaires, provided an economic overview of the students' perceptions of their learning environment and engagement to mathematics and was used as a starting point from where different research methods, including observations, interviews and narrative stories were used to provide more in-depth insights into the research problem. The collection of qualitative information also enabled me to examine causal explanations.

This section reports on how the data were analysed, and integrated with qualitative information in order to answer each of the research questions.

3.6.1   Research Question # 1

To answer research question 1, which investigated whether the modified What Is Happening in This Class? (WIHIC) questionnaire and the Students' Adaptive Learning Engagement in Mathematics (SALEM) questionnaire were valid and

reliable instruments for use in regional Western Australia, the data from 365 students in 16 classes was used to examine the factor structure, internal consistency reliability and capability of the questionnaires to differentiate between students in different classrooms.

To examine the factor structure of both the WIHIC and SALEM, principal axis factor analysis with varimax rotation was used. The goal of the analysis was to reduce the number of correlated variables into a small number of uncorrelated dimensions called components (Coakes & Ong, 2010). In line with Stevens' (1992) recommendation, the criteria for retaining an item was that it should have a factor loading of more than 0.40 on its *a priori* scale and less than 0.40 on any other scale. Eigenvalues were calculated to examine the relative importance of each factor and were required to have a value greater than 1, as recommended by Kaiser (1960).

To measure whether each item in a scale assessed a similar construct (internal consistency reliability), the Cronbach alpha coefficient (Cronbach, 1951) was computed with both the individual student and class mean as units of analysis. Alpha coefficients range from 0.00 to 1.00, with 0.00 indicating no reliability and 1.00 indicating a perfect reliability. While De Vellis (1991) considers a value of 0.5 to be a sufficient level for scale internal consistency for questionnaires, Cohen et al (2000) argues that a cut-off value of 0.6 is required for a good scale.

One characteristic that is desirable of a classroom environment scale is that it is capable of differentiating between the perceptions of students in different classrooms. Theoretically, students in a class should perceive their learning

environment in similar ways but differently to students' in other classes. To determine the ability of each instrument to differentiate students' perceptions of their learning environment and their engagement from other groups, a one-way analysis of variance (ANOVA) with class membership as the independent variable, was computed for each WIHIC and SALEM scale.

3.6.2   Research Question # 2

Both quantitative and qualitative data were used to examine whether and why differences existed between students who were frequently exposed to multimedia in mathematics classes and those who were not (Research Question 2). First, a multivariate analysis of variance (MANOVA) was conducted using the sample of nine classes (n=197 students) that were frequently exposed to multimedia and seven classes (n=168 students) that were not frequently exposed to multimedia. The set of six WIHIC scales (Student cohesiveness, Teacher Support, Involvement, Task Orientation, Cooperation and Equity) and four SALEM scales (Learning Goal Orientation, Task Value, Self-Efficacy and Self-Regulation) constituted the dependent variables whilst frequency of exposure to multimedia (frequently and not frequently exposed) constituted the independent variables.

The use of MANOVA, which allows several dependent variables to be analysed simultaneously, was considered preferable to a series of analysis of variance (ANOVA) tests because the MANOVA gives an indication of the overall relationship between the set of dependent variables and the independent variables. Stevens (2002) points out three statistical reasons that favour MANOVA. First, the use of a series of

univariate ANOVAs leads to an inflated overall Type 1 error rate. Second, univariate tests ignore the correlation among variables. Third, multivariate test are more powerful, especially when small differences on several of the variables combine to produce a significant result. It is possible to yield non-significant ANOVA results, even though the MANOVA results are significant.

The effect sizes were calculated to provide a measure of the strength or magnitude of the differences (in terms of the standard deviation) in students' learning environment and engagement (motivation and self-regulation) between the two groups (one frequently exposed to multimedia and the other not frequently exposed to multimedia). The effect sizes were calculated by dividing the difference between the average item mean for the two groups by the pooled standard deviation (Thompson, 1998b).

To gain deeper insights into students' perceptions of their environment and engagement in mathematics (and hence determine any causal explanations of the differences between the two groups), I took the role of *bricoleur,* as described by Denzin and Lincoln (1994), to piece together the data collected using observations and interviews with students and teachers. Based on these observations and interviews, narrative stories were written to provide a portrayal of what was happening in the classrooms of these groups. A commentary, using a method of constantly comparing (Kolb, 2012) the two narratives (one from a class infrequently exposed to multimedia and the other from a class frequently exposed to multimedia) was used to help to explain differences in students' scores in the two groups. The most poignant quotes from interviews and observations were included to support

causal explanations or refute the existence of any differences in students' perceptions of their learning environment and engagement to mathematics.

The analysis of the qualitative information was guided by the Framework Approach to Data Analysis by Pope, Ziebland and Mays (2000). The key stages involved:

1. Familiarisation: Once the interviews were transcribed and field notes entered, immersion into the raw data commenced to enable familiarisation with the information collected. A brainstorm of initial key themes was drawn to allow grouping of ideas.

2. Indexing: The interview documents and field notes were carefully re-read, common themes or philosophies were investigated (indexed) from the transcripts and field notes; individual perspectives were considered. A second and sometimes third, indexing took place to find the major points of emphasis from the responses given. Every quote that represented an experience, issue, need, conflict or strategy was highlighted and assigned a colour. Individual colours represented different themes.

3. Charting: Once all interviews and field notes were colour coded, each coloured quote was collated into individual themed documents. The most poignant quotes were included in summary charts. The completed chart then provided distilled summaries of the views, experiences and perceptions of participants.

Finally, qualitative findings were examined in light of the quantitative findings to help provide casual explanations.

3.6.3 Research Question # 3

The third research objective was to examine whether differences existed for male and female students who were frequently exposed to multimedia in mathematics classes. The sample of 197 students (in nine classes) who were in classes that were frequently exposed to multimedia (n=107 male students and 90 female students) was used to conduct a one-way multivariate analysis of variance (MANOVA). As with the previous research objective, MANOVA was consider to be preferable to a series of ANOVA (see Section 3.6.2). The set of six learning environment scales and four engagement scales constituted the dependent variables and sex (Male and Female) constituted the independent variable. To provide a measure of any differences between male and female students, effect size and F values were computed for all comparisons.

3.6.4 Research Question # 4

The fourth research objective sought to investigate whether exposure to multimedia was differentially effective for male and female students. The sample of 365 students in 16 classes was used to examine the interactions, exposure to multimedia, sex, and exposure to multimedia by sex, for each learning environment and engagement scale using a two-way multivariate analysis of variance (MANOVA). The dependent variables for the two-way MANOVA were the WIHIC and SALEM scales and the

two independent variables were exposure to multimedia (frequent and infrequent) and student sex (male and female). Because the multivariate test, using Wilks' lambda criterion, yielded significant differences for the main effects and for the interaction, the univariate analysis of variance (ANOVA) was interpreted for each scale. The eta² statistics was calculated to provide an estimate of the strength of association for each effect (exposure to multimedia, sex and the interaction) for each WIHIC and SALEM scale.

3.6.5   Research Question # 5

The fifth research objective was to investigate whether, for students who were frequently exposed to multimedia, there was a relationship between students' perceptions of their learning environment and their engagement in mathematics. The data collected from students in classes that were frequently exposed to multimedia (n=197 students in 9 classes) were used to determine whether the introduction of multimedia at this school brought with it positive relationships with respect to the students' sense of engagement in mathematics classrooms. Simple correlation (r) and multiple regression analyses (R), with both the individual and class mean as units of analysis, were used to determine whether associations existed between students' perceptions of the learning environment (Student Cohesiveness, Teacher Support, Involvement, Task Orientation, Cooperation and Equity) and Engagement (Learning Goal Orientation, Task Value, Self-efficacy and Self-Regulation) in those mathematics classes that were frequently exposed to multimedia.

Whereas simple correlation (r) analysis was used to examine the bivariate relationships between the WIHIC scales and SALEM scales, multiple regression analysis was used to provide information about the association between an engagement scale and the set of six environment scales. The standardised regression coefficients were examined to identify the specific environment scale that made a significant contribution to explaining the variance in engagement when the other environment scales were mutually controlled. Therefore the standardised regression coefficients (β) were computed to identify the environment scales which contributed uniquely and significantly to the explanation of the variance in engagement to mathematics.

3.7   Ethical Considerations

Ethics is concerned with relations and commitments to the researcher and to other people, and is inherent in every human interaction (Howitt, 2008). As a researcher, I was both ethically and legally bound to protect the participants in my research from any potential harm (be it physical, psychological, spiritual, emotional or cultural) or abuse of power as a consequence of my research. My role as a researcher was to minimise the potential risk of harm to my participants and to ensure that my participants were fully aware of how my research would affect them; specifically making my participants aware of all harm that could arise as a consequence of my research. The following sections describe the ethical protocols that were considered in the course of this study, these being: informed consent (Section 3.8.1); permission (Section 3.8.2); privacy and confidentiality (Section 3.8.3); and consideration (Section 3.8.4).

3.7.1 Information

Principals, teachers, parents/carers and students were all provided with an information sheet which stated the intended aims of the research. The information sheet was designed and structured in plain language so that they could understand, so that they could give informed consent. Before the data were collected they were informed of the potential risks and benefits and how the results would be used. Copies of the information letters to the teachers, parents/carers and students can be found in Appendix D, Appendix E and Appendix F, respectively. The research was also described verbally to students prior to data collection. All participants were informed that their participation was voluntary and we had given the opportunity to ask questions both at the start of the research and as an ongoing concern.

Participants were provided with feedback about the progress of the study, including interim results. Member checking was an ongoing exercise that allowed participants to critically reflect and make changes to their 'stories' as necessary. This included giving participants the opportunity to verify the data collected, particularly qualitative information obtained through interviews.

3.7.2 Permission

Written permissions to conduct research were obtained from the stakeholders including the Department of Education (see Appendix G) and Curtin's Human Research Ethics Committee (see Appendix H) the school principal, teachers, parents and students. After receiving the principal's consent, parents were provided with

information letters and asked to consent to their child's participation in the study. The information letter and consent form were both sent to parents via the school's monthly electronic newsletter. A copy of the information letter can be found in Appendix I.

Teachers and students were informed that they had the right to withdraw from the research at any time, without prejudice or negative consequences. Further, it was made clear that no aspect of the research would be used in determining students' grades in their mathematics courses. To ensure that individuals were not directly or indirectly coerced into participation through unequal power relationships, participants were given the opportunity to put their consent forms into a pigeon hole or to a third party, such as the class teacher if they preferred. Parents or guardians were given the opportunity and encouraged to be present at interviews, particularly for those held with younger students.

3.7.3 *Privacy and Confidentiality*

The privacy of individuals and the confidentiality of data were considered to be paramount. Privacy and confidentiality, with respect to my research, meant protecting the participants' identities so that the information did not embarrass or harm them (Bogdan & Biklen, 1998). During the course of this study I took special care to protect the privacy and confidentiality of all participants and the data obtained from them. No identifiable information was put on the questionnaires or used in the final report. Pseudonyms were used for all participants involved in the collection of qualitative data to ensure that they could not be identified. Some information was

deliberately changed to ensure anonymity. The participants were informed that the information would be used to write a doctoral thesis, and to publish various papers after completion.

The participants were informed that data would be stored for seven years on a computer that was password protected before a decision is made as to whether the data should be destroyed. Only myself and my research supervisor would have access to the data. Once transcribed, interview data were erased and raw survey data stored in a locked cabinet.

3.7.4 Consideration

Consideration was made to ensure that disruption to the participants' normal teaching-learning program was minimised. To minimise disruption to their program, interviews were held at suitably negotiated times and places. Because I was a teacher-researcher-participant at the research site, most interviews were conducted during break times with minimal or no interference to their classes. During classroom observations, the participating teachers and I agreed on what to record and how I would be introduced to the class.

3.8   Chapter Summary

This chapter described and justified the design of the study and provided details regarding the sample and methods of data collection and analysis used. The study was driven by a post-positivistic view, relying on multiple methods of research in

order to 'capture', as far as possible, classrooms that were frequently and not frequently exposed to multimedia learning environment. As such, this study involved moving between different paradigms. The study was guided by an explanatory mixed-method design that was carried out in two phases.

In the first phase, quantitative data were collected from a sample of 365 students in 16 classes. Of these classes, nine (*n*=197 students) were frequently exposed to multimedia and seven (*n*=168 students) were not. The sample of 365 students included 191 male and 174 female students. In the second phase, qualitative data were collected from a sample of 10 students. Six of these students (*n*= 3 boys and 3 girls) were in classes frequently exposed to multimedia and four of the students (*n*= 2 boys and 2 girls) were in classes not frequently exposed to multimedia.

The quantitative data were collected using two surveys, the What is Happening In this Class? (WIHIC) questionnaire (to assess students' perceptions of the learning environment) and the Student Adaptive Learning Engagement in Mathematics (SALEM) questionnaire (to assess students' engagement in mathematics). The WIHIC included 48 items, with 8 items in each of 6 scales, namely, Student Cohesiveness, Teacher Support, Involvement, Task Orientation, Cooperation, and Equity. The SALEM was adapted from the Students' Adaptive Learning Engagement in Science (SALES) and consisted of four scales (Learning Goal Orientation, Task Value, Self-efficacy and Self-regulation). The SALEM has a total of 32 items with 8 items in each scale. The response scale for the WIHIC involved a five-point frequency-response format of Almost Never, Seldom, Sometimes, Often and Almost Always Strongly Agree, Agree, Sometimes, Disagree and Strongly Disagree. For

both instruments, the items were arranged in a cyclic order to guard against passive responses.

Qualitative data were collected using observations and interviews. Formal observations were carried out over a period of six weeks, during which two classes (one frequently exposed to multimedia and one that was not) were observed. In each week the selection of classes was based on grade level and student ability (based on streaming discretion) and teacher ability to ensure that classes were as comparable as possible.

Based on their willingness to be interviewed, ten students (five males and five females) were selected from the population and participated in the interviews. Three of the six mathematics teachers at the school also were included in the qualitative sample because they expressed their willingness to be observed and interviewed.

The data collected from the 365 students in 16 classes was used to examine the reliability and validity of the modified WIHIC and SALEM questionnaires. As a first step, the principal axis factor analysis with varimax rotation was employed to determine the factor structure of each instrument. In addition, the Cronbach alpha reliability coefficient was used as an index of scale internal consistency and finally, an analysis of variance (ANOVA) with class membership as the main effect, was used to examine the ability of each scale of the modified WIHIC and SALEM to differentiate between the perceptions of students in different classrooms.

A multivariate analysis of variance (MANOVA) was used to determine whether differences existed between the perceptions of students in the nine classes (n=197 students) that were frequently exposed to multimedia and their counterparts in seven classes (n=168 students) who were not frequently exposed to multimedia. The set of six WIHIC scales and four SALEM scales constituted the dependent variables and the two independent variables were Frequent and Infrequent Exposure to Multimedia. Because the MANOVA produced statistically significant results using Wilks' lambda criterion, the univariate ANOVA results were interpreted for each of the dependent variables. The effect size, calculated by dividing the difference between the average item mean for the two groups by the pooled standard deviation, was calculated to provide an estimate of the magnitude of differences between the two groups.

Based on observations and interviews with students and teachers, narrative stories were written to portray differences in the classes of these two groups. A commentary, in addition to the most poignant quotes from interviews and observations, were included to provide insights into the quantitative results. Analysis of qualitative data helped to explain the general picture portrayed by the quantitative results.

The sample of 365 students in 16 classes was used to examine the interactions, exposure to multimedia-by-sex, for each learning environment scale and engagement scale to determine whether exposure to multimedia was differentially effective for male and female students. A two-way multivariate analysis of variance (MANOVA), for which the dependant variables were the WIHIC and SALEM scales and the two independent variables were exposure to multimedia and student sex, was used.

Because the multivariate test, using Wilks' lambda criterion, yielded significant differences for the main effects and for the interaction, the univariate analysis of variance (ANOVA) was interpreted for each scale. The eta² statistics was calculated to provide an estimate of the strength of association for each effect for each modified WIHIC and SALEM scale.

To investigate associations between the learning environment perceptions of students and their engagement towards mathematics, simple correlations and multiple regression were conducted using the data from students in classes frequently exposed to multimedia (n=197 students in 9 classes). Simple correlation analysis was used to examine the bivariate relationship between each learning environment scale and each engagement measure. Multiple regression analyses were carried out to determine the joint influence of the set of WIHIC scales on each engagement scale. In both cases, analyses were conducted separately for both the individual and class mean as the unit of analysis.

In line with contemporary ethical considerations, the school principal, teachers, parents/carers and students were provided with detailed information in plain language that ensured they gave real informed consent. All participants were provided with information about the nature and methods of the research, its purpose, risks and benefits to the participants and possible outcomes of the research. Participants were informed that participation was voluntary and that they were free to withdraw from the research at any time, without prejudice or negative consequences. Students' were made aware that no aspect of this research would be used in determining their grades in mathematics.

All data were collected with the permission of the school principal, Head of Department, co-operating teacher and parents/caregivers. Every attempt was made to minimise the disruption to participants normal teaching-learning program. However, approximately 20-25 minutes was taken, to complete the questionnaires. Interviews were held at a suitably negotiated time and place. Because I was a researcher-participant, there was minimal interference in classes that were observed.

Only aggregated results of survey data were used, ensuring confidentiality and anonymity of participants. Use of pseudonyms was employed for qualitative data. Participants were assured that anonymity in the final thesis and any publications that may result from the study would be achieved through name changes.

The next chapter, Chapter 4, reports the results of the present study.

CHAPTER 4

DATA ANALYSIS AND RESULTS

4.1   Introduction

The purpose of this chapter is to describe the data analysis and findings with respect to the five research objectives (introduced in Chapter 1). As such this chapter is organised around the five research objectives using the following headings: validity and reliability of the instruments (Section 4.2); differences between students frequently exposed to multimedia and those who were not (Section 4.3); differences for male and female students frequently exposed to multimedia (Section 4.4); differential effectiveness of exposure to multimedia in mathematics classrooms for different sexes (Section 4.5); associations between students' perceptions of the learning environment and student engagement in mathematics for students frequently exposed to multimedia (Section 4.6). Finally, the chapter is summarised in Section 4.7.

4.2   Validity and Reliability of the Instruments

To provide support for subsequent research questions, it was important to ensure that the instruments, used to collect the data, were valid and reliable when used with secondary school mathematics students in regional Western Australia. Therefore, the first research objective was:

To investigate whether the instrument used to assess students' perceptions

of the learning environment and self-reports of adaptive learning

engagement in mathematics were valid and reliable for use in a school

located in regional Western Australia.

This section reports the reliability and validity of the two surveys used to collect the

quantitative data, these being, the WIHIC (reported in Section 4.2.1) and SALEM

(reported in Section 4.2.2).

4.2.1   *Validity and Reliability of the WIHIC*

To determine whether the WIHIC, used to assess students' perceptions of the

learning environment, was valid and reliable when used with high school students in

regional Western Australia, the data collected from 365 students in 16 classes were

analysed to examine the: factor structure (reported in Section 4.2.1.1); internal

consistency reliability (reported in Section 4.2.1.2); and ability of the WIHIC scales

to differentiate between classrooms (reported in Section 4.2.1.3).

4.2.1.1   *Factor Structure of the WIHIC*

Principal axis factoring with varimax rotation was used to examine the internal

structure of the 48-item, six-scale version of the WIHIC. The goal of principal axis

analysis was to reduce the number of correlated variables into a small number of

uncorrelated dimensions or components. For an item to be retained, two criteria,

recommended by Stevens (1992), were required to be satisfied: the loading was

required to be at least 0.40 on an item's *a priori* scale and less than 0.40 on each of the other five WIHIC scales.

The factor loadings for the modified WIHIC questionnaire are reported in Table 4.1. There were 288 possible loadings (48 items x 6 scales = 288 cases). During item analysis, eight items (or 48 cases) of the possible 288 cases in the original six-factor structure were found to be problematic and removed from further analysis, leaving a total of 40 of the 48 original items. These eight items (items 31 and 43 for the Student Cohesiveness scale, items 15, 27 and 39 for the Involvement scale and items 5, 17 and 23 for the Cooperation scale) were omitted from all subsequent analyses. For each of the remaining 240 loadings (40 items x 6 scales), reported in Table 4.1, the factor loading was at least 0.40 on its *a priori* scale and less than 0.40 for every other scale, with one exception, this being Item 47 for the Cooperation scale, which loaded on the Equity scale as well as its own scale.

The bottom of Table 4.1 reports the percentage of variance and eigenvalue (the relative importance of each factor) for each scale. The percentage variance ranged from 1.98 to 28.95% for different scales with the cumulative percentage of variance being 60.49%. The eigenvalues for different scales varied from 1.49 to 12.16 all of which satisfied Kaiser's (1960) recommendation that the eigenvalue for a factor should be greater than 1.

All six of the WIHIC scales, namely, Student Cohesiveness, Teacher Support, Involvement, Task Orientation, Co-operation, and Equity, were retained and the results, reported in Table 4.1, provide strong support for the factorial validity of the instrument when used with this sample.

Table 4.1   Factor Loadings (Principal Axis Factoring with Varimax Rotation), Percentage of

Variance and Eigenvalues for the Six-Scale WIHIC

Item No	Factor Loading					
	Student Cohesiveness	Teacher Support	Involvement	Task Orientation	Cooperation	Equity
1	0.59					
7	0.68					
13	0.57					
19	0.72					
25	0.66					
37	0.61					
2		0.51				
8		0.71				
14		0.74				
44		0.63				
20		0.75				
26		0.76				
32		0.71				
38		0.65				
3			0.72			
9			0.75			
21			0.63			
33			0.54			
45			0.42			
4				0.71		
10				0.74		
16				0.56		
22				0.65		
28				0.66		
34				0.72		
40				0.58		
46				0.62		
11					0.44	
29					0.57	
35					0.58	
41					0.67	
47					0.49	0.45
6						0.66
12						0.70
18						0.46
24						0.67
30						0.67
36						0.57
42						0.54
48						0.61
% Variance	1.98	28.95	3.55	9.51	5.91	10.59
Eigenvalue	4.72	12.16	1.49	3.99	2.48	5.42

Factor loadings smaller than 0.40 have been omitted

$N = 365$ students in 16 classes

Items 5, 15, 17, 23, 27, 31, 39 and 43 were removed from the analysis.

4.2.1.2   *Internal Consistency Reliability of WIHIC*

The internal consistency reliability indicates whether the items in a scale assess a

similar construct. In this study, the Cronbach alpha reliability coefficient was used as

an index of scale internal consistency. The alpha coefficient for different WIHIC scales, reported in Table 4.2, ranged from 0.75 to 0.87 with the individual as the unit of analysis and from 0.91 to 0.98 with the class mean as the unit of analysis. Using the conventional cut off of 0.70, for a reliable coefficient (Streiner & Norman, 2003), the coefficients were considered to be acceptable. These internal consistency indices were comparable to those obtained when the WIHIC was used with other Australian samples (see for example, Aldridge, Fraser & Huang, 1999; Fraser, Fisher & McRobbie, 1996), suggesting reasonable reliability for the revised version of the WIHIC.

4.2.1.3   *Ability of WIHIC to Differentiate Between Classrooms*

To determine whether the scales of the WIHIC was able to differentiate between the perceptions of students in different classrooms a one-way analysis of variance (ANOVA) was performed. The independent variable was the 16-level class membership variable. The last column of Table 4.2 reports the eta^2 statistic, which represents the proportion of variance in scale scores accounted for by class membership and provides an estimate of the strength of association between class membership and the dependent variable (WIHIC scale). The eta^2 statistic, reported in Table 4.2, ranged from 0.04 to 0.13 for different WIHIC scales. Statistically significant differences ($p < 0.01$) between students' perceptions in different classes were reported for all six WIHIC scales, suggesting that the scales of the WIHIC were able to differentiate between the perceptions of students in different classes.

Table 4.2   Internal Consistency Reliability (Cronbach Alpha Coefficient) and Ability to Differentiate Between Classes (ANOVA Results) for Two Units of Analysis for the Six-Scale WIHIC

Scale	Unit of Analysis	No of Items	Alpha Reliability	ANOVA Eta^2
Student Cohesiveness	Individual	6	0.78	0.04[**]
	Class Mean		0.91	
Teacher Support	Individual	8	0.84	0.13[**]
	Class Mean		0.97	
Involvement	Individual	6	0.80	0.11[**]
	Class Mean		0.95	
Task Orientation	Individual	8	0.86	0.11[**]
	Class Mean		0.98	
Cooperation	Individual	6	0.75	0.05[**]
	Class Mean		0.93	
Equity	Individual	8	0.87	0.11[**]
	Class Mean		0.98	

** $p<0.01$ *$p<0.05$
N= 365 students in 16 classes.
The eta^2 statistic (which is the ratio of 'between' to 'total' sums of squares) represents the proportion of variance explained by class membership.

The results of the present study replicate past research which has supported the factor structure of the WIHIC in Australia (Aldridge & Fraser, 2000; Aldridge, Fraser & Huang, 1999; Dorman, 2003; Velayutham, Aldridge & Fraser, 2011; Zandvliet & Fraser, 2004, 2005). Further the strong reliability and validity of the WIHIC, when used with this sample, suggest that the results of the subsequent analyses can be interpreted with confidence.

4.2.2   *Validity and Reliability of the SALEM*

The data collected from 365 students in 16 classes was also used to examine the reliability and validity of the SALEM. This section reports, for the SALEM: the

factor structure (described in Section 4.2.2.1); internal consistency reliability (described in Section 4.2.2.2); and the ability of each scale to differentiate between classrooms (described in Section 4.2.2.3).

4.2.2.1   *Factor Structure of the SALEM*

Principal axis factor analysis with varimax rotation was used to examine the internal structure of the 32-item, four-scale SALEM. Item analysis revealed that six items were problematic and were removed from further analysis. These six items were items 5, 21 and 29 of the Learning Goal Orientation scale, items 3 and 15 for the Self-Efficacy scale and item 20 for the Self-Regulation scale. Removal of these six items improved the internal consistency reliability and factorial validity and resulted in the acceptance of a revised version of the instrument comprising of 26 items in four scales. Factor loadings for the remaining items, in four scales (Goal Orientation, Task Value, Self-Efficacy and Self-Regulation), are reported in Table 4.3, which shows that, for the remaining 26 items, all items had a factor loading of at least 0.40 on their own scale and a loading of less than 0.40 on the other three scales.

The bottom of Table 4.3 reports the percentage of variance and eigenvalue for each SALEM scale. The percentage variance for the different scales ranged from 4.12% to 43.66%, with the cumulative percentage variance, explained by all factors, being 61.67%. The eigenvalue for different scales ranged from 1.07 to 11.35 for the sample. These results indicate that the eigenvalue for each factor was consistent with Kaiser's (1960) recommendation that values be greater than 1.

Table 4.3   Factor Loadings (Principal Axis Factoring with Varimax Rotation), Eigenvalues and Percentage of Variance and for the SALEM

Item No	Factor Loading			
	Learning Goal Orientation	Task Value	Self- Efficacy	Self-Regulation
1	0.42			
9	0.40			
13	0.55			
17	0.64			
25	0.77			
2		0.76		
6		0.64		
10		0.77		
14		0.73		
18		0.65		
22		0.41		
26		0.60		
30		0.55		
7			0.58	
11			0.65	
19			0.74	
23			0.52	
27			0.70	
31			0.76	
4				0.76
8				0.77
12				0.71
16				0.72
24				0.60
28				0.73
32				0.56
% Variance	4.12	43.66	7.44	6.45
Eigenvalue	1.07	11.35	1.94	1.68

Factor loading smaller than 0.40 have been omitted.
N=365 students in 16 classes
Items 3, 5, 15, 21 and 29 were removed from the analysis.

4.2.2.2   *Internal Consistency Reliability of SALEM*

The Cronbach alpha reliability coefficient was used as an index of scale internal consistency. Table 4.4 reports the internal consistency reliability (Cronbach alpha coefficient), for the revised 26-item version of the SALEM, for the individual and class mean as units of analysis.

For the sample of 365 students in 16 classes, the alpha coefficients, using the individual student as the unit of analysis, ranged from 0.84 to 0.90. With the class mean as the unit of analysis, the alpha reliability coefficients were higher and ranged from 0.98 to 0.99. These internal consistency indices for the SALEM were considered to be high.

Table 4.4   Internal Consistency Reliability (Cronbach Alpha Coefficient), and Ability to Differentiate Between Classes (ANOVA Results) for Two Units of Analysis for the SALEM

Scale	Unit of Analysis	No of Items	Alpha Reliability	ANOVA Eta^2
Learning Goal Orientation	Individual	5	0.86	0.13**
	Class Mean		0.99	
Task Value	Individual	8	0.89	0.16**
	Class Mean		0.99	
Self-Efficacy	Individual	6	0.84	0.12**
	Class Mean		0.98	
Self-Regulation	Individual	7	0.90	0.10**
	Class Mean		0.98	

** $p<0.01$ *p<0.05
The sample consisted of 365 students in 16 classes.
The eta^2 statistic (which is the ratio of 'between' to 'total' sums of squares) represents the proportion of variance explained by class membership

4.2.2.3   *Ability of SALEM to Differentiate Between Classrooms*

The ability of each scale of the SALEM to differentiate between students in different classrooms was examined using one way ANOVA with class membership as the main effect (the independent variable). The results, reported in Table 4.4, show that the eta^2 statistic ranged from 0.10 to 0.16 for different SALEM scales. Statistically significant differences ($p<0.01$) between students' perceptions in different classes

were found for all four SALEM scales, indicating that the four scales were all able to differentiate between the perceptions of students in different classes.

These results reported in Section 4.2.1 and 4.2.2 provide strong support for the reliability and validity of the six-scaled What Is Happening in This Class? (WIHIC) questionnaire and the Students Adaptive Learning Engagement in Mathematics (SALEM) questionnaire when used with high school students in regional Western Australia. Further these results suggest that this data can be used with confidence and the results used to infer valid assertions about the sample involved.

4.3   Differences between Students Frequently Exposed to Multimedia and Those Who Were Not

A focus of the present study was to examine whether students who were exposed to multimedia differed (in items of their perceptions of the learning environment and their engagement in mathematics) to those who were not exposed to multimedia. If differences existed in their perceptions (between students exposed to multimedia and those who were not), then the study would further explore the causal explanations for those differences.

As discussed in Chapter 3 (Section 3.4.2), and reiterated here, the selection of classes was made to ensure a meaningful comparison between the two groups. Students who had access to an interactive whiteboard in their classrooms and/or had more than two class hours (out of four) per week of mathematics instruction in the computer laboratory, were considered to be frequently exposed to multimedia, while the

remaining classes were considered to be infrequently exposed to multimedia. The total sample involved 365 students in 16 classes, of which nine classes (*n*=197 students) were frequently exposed to multimedia and seven classes (*n*=168 students) were not frequently exposed to multimedia.

The data collected using the six-scaled WIHIC (to assess students' perceptions of their learning environment) and SALEM (to assess students' perceptions of their engagement in mathematics), were analysed to address the second research question, which was:

> To examine whether differences exist for students who are frequently
> exposed to multimedia in mathematics classes and those who are not
> (in terms of perceptions of the learning environment and engagement
> in mathematics) and, if so, investigate why.

To address this research objective, a mixed method approach was used (described previously in Section 3.3). This section reports the differences that existed for students who were frequently exposed to multimedia and those who were in two sections. First, the results of the MANOVA are reported to provide an overview of the differences in learning environment perceptions and engagement for the student in the two groups (described in Section 4.3.1). Second, Section 4.3.2 provides the reader with insights into the classroom life experienced by students in the two groups, through the use of narratives. These narratives are followed by themes that emerged from the analysis of the qualitative data to provide an understanding of the quantitative results.

4.3.1   MANOVA Results for Differences in Learning Environment Perceptions and Engagement

Multivariate analysis of variance (MANOVA) was used to determine whether differences existed between the students' perceptions of the learning environment and engagement for students in classes that were frequently exposed to multimedia and their counterparts who were not. The set of six WIHIC scales (Student cohesiveness, Teacher Support, Involvement, Task Orientation, Cooperation and Equity) and four SALEM scales (Learning Goal Orientation, Task Value, Self-Efficacy and Self-Regulation) constituted the dependent variables whilst exposure to multimedia (frequent and not frequent) was the independent variable.

The average item mean (the scale total divided by the number of items in that scale) and average item standard deviation, reported in Table 4.5, indicate that, for each of the six WIHIC scales and four SALEM scales, the scores for students who were in classes that were frequently exposed to multimedia were higher than the scores for students who were in classes not frequently exposed to multimedia.

Effect size is the difference in means expressed in standard deviation units. To provide an indication of the educational importance of these differences (in addition to their statistical significance) effect size was used as a measure of the strength or magnitude of any differences. The effect sizes reported in Table 4.5 were calculated by dividing the difference between the average item mean for the two groups by the pooled standard deviation (Thompson, 1998a, 1998b). The effect sizes for the six scales of the WIHIC questionnaire ranged from slightly above on half (0.57) of a standard deviation to almost one and quarter (1.22) standard deviations. For the four

146

SALEM scales, the effect sizes range from just over one (1.08) standard deviation to more than one and a half (1.56) standard deviations.

Table 4.5   Average Item Mean, Average Item Standard Deviation and Differences for Students in Classes Frequently Exposed to and Infrequently Exposed to Multimedia (Effect Size and One-Way MANOVA Results) for WIHIC and SALEM scales using the Individual as the Unit of Analysis

Scale	Average Item Mean [a]		Average Item Standard Deviation		Difference	
	Frequently Exposed	Not frequently Exposed	Frequently Exposed	Not frequently Exposed	Effect Size[b]	*F*
Learning Environment						
Student Cohesiveness	4.14	3.77	0.56	0.73	0.57	30.31**
Teacher Support	3.52	2.80	0.73	0.80	0.94	82.22**
Involvement	3.29	2.62	0.69	0.68	0.98	87.09**
Task Orientation	4.02	3.26	0.56	0.68	1.22	137.60**
Cooperation	3.73	3.22	0.62	0.69	0.78	55.48**
Equity	3.74	3.03	0.70	0.77	0.96	85.95**
Student Engagement						
Learning Goal Orientation	4.24	3.25	0.49	0.77	1.53	220.58**
Task Value	3.87	2.94	0.58	0.61	1.56	222.70**
Self-Efficacy	3.86	3.18	0.57	0.68	1.08	109.47**
Self-Regulation	3.86	2.97	0.61	0.78	1.38	147.23**

*$p<0.05$ **$p<0.01$
The sample consisted of 365 students in 16 mathematics classes (197 students in 9 classes frequently exposed to multimedia and 168 students in 7 classes not frequently exposed to multimedia)
[a] Average Item Means = Scale Score divided by the number of items in that scale
[b] Effect size (Cohen's d) is the difference in means expressed in standard deviation units
Cohen's $d = M_1 - M_2 / \sigma_{pooled}$ where $\sigma_{pooled} = \sqrt{[(\sigma_1^2 + \sigma_2^2)/2]}$

Cohen (1992) and Klines (2010) suggest that effect sizes with values ranging from 0.10 to 0.29 standard deviations can be considered small, those ranging from 0.30 to 0.49 standard deviations can be considered medium/moderate and values of more

than from 0.50 standard deviations are considered to be large and of educational significance and importance. Given this criteria, then, the effect size for the differences can all be considered educationally significant and important.
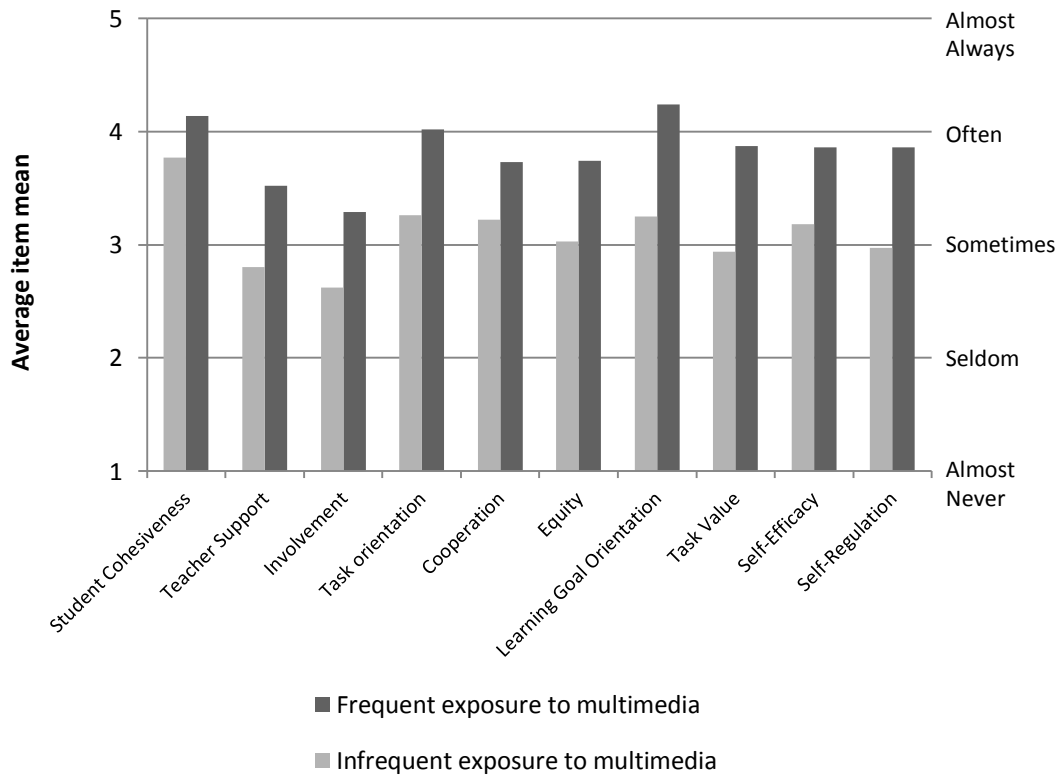
Figure 4.1   Average Item Means and responses for students who were frequently exposed to multimedia and those who were not for the scales of the WIHIC and SALEM (*N*=365)

4.3.2   *Explaining Students' Responses to the WIHIC and SALEM*

To help to explain these large effect sizes and statistically significant differences in learning environment perceptions and engagement for students in classes frequently and infrequently exposed to multimedia, qualitative information was gathered using classroom observations and interviews with 10 students and three teachers. As such, the focus for this research question moved from a more positivistic approach towards

148

the use of multiple paradigms which were to guide the collection and interpretation of information. With it came a shift from empirical to descriptive terminology and a new way of representing the differences and/or similarities between the learning environment and engagement of the students in the two groups.

Based on the analysis of qualitative data, the focus of this section was to draw together ideas and conclusions that have emerged from the qualitative information that might provide insights for the quantitative data (described previously in Section 4.3.1). Analysis of information gathered during classroom observations (including field notes) and interviews with teachers and students led to the emergence of common themes that were the result of the distillation of major ideas or conclusions. Throughout the analysis, I have used the *bricolage* method, described by Denzin and Lincoln (1994), to draw together the information collected using a variety of research methods. Narratives (based on classroom observations), based on field notes of my observations and quotations from interviews with students and teachers, helped me to distil these themes. (See Section 3.6.2 for details related to the procedures used to analyse the qualitative information.)

4.3.3   *Narratives and Interpretative Commentary*

To provide the reader with insights into the classroom life of the two groups, this section provides two narratives, one based on observations of classes that were not frequently exposed to multimedia and another based on observations of classes that were frequently exposed. These narratives, written to describe mathematics

classrooms that could be considered typical of each group, are used to 'capture' the essence of classroom life (Clandinin & Connelly, 2000).

Although the two narratives were based, largely on two Year nine classes (one that was frequently exposed to multimedia and the other with limited exposure to multimedia) these portrayals were based on observations of a number of classes at the school. The classes, described in the narratives, were both taught by the same teacher. Although all aspects of the stories might not be present in any one classroom, as discussed in Section 3.5.3.2, none were uncommon in the mathematics classrooms that were observed. All of the quoted statements were made by the students and/or teachers during in-depth interviews or discussions.

The two stories and their subsequent interpretative commentaries, as suggested by Geelan (1997), provide a sensitive basis upon which I was able to explain the differences in learning environment and engagement scores (reported in Section 4.3.1) and to help to make sense of the data, as recommended by Polkinghorne (1995).

4.3.3.1   *Narrative 1: A mathematics class infrequently exposed to multimedia*

Andrew, the teacher whose lesson I am going to observe, has 20 years of experience as a mathematics teacher, five of which we have worked together. Ever punctual for his lessons, Andrew has his equipment ready and makes himself a drink. As he drinks, Andrew explains that the lesson that he is going to deliver is about averages and that the students had left his last lesson with a somewhat hazy idea of measures of central tendency and an agreement that there were many types of averages. As he talks, the siren wails, reminding me of an air raid warning, and we get up to go to his classroom. We wait outside the room for the students to

arrive from their English lesson, held on the floor below. As we wait, Andrew compliments one of the students on how well she had done at the sports carnival the day before. I notice that the boys, as they wait to go inside, are getting restless.

Once the late comers arrive, we move inside and Andrew instructs the students to move to their allocated seats (based on a pre-determined seating plan). The classroom is a spacious, bright room, with large windows along the rear wall. There are spectacular views that include manicured lawns and pathways that surround the school. The classroom accommodates 32 students, with five rows, each with six desks. Two more desks are strategically placed at the front of the class, next to the teacher's desk, for students with visual and/or hearing impairments.

Andrew greets the students and introduces me as an observer in today's lesson. (I am known to the students as I also teach at the school.) He then moves quickly to begin the lesson by complimenting all of the students who had participated at the sports carnival. The students listen with interest as Andrew tells them a short story about how the Greeks valued what is now known as a 'marathon'. Andrew randomly asks a few students how long they took to run the 100 meter race. Further, he asks how the time keepers had arrived at the time that it took students to complete the race (given that each competitor made three attempts). Before he has finished asking the question, the students started to shout out an assortment of answers. Some state that the time keepers used the shortest time of the three attempts, others stated that the time keepers had manufactured a time that they had not even taken. Most of the students were either shouting or calling out responses and Andrew asks them to raise their hands up if they know the answer. There is a sudden silence and no hands are raised. Andrew does not tell them the answer but, rather, proceeds to explain the purpose and objective of the lesson. As he does so, he asks the students to first answer the questions that have been placed on the whiteboard.

One of the students, Brian, refuses to work; stating that he thought it was a Friday and would be doing 'Mathletics' (an interactive computer software programme available in the computer laboratory). In a bid to get Brian to complete the exercises, Andrew warns him that, if he did not do his work, he would be given detention and that his parents will be informed of his behaviour. Brian's reaction is

belligerent and he demands "Sir, go and get me a laptop if you want me to do your work today!"

In an exasperated tone, Andrew explains, "It is not my work but yours, Brian." Brian immediately retorts, *"*No! It is your work, sir. If it's mine, then why do you force me to do it?"

At this point, Andrew chooses to ignore Brian and walks away. He then notices another student, Tracy, writing on her desk and when he asks her to stop, she shouts: "For Christ's sake, leave me alone; pick on somebody else for a change!" Before Andrew has a chance to respond, Mark, another student, shouts, "Shut up! You stupid, queer girl!" Tracy immediately reaches for Mark's work, rips and screws it up then throws it into the bin. The teacher patiently responds by asking Mark and Tracy to be polite to one another, moving Mark to a desk at the front of the class and Tracy to one at the back of the class. Tracy throws her pencil case out through the window but Andrew ignores it. Mark and Tracy stop shouting at each other and Andrew proceeds to ignore them both.

Another student shouts to the teacher, "Can you please sit me next to John? I can't do my work here because Brody is always copying me!" The teacher moves closer to the student and, as if he did not hear it, the teacher responds by quietening the remainder of the class and instructing them to complete the work that is on the whiteboard. Another student asks, "Sir, I have finished my work. What do you want me to do next?" Realising that most of the students have finished the individual exercises on the whiteboard and are waiting for further instructions from him, he proceeds to write the answers on the whiteboard. Andrew asks the students to mark their own work, reminding them to be honest. He then commences the lesson, developing the concept of averages (mean, mode and median) and works through some examples on the board. The students are all quiet during the development of the concept but none of them participates in the 'construction' of the concept. When the teacher asks the sum of a pair of single digit numbers, only one student raises his hand. Andrew decides to pick a student whose hand is not raised. I find myself feeling nervous for him, willing him to get the answer right. I need not have been concerned because he confidently responds correctly, leaving me wondering why he did not raise his hand up in the first place.

With the exception of Brian, Mark and Tracy, Andrew divides the students into five groups of four to solve the problems involving averages that he had photocopied. Andrew distributes the sheets to the students and, as he does, he instructs the students to join up their desks and arrange their chairs so that they are facing each other. The speed at which this instruction is carried out suggests that this is something that is done frequently. In the commotion, two of the students swap groups but this does not go unnoticed by Andrew, who instructs them to go back to their original groups.

Andrew instructs the students to work, first in pairs, and then to share and compare their results with the other pair in their group. As the students proceed with working through the exercises the noise level rises. Despite having correctly worked out three of the exercises, I hear two of the girls discussing that they are not sure whether they have understood the concept and question where they will ever use what they are learning. Another student responds that averages are not used in real life but the concept had an intra-mathematical application. Andrew overhears this conversation and jumps in to explain its usefulness, both in life and within mathematics. Students in other groups stop discussing their work and listen to the teacher as he explains the relevance of averages to their life.

Within the groups the students continue to share and discuss their ideas. One group calls to the teacher to explain again the concept of mode. Andrew shows his happiness with the discussions going on in class and rewards all of the students (with exception of Brian, Tracy and Mark) with a star to stick into their books. He then winds up the group discussions by summarising the concepts of mean, mode and median, and promises one of the groups that he will send 'goldie' letters home (commendation letters sent home celebrating good work and/or behaviour in class).

It's now about 10 minutes before the end of the lesson. Andrew asks the students to pay attention. Once they have stopped talking, he asks a number of questions designed to check their understanding of the concept of averages. Only two of the students raise their hands to answer the questions. At random, Andrew selects students whose hands are not raised. Invariably they stumble to answer correctly, suggesting that they may not have fully grasped the concept. For the benefit of these students, Andrew goes through the concept of averages again, to help clarify the weak points. Once finished, he asks the students to pair up and to solve two more problems on averages from their textbooks while they wait for the bell.

At this point, Andrew turns to the three students who have been isolated in class. Mark has completed one exercise and is working on a second, Brian is drawing a dragon and Tracy is intent on breaking her only remaining pencil into pieces – having thrown her pencil case outside through the window. Tracy asks the teacher, "Sir, I don't know who threw my pencil case outside, may I please go and collect it?" Andrew responds, "You will collect it after the lesson" and goes on to ignore her. Andrew asks them to make a comparison between the quantity and quality of their work and what a future employer would expect. Tracy retorts "I'd do more if I was being paid" whilst Brian said "I would do more if I were using a computer. Besides, I won't be doing maths then, will I?" The teacher looks annoyed but does not make an issue of it.

Mark is now working quietly and is about to complete his two exercises. He asks the teacher politely to pair him with another student. Andrew agrees and instructs Mark to join the pair of students sitting next to him. As Mark is walking to join the pair, he asks the teacher never to sit him close to Tracy again and asks whether the teacher would put Tracy in detention for bullying and screwing up his work. The teacher ignores his second request and moves over to help the students who have been paired.

Andrew looks at the classroom clock and realises that the lesson is almost finished. He praises those students who had worked hard throughout the lesson and reiterated his promise to post their 'goldies' home that day. The bell rings and the students pack away their books for the next lesson, even though Andrew is still talking to them. Brian makes a point of screwing up his work and throwing it in the bin as he leaves the room. Tracy turns on her iPod and put in her earphones as she saunters out.

Interpretive Commentary for Narrative 1

The narrative is typical of a Year 9 mathematics class at this school that was not frequently exposed to multimedia. The narrative describes how the teacher insisted that students sit according to his predetermined fixed seating plan. During the

observation, when the students were asked to move into groups, two of the students tried to change groups but were instructed to return to their original places.

The story describes a minority of students showing a lack of respect towards one another and the teacher. The story portrays a variety of disruptions to the lesson, ranging from students talking back to the teacher, a general lack of respect for the teacher and their classmates, and a lack of value for the learning of mathematics. Although this behaviour was displayed by only a handful of students, it was not uncommon in the other classrooms I observed that were not frequently exposed to multimedia.

My observations suggested that it was not unusual for students, like Brian, to request to use computers in lessons in these classrooms. During one observation, a student said, "I would do more if I were using a computer" and another said, "Sir, go and get me a laptop if you want me to do your work." Such responses were often said in ways that were clearly rude.

The use of stories and everyday practical problems is described. From my observations, it would appear that, at the start of the lesson, most of the students showed generally positive emotions, including enthusiasm, curiosity and interest. As described in the story, during this point in the lesson, the students were quiet and attentive as the teacher told them the 'marathon' story.

The narrative also describes some of the students in the class being off-task and having limited or no value for the learning tasks provided during of the lesson. For example, two students argued that the work was the teacher's and that they would

complete more work if it was paid for. When asked to compare the quantity and quality of their work with what a future employer would expect, one of the two students said, "I won't be doing maths then, will I?" Another of the students, described in the narrative, did not do any work but, rather, spent the lesson drawing dragons and then ripping and binning his drawing as he left the classroom.

Finally, the narrative depicts a class of students who, even if they knew the answers to some of the questions, did not raise their hands. During the observation when the teacher was telling the class the 'marathon' story, the students responded in chorus. When the teacher asked students to raise their hands if they knew the answer (or were interesting in saying something), none did. Towards the end of the lesson, during a question and answer session only two of the students regularly raised their hands and the majority of the students did not.

The next story is based on observations of a class that was frequently exposed to multimedia (Narrative 2). This narrative, like the one used to describe a class that was not frequently exposed to multimedia, develops themes that were common over a number of observations.

4.3.3.2   *Narrative 2: A mathematics class frequently exposed to multimedia*

Today I am to observe another class taught by Andrew, one that is frequently exposed to multimedia. There is about 10 minutes before the bell goes and, as we walk to the classroom, Andrew explains that the class that I am about to observe is comparable to the previous class in terms of behaviour and ability level of the students (based on the Year 8 academic results and behaviour reports). While the other class had an enrolment of 16 boys and 15 girls, this class has an enrolment of 17 boys and 15 girls. Both groups are Year 9s and are aged between 14 and 15.

As we enter the classroom, Andrew moves to the front of the room to put down his equipment. Like the previous class, the room is spacious and air conditioned and has a row of large windows along one side, making it light and bright. At the front of the room, however, there is an interactive white board and an LCD projector hanging from the ceiling. In one corner there is a charging trolley (a trolley used to keep laptops or iPads while they are charging) with 15 iPads neatly packed inside. There are another 33 computers that are placed against three of the walls and a computer on the teacher's desk. In the middle of the room, there are six laboratory-style desks with high stools, each accommodating six students.

The bell rings and Andrew excuses himself as he moves to the door to welcome the students who are waiting outside. There is much movement in the corridors as the students get their equipment from the lockers and move to their first class of the day. Although not all of the students have arrived, the teacher invites those who are waiting outside to enter. One by one the students filter into the classroom, with some saying "Good morning, sir!" For each of these, the teacher smiles and nods his head in acknowledgement before responding, "Morning."

As they enter the classroom, the students move to a computer and log in. I note that the students who entered first have already opened up the Mathletics programme (an interactive computer software programme available in the computer laboratory) while others are on the 'Khan Academy' (a mathematics software programme available on the internet) website. As the students busy themselves on the computer, the teacher goes to his desk to mark the attendance role before sending it, with a runner, to the school clerk. (The parents of absent students will be sent an SMS message to inform them of their absence.)

While the student takes the role to the office, Andrew tells the remaining students to continue with the activity that they have opened on their computer. Once the student returns, Andrew stands up and greets the students, drawing their attention to the front of the class. The students take this as a cue to stop working on their computers and move to the laboratory-style tables in the middle of the room. Amid the scraping of stools and chatter amongst friends, the students gradually find a chair. I overhear one group discussing how they had just beaten their friends in the interactive activity that they had been playing, and the friend excuses his loss

because of a 'frozen' computer. I note that Andrew ignores the noise and focuses on his computer.

Once the students are seated, Andrew signals the start of his lesson by clapping his hands and thanking the students for being quiet. He informs the class of the purpose and objective of the lesson and tells them that, as usual, they would begin the lesson by going through the Ten Quick Questions (a computer generated programme that rolls 10 questions, one after the other, giving the students a programmed time to answer). There is deafening silence as the students answer the questions projected on the interactive white board. The students focus on responding as a range of questions are displayed, such as adding two digit numbers, arranging a set of numbers in ascending or descending order and finding the middle number in a set of data. At the end of the exercise the computer displays the answers. The teacher reminds the students to be honest as they mark their work and to question the logic of the responses that they did not get right.

One of the girls raises her hand and, when acknowledged by the teacher, she says that there is a mistake because, when finding a middle number in an even set of numbers there won't be any. The teacher opens this question up to the class. There is no response. After providing some clues, there is still no response, so the teacher explains that, if there is an even set of numbers, then the middle number is the arithmetic mean of the middle two. Although a number of boys appear to understand what the teacher says, there are three girls at the back of the class who still insist that the question was wrongly worded as it asked for a number (within the list) that was in the middle. Andrew acknowledges that the girls have made a good point and that the next lesson might help them to better understand what they were asking.

Andrew moves the lesson forward, informing the students that they are going to learn about averages. He defines and explains the concepts related to mean, mode and median. This explanation is followed by the teacher working a number of examples on the board. Once satisfied that the students have a basic understanding of these concepts (mean, mode and median), Andrew moves to the trolley upon which the ipads are stored and allocates one to each of the groups (made up of five students), directing them to a website upon which there is a set of problems. The noise level starts to escalate but, before allowing the students to commence, Andrew demands their attention and tells them that he will, towards the end of the

lesson, randomly pick students to explain how they arrived at their solution and why they thought their answer was right.

As the students start working on their iPads, Andrew moves between the groups, listening to their discussions and, on occasions, asking members to consider their answer more carefully. The noise level escalates and I am amazed that anything could be heard. Students in four (of the five groups) are leaning against the table talking loudly but all with eyes fixed at the iPads. The body language and hand gestures show enthusiasm and interest in what they are doing. One group at the front is particularly noisy but Andrew ignores it until it reaches an unacceptable level, at which stage, he calls out to the students to keep the noise-level down. At this, one student retorts: "We know what we are doing. We have done this in primary school." The manner of his response borders on rude, but the teacher ignores him and reminds the students to cooperate, share and work together.

The fifth group is at the back of the class. Unlike the other groups, only three of the students are looking at the iPads and two girls in this group are using their mobile phones and giggling. Andrew also notices them, stops talking and stands, dead still, staring at the pair. It is clear that the girls have seen him and know what is expected. They are immediately quiet and Andrew, whilst showing his disappointment, thanks them for responding and asks them to put their mobile phones in their bags.

After a while, Andrew quietens the class. Once settled, he starts to randomly select students and ask how they, together with the group, had solved particular problems. The first student demonstrates some understanding of the concept but his answer appears to be different from what the teacher expected. The group agree with their peer, saying "Yes, that's right, sir! Give us a chance to explain it, sir!" Some of the members are standing, waving their hands requesting the teacher to give them a chance to explain their answer. The student asks the teacher for permission to consult his group further (on how they had arrived at that answer). The discussions that are generated indicate that the group members had worked together, negotiated their answer and and come to a compromised agreement on their answer. At this point, Andrew went through the exercise with the class, and confessed that the group was correct. He had misread one of the numbers. The group jumps and shouts boisterously celebrating their win.

The exercises continue as Andrew randomly picks students from the class role. In the midst of a big "*Yeee!*" from the class, a female student stands and confidently tells the class to be quiet. Andrew asks her to explain the difference between mode and median. She explains that "mode comes from mo-mo-most often, whereas median comes from the mid-mid- middle when arranged in order." The class is happy with her response and they clap. Andrew picks a further three students who all show some understanding of the concepts. Andrew gives a summary of the lesson with emphasis on the definitions of the mean, mode and median.

At this point, Andrew goes to his computer and projects a website on the board. He explains that he wants the students to work individually and that the exercises will give them some practice working with averages. He explains that the exercise should not take long and that, once they are finished they could visit the Mathletics website.

As Andrew finishes explaining, there is a sudden increase of noise as students rush to their computers. The noise-level quickly dies down as the students, with headphones on, concentrate on their screens. Andrew moves to his computer to monitor what they are doing. He commends two of the boys who have finished and have started an extension exercise, promising them that he will send 'goldie' letters home to their parents.

Still looking at his computer screen, Andrew politely asks three girls to close the Facebook website that they have open on their computers and to do as instructed. I can hear the students giggling and overhear a whisper that the teacher has magic powers.

After a while, the teacher glances at the clock on the wall and thanks the class for participating and behaving so well on their computers. The siren goes and, for a little while, the students remain glued to their screens before the teacher reminds them again to pack away their books and go to the next lesson.

Interpretive Commentary for Narrative 2

This second narrative depicts a typical class that is frequently exposed to multimedia. The story describes how the students' used the multimedia equipment and how they respond in and to such an environment. Like the previous story, this narrative, although based on a number of lessons, can be considered typical of such a class at the school. The narrative describes a lesson in which the teacher uses a variety of teaching styles and moves from individual work to small group work, to class discussions and to individual work again. Although the two narratives each describe classes that were taught by the same teacher and were comparable (in terms of the proportion of males and females as well as the ability level of the students), my observations indicated that there were a number of differences between the two that helped to explain the quantitative results. This section uses a constant comparison approach (Boeije, 2002; Glazer & Strauss, 1967; Kolb, 2012) to help to explain differences in students' scores, in the two groups.

Whilst the observations and interviews were useful in explaining the quantitative results, it should be noted that the themes that emerged during analysis were not confined to explaining any one dimension of the surveys. Given the overlapping nature of the various elements of the learning environment and their influence on each other and on student engagement (see Section 4.5), the themes that follow would appear to influence students' perceptions of a number of the scales. During the analysis of the data, three overarching themes emerged that served to explain differences in students' scores, namely: autonomy and flexibility; interpersonal

(classroom) relationships and collaboration; and engagement and involvement in learning.

Autonomy and Flexibility. The classroom observations, portrayed in the narratives, indicated that one of the biggest differences between the two groups was the amount of autonomy experienced by the students as well as the flexibility of the lessons and their content. Observations suggested that the students in classes that were frequently exposed to multimedia were afforded more autonomy and flexibility than those in classes that were not. The degree of autonomy and flexibility differed in terms of the seating arrangements, speed at which students could progress with their work and the degree of independence given to students during the lesson. Each of which is described below.

First, classroom observations indicated that the seating arrangements were quite different for the students in the two groups (those that were frequently exposed to multimedia and those who were not). Students who were frequently exposed to multimedia could choose where they sat and the groups that they would work with during the various activities. In contrast, the seating arrangements for students who were not frequently exposed to multimedia were, on the whole, inflexible, involving a fixed seating plan, decided on by the teacher, that students were required to adhere to. The first narrative, for example, depicts the teacher enforcing the seating plan during the lesson, asking two of the students, who had tried to swap groups without permission, to go back to their original places. When asked why the seating arrangements were different for the two groups, all three of the teachers who were interviewed indicated that this arrangement was necessary to help to control the

behaviour issues that frequently arose in these classes. Talking of his students in classes that were not frequently exposed to multimedia, one of the teachers said:

With the seating arrangement in this class, my objective is to reduce unnecessary movement and minimise off-task chatting. The best way to control negative behaviour and get serious work out of the boys in this class [infrequently exposed to multimedia class] is to get them to sit with slightly lower ability girls. If they are sat with higher ability girls then they just go into 'learned helplessness mode' and get the girls to do their work for them. If they are sat with girls of the same ability range they go all stupid and competitive. But if you sit them with girls they can help, they change character: becoming more nurturing, supportive and interested in their own attainment and that of others. The reverse also works if you want to get work out of girls. I use this strategy in this class and, tell you what, it kind of works. [Teacher 2]

In contrast, the students who were in classes frequently exposed to multimedia generally sat where they wanted to, thereby self-selecting their groups. Of the teachers who were interviewed all agreed that this arrangement worked only because there were fewer behaviour problems and that students in classes that were frequently exposed to multimedia were less likely to be disruptive. To this end, one of the teachers said:

Seating plans are not necessary in this class [frequently exposed to multimedia] because students do not show tendencies of distraction and boredom. They are generally engrossed in their work when using multimedia. With this view in mind, I don't really mind where or with whom the students sit. [Teacher 1]

Interviews with students in classes that were frequently exposed to multimedia with non-fixed seating arrangements in their classes indicated that this arrangement facilitated discussions within and among themselves. To this end, one student stated:

> I don't want to be a loner. I always sit next to my friends and we help one another whenever we have problems with our class work on our computers. We don't laugh at each other when we make mistakes and our teacher likes that too. [Student 1.3]

In an interview that followed one of my classroom observations, the teacher noted that using an open seating arrangement was an advantage when using multimedia.

> Multimedia gives me the advantage of ensuring that learning experiences provide opportunities for students to collaborate with and learn from each other. This is best achieved if students are sat with friends that they can share their ideas with. [Teacher 1]

With respect to autonomy and independence, the narratives also differed in terms of the pace of progress that was made by the students in the two groups. In classes that were not frequently exposed to multimedia, the pace of the progress was determined largely by the teacher and the speed at which the other students in the class progressed. In contrast, the pace and progress of students in the class that was frequently exposed to multimedia was not determined by either the teacher or the pace of other students but, rather, it was set by the students themselves. For example, while the teacher was attending to behavioural problems during the first narrative, a student who had finished the starter questions written on the board asked, "Sir, I have finished. What do you want me to do next?" [Student 2.1]

In follow-up interviews, the three teachers who were interviewed all agreed that, in classes that were not frequently exposed to multimedia, it was better to give students a limited number of exercises at a time to allow the teacher to monitor the students' progress and to give feedback on what they were doing. One of the teachers commented:

> For these classes [not frequently exposed to multimedia], I always give students a few exercises at a time. The advantage of doing this is to make sure that they all do the work and that they all get feedback as we go. If students are working at different paces, they tend to ignore me when I correct them. [Teacher 3]

When students who were in classes that were not exposed frequently to multimedia were asked whether they liked this lesson format, they generally were positive about how their lessons were conducted. One student responded:

> I like my teacher to correct me as I go. It does not make sense for me to continue working even if I am not getting the answers right. My teacher allows us to work and revise every question we do. [Student 1.7]

In contrast, the students in class that were frequently exposed to multimedia were given more autonomy and flexibility in terms of the lesson activities and speed at which they could progress. The second narrative depicts students getting into their classroom and logging onto a mathematics-related website of their choice. At the end of the same narrative the teacher acknowledged and commended students who were working on extension tasks while the others were still working on the assigned tasks. In this respect, students were able to work at different paces. All of the teachers who

were interviewed agreed that students in classes that were frequently exposed to multimedia were more likely to work at different paces than those who were not. To this end, one teacher said:

> One advantage of using multimedia is that my students can progress at different paces giving me the opportunity to individualise the needs of specific students and to implement individual educational programmes. In this way, one student's progress does not hinder another student's progress. [Teacher 2]

In terms of autonomy and flexibility, the narratives also highlighted differences in the way in which students in the two groups received feedback. Observations indicated that the students who were frequently exposed to multimedia were able to receive real-time feedback about their work. For example, the answers to the computer generated questions were displayed on the interactive whiteboard immediately after the last question. Another example, described in the narrative, was when, towards the end of the lesson, the teacher remotely (electronically) supervised, monitored and provided immediate feedback about students' progress as they worked at different paces. The narrative described the teacher, relying on real time information obtained from his computer, commending students who were on task or had commenced the extension task and castigated students who were off task.

In contrast, students in classes that were not frequently exposed to multimedia classes were reliant on the teachers' presence for feedback. Observations indicated that the students were required to either wait for the teacher to write the answers on the board or for the teacher to make his or her routine checks while they were doing their work. These students were more likely to have to wait for the feedback from the teacher which was generally provided either orally or written on the whiteboard.

Therefore, the degree of autonomy and flexibility for students in classes that were frequently exposed to multimedia, when compared to those who were not, differed in terms of the seating arrangements, speed at which students could progress with their work, time it takes to get feedback and the degree of independence given to students during the lesson. Perhaps these differences, given that they would influence the environment created by the teacher, might explain some of the differences in student scores on the learning environment and engagement surveys. For example, it is possible that students, who were working more independently, were more focused on what they needed to get done (*Task Orientation scale*). It is also possible that students who received real-time feedback and were able to work at a pace that suited them would be more goal orientated (*Learning goal Orientation scale*), feel that they were better supported by the teacher (*Teacher Support scale*) and were more focused on what they needed to get done (*Task Orientation scale*). It is worth noting that, while autonomy and flexibility influenced the themes that followed, they were also influenced by these other themes.

Interpersonal (Classroom) Relationships and Collaboration. Another perceptible difference between the two groups, noted during the observations and interviews, was the behaviour of the students and, in particular, the interpersonal relationships between the students and between the students and the teacher. Observations suggested that the students in classes that were frequently exposed to multimedia had more positive interpersonal relationships than those in classes that were not.

The observations, described in the narratives, indicated that the interactions between students and the teacher were different for students frequently exposed to multimedia

and those who were not. Observations indicated that, in general, the students in classes that were frequently exposed to multimedia were more respectful towards the teacher. For example, students in classes that were frequently exposed to multimedia were more likely to greet their teacher as they entered their classroom. In addition, notes from the field indicated that the tone of the conversations between the students and their teachers was more respectful in classes that were frequently exposed to multimedia than in classes that were not. For example, according to my field notes, a student from a class frequently exposed to multimedia responding to his teacher who had asked if he was able to solve the question that the teacher had posed, said "No, thanks for asking. Could you please help me by explaining what is actually being asked?"

In contrast, observations of classes that were not frequently exposed to multimedia indicated more strained relationships between the students and the teacher. For example, students who were in classes not frequently exposed to multimedia were more likely to talk back to the teacher. For example, in one class that I observed, a student kept leaving his seat during the lesson and distracting other students with paper planes. The teacher tried to send him to the 'out of class isolation' room (a room set aside for disruptive students to cool down and to reflect on their actions), but the student refused to go telling the teacher that he had the right to learn and going to 'out of class isolation' would disadvantage him. The Head of Department was required to be called to assist with removing the student from the room. Such incidents were not isolated cases in classes that were not frequently exposed to multimedia. My observations also indicated that students talked back to the teachers

more frequently and were more likely to be rude to the teachers than in classes that were frequently exposed to multimedia.

In all of the classes that I observed that were not frequently exposed to multimedia, the manner in which a majority of the students talked to the teachers or responded to questions bordered on being rude or disrespectful. For example, when asked by the teacher to stop writing on the desk, one student whose class was not frequently exposed to multimedia responded, "For Christ's sake, leave me alone! Pick on somebody else for a change!" [Student 2.4]

All of the teachers who were interviewed agreed that the students' behaviours towards the teachers in classes where students were not frequently exposed to multimedia, was less than acceptable or desirable than those in classes that were frequently exposed to multimedia. One of the teachers commented:

It is a different experience altogether [teaching in class where students are not frequently exposed to multimedia]. These students [in class not frequently exposed to multimedia] have no respect for teachers. They are just rude and arrogant. I think the school's behaviour system is failing to reign in such bad behaviour. I wish I were teaching all my lessons in the computer lab [in which students are frequently exposed to multimedia] where students attention is more focused. [Teacher 3]

The two narratives portrayed students as relating to each other quite differently. Observations suggest that the students who were in classes that were frequently exposed to multimedia were more likely to share their ideas and to collaborate with each other. As portrayed in the narratives, students in classes that were frequently

exposed to multimedia discussed their ideas and supported one another in their groups. My observations of classes exposed frequently to multimedia indicated that there was more camaraderie and support between students during the class activities than in classes that were not frequently exposed to multimedia. For example it was not uncommon in classes frequently exposed to multimedia to observe pairs of students working together to solve mathematical problems. In contrast, in classes that were not frequently exposed to multimedia, this seldom occurred, with students more likely to work independently or to ridicule fellow students who answered questions.

My observations suggested that students in classes that were frequently exposed to multimedia were more likely, during classroom activities, to collaborate on tasks and discuss their ideas with their class mates. All of the students who were interviewed confirmed that they did their classwork together and shared their thoughts when solving their work with their friends in class. To this end, one of the students (from a class frequently exposed to multimedia) said: "I always sit next to my friends and we help one another whenever we have problems. …" [Student 2.3]

In contrast, my observations suggested that students in classes that were not frequently exposed to multimedia were less likely to show camaraderie towards their classmates. The first narrative (about a class not frequently exposed to multimedia), described a student asking the teacher to move another student away because the student allegedly copied him. My observations revealed other incidences of negative interactions. For example, when waiting to go to the classroom, I overheard one student threatening to beat up another student for collecting a soccer ball from the office when it was not his job. I also observed students in the classroom provoking

and antagonising others during the lessons. For example, knowing very well that it would upset others, a student was observed calling other students names and telling them that they were 'fat' and that they were 'losers'. Students were also observed to be frequently rude to each other and to the teacher.

Such interactions are likely to lead to more negative student to student relationships in the class, as opposed to developing cohesiveness or friendships among the students. When asked why the student to student relationships were different for the two groups, all three of the teachers who were interviewed indicated that much of this was caused by frustrations related to the lack of multimedia. Talking of his class that was not frequently exposed to multimedia, one of the teachers said:

> My view is that, if all the classes at this school had sufficient computers for all of the students, then these relations would improve; because multimedia impacts positively on students' behaviour towards each other by keeping them away from classroom distractions. Students who have moved to the other side of the timetable (the side of the timetable that allows students to have more than three class periods in the computer laboratory) appear to have improved their relations with their classmates. [Teacher 1]

It would appear that these differences in interpersonal relationships between students and between the students and the teachers may have brought with them differences in students' perceptions of the learning environment and engagement in mathematics. It is possible that, students who feel socially accepted and are supported by their peers are likely to perceive greater acceptance (*Student Cohesiveness scale*), and that this would lead to increased participation in classroom discussions (*Involvement scale*)

and improved collaboration between peers (*Cooperation scale*). These relationships and improved involvement might also lead to a more positive belief in their capabilities to perform tasks (*Self-Efficacy scale*). It is possible that the improved relationships between the students and their teacher, observed in classes that were frequently exposed to multimedia, would lead to more positive views of the extent to which the teacher was supportive, approachable and interested in their problems (*Teacher Support and Equity scale*).

Student Engagement and Involvement in Activities and Tasks. The third theme that emerged during my analysis of the qualitative data were the differences between the two groups in terms of their engagement and involvement in class activities. My observations indicated that students in classes that were frequently exposed to multimedia were more likely to be engaged and involved in classroom activities and tasks than those who were not. Without exception, in the classes that were frequently exposed to multimedia, I observed the students to be generally interested in what they were doing and having more opportunities for discussions than in classes that were not. All of the teachers' who were interviewed were in agreement that multimedia in the mathematics lesson served to hold the students' attention. To this end, one teacher remarked: "Multimedia excites students' interest and curiosity as it brings mathematical problems to life for students of all abilities." [Teacher 1]

In addition, the teachers who were interviewed all agreed that students in classes that were frequently exposed to multimedia had lower disruptive tendencies than those whose classes were infrequently exposed to multimedia. According to one of the

teachers, "Multimedia helps to keep students on task by keeping them away from distractions and the bad influence of others." [Teacher 2]

Observations of the lessons indicated that students who were frequently exposed to multimedia exhibited behaviours that suggested that they were enthusiastic about their learning, including, actively participating in the learning process, going beyond what the teacher had instructed, and tackling extension tasks (especially when they were working on their iPads and computers).

For students who were frequently exposed to multimedia, my observations, as depicted in the narrative, showed that, as soon as students arrived for the lesson, they moved to a computer (without instruction from the teacher) and opened up a mathematics-based programme (in most cases this was mathletics). Some of the programmes appeared to involve a competitive element. Judging by the banter between students, during and after the use of these programmes, it was apparent that they enjoyed working on these. It was noted that much of the banter came from the male students, suggesting perhaps that they enjoyed this element of the activities more than their female counterparts. I noticed that the students' were rarely off-task during these activities and that the activity appeared to hold the students' attention.

My observations of classroom discussions indicated that students who were in classes that were frequently exposed to multimedia differed from those who were in classes that were not frequently exposed to multimedia in terms of their involvement in classroom discussions. For example, during class discussions, as reflected by the narratives, students in classes that were frequently exposed to multimedia were

observed putting up their hands and were forthcoming with ideas, suggestions and answers to questions. In contrast, the observations in classes that were not frequently exposed to multimedia was that, for whatever reason, the students were generally reluctant to discuss their ideas openly, answer questions and appeared reluctant to engage in class discussions. For example, as described in the first narrative, the students did not raise their hands during the discussion. When the teacher asked a student, whose hand was not raised to respond to a question, the student responded correctly, indicating that, even though he knew the answer, he was, unwilling to offer it to the class. In another example, during the classroom discussion, a student threw her writing equipment out of the window and, a little later, said, "Sir, I don't know who threw my pencil case outside. May I please go and collect it?" [Student 2.4]

The teachers who were interviewed all agreed that students in classes not frequently exposed to multimedia were likely to avoid joining or contributing to discussions. To this end one of the teachers said:

> This class is rather passive. Discussions in the class are a little dull. They don't like raising their hands either to ask or respond to questions. In most cases I rely on their individual work to check on their understanding of concepts. [Teacher 1]

Students in classes that were frequently exposed to multimedia were more likely to be involved in classroom discussions. In these classes, students were more willing to participate in classroom discussions. Further, the observation described in the narrative, of students supporting other members of their group and their refusal to accept the teachers' wrong answer, would suggest that the students involved themselves more deeply in class discussions.

The nature of questioning and the way in which students responded to the questions that were computer generated also appeared to contribute to holding the attention of students in classes that were frequently exposed to multimedia. These students were given starter questions that were generated by the computer and projected onto the whiteboard. As the students were responding, the questions would appear automatically, one after the other until the last one. In order to be able to respond to the questions and to keep pace with the questions, the students (frequently exposed to multimedia) had to pay attention and stay focused on what they were doing.

The classroom observations, portrayed in the narratives, indicated that there were differences in types of activities that were available to the teacher and the students in the two groups. Observations indicated that, in classes that were frequently exposed to multimedia, activities involved working in small groups, discussing ideas as a class and individually consolidating their knowledge by using computer programmes. It was not unusual to see students in classes that were frequently exposed to multimedia, going out of their classrooms, to shoot videos of natural phenomenon taking place. For example, I observed a year 11 class taking videos of paths followed by moving objects and taking these back to class to find mathematical properties of such paths. In contrast, the activities available to students in classes that were not frequently exposed to multimedia were largely comprised of work written on the white board or on handouts.

During many of the observations that I made in classes that were frequently exposed to multimedia, students were provided with challenge games (such as multiplication challenges) that were played on their computers. Such challenge competitions were

often used at the beginning (described in the narrative) and end of the lesson. These challenges appeared to excite the students who were keen to beat their friends. Other challenges made available to the students who were in classes frequently exposed to multimedia involved tasks that enabled students to progress in their learning (without limiting the progress of the other students in the completion of their tasks) such as extension activities that were available if they finished early.

The students who were interviewed generally agreed that having a range of activities helped to keep them interested in that mathematics classes. To this end, one of the students said:

> Even if the teacher is away, I always have something to do. In this class [frequently exposed to multimedia], I am not starved of work to do. I can log onto Mathletics, do 'Mr Farmer's 10 quick questions', do 'challenges' with a friend or if I want to do my work alone, I can log onto the 'Khan Academy' [an online programme that delivers free mathematics resources to students]. [Student 1.3]

In contrast, the activities carried out by students in classes that were not frequently exposed to multimedia were generally restricted to the work that the teacher had photocopied or instructed. My observations indicated that, in these classes, students generally worked from their textbooks. During class exercises, my observations suggested that the students in these classes were less enthusiastic towards their activities than their counterparts in classes frequently exposed to multimedia

Observations indicated that the teachers used different motivation strategies for the students in the two groups. For the students in the classes that were not frequently

exposed to multimedia, the teachers relied more heavily on extrinsic motivation rewards. In these classes, the teachers were more likely to use 'stars' or 'goldies', to motivate the students and to acknowledge and encourage them to continue doing their work. In contrast, in the classes that were frequently exposed to multimedia the teachers were more likely to use verbal praise as opposed to extrinsic rewards to motivate students. In these classes, phrases such as 'well done!' or 'good job' were used more often.

My observations, depicted in the narratives, indicated that the students in classes frequently exposed to multimedia tended to be more determined to complete their class tasks than their counterparts who were not. For example, when the bell rung to signal the end of the lesson, the students in classes that were frequently exposed to multimedia kept working and had to be reminded by their teacher to pack their bags and go to their next lesson. In contrast, in classes infrequently exposed to multimedia, when the bell rung, the students began packing their bags and making moves to leave the classroom even if the teacher was still talking to them.

The teachers who were interviewed all agreed that students in classes frequently exposed to multimedia were more task-persistent in their learning. To this end, one of the teachers commented:

…The advantage of using multimedia is that students are willing to spend more time, effort and persist longer towards completing their activities. I design my lessons for this class with multimedia in mind to excite their interest and stimulate their love for the subject [Teacher 1].

Interviews with students indicated that the students in classes that were frequently exposed to multimedia enjoyed being in their classes. To this end, one of the students said:

> I like being in this class because it is fun. Computers explain and produce pictures that help me understand the maths topics more thoroughly and if I don't understand a question, I can repeat the question again without bothering the teacher. [Student 1.9]

Such differences in class activities may have brought with it differences in students' perceptions of the learning environment and engagement levels. The increased engagement and involvement in activities, in classes frequently exposed to multimedia, may serve to explain differences in students' scores on the WIHIC. For example, the increased discussions between students in classes with multimedia (possibly influenced by the improved interactions in these classes discussed in the previous section) may have influenced the Involvement and Cooperation scales. Intuitively, it would make sense for these differences to influence students' scores on the SALEM. The increased levels of interest and enthusiasm towards activities were likely to have influenced all four of the engagement scales. For example, in classes that were exposed to multimedia the students' felt that the activities helped them to understand the topic more clearly. Therefore it is likely that the students in these classes will also value the activities more (*Task Vale scale*). My observations of classes, and subsequent interviews with teachers and students indicated that, in classes exposed to multimedia there were fewer distractions resulting from disruptive behaviour and more positive interactions between class members, leading to a learning environment in which students might tend to be more goal orientated

(*Learning Goal Orientation scale*). Further, access to multimedia tools gave the teachers the means to set tasks that allowed students to work independently and at their own pace, providing opportunities for students to set themselves challenges and persist in reaching these goals (*Self-Regulation scale*).

My findings indicate that there were three overarching differences between classes exposed to multimedia and those that were not, these being: the degree of autonomy and flexibility afforded to students; the interpersonal relationships and extent to which the students collaborated; and the involvement during the class activities. These observable differences between the two classes helped to explain differences in students' scores on the WIHIC and SALEM.

4.4   Differences between Males and Females for Students Frequently Exposed to Multimedia

The third research objective was to:

To examine whether differences exist for male and female students who were frequently exposed to multimedia in mathematics classes in terms of: a) perceptions of the learning environment; and b) engagement in mathematics.

To examine whether differences exist for male and female students in classes that were frequently exposed to multimedia, the subsample of 197 students in nine

mathematics classes was used. This subsample drawn from the larger sample of 365 students included 107 male students and 90 female students.

As discussed previously, the data analysis procedure used to compare the group means (in this case student sex formed the group) was multivariate analysis of variance (MANOVA). In general, the significance level adopted for all influential tests of significance was 0.05. Because of the different numbers of male and female students frequently exposed to multimedia, the in class sex mean was used to provide a comparison of the scores for male and female students. The set of six WIHIC scales (Student cohesiveness, Teacher Support, Involvement, Task Orientation, Cooperation and Equity) and four SALEM scales (Learning Goal Orientation, Task Value, Self-Efficacy and Self-Regulation) constituted the dependent variables whilst sex (male and female) was the independent variables. Because the MANOVA produced statistically significant results using Wilks' lambda criterion, the univariate ANOVA results were interpreted for each of the ten dependent variables (reported in Table 4.6).

The MANOVA results, reported in the last column of Table 4.6, show that there were no statistically significant sex differences for students' perceptions of the learning environment. However, for student engagement, there were statistically significant differences between male and female students who were exposed to multimedia for Task Value ($N= 197$, $F= 8.03$, $p<0.01$, effect size = 0.41 standard deviations, $r_{Y\lambda} = 0.20$) and Self-Efficacy ($N= 197$, $F= 4.47$, $p<0.05$, effect size = 0.34 standard deviations, $r_{Y\lambda} = 0.17$). Both scales have a statistically significant difference; males scored higher than female students. The results indicated portrayed that male

and female students, in classes frequently exposed to multimedia, perceive the learning environment in relatively similar ways. Although there are some differences in the average item mean, these are not statistically significant. In terms of engagement, males and females portray similar levels of engagement for Learning Goal Orientation and Self-Regulation. However, as explained earlier, male students in classes exposed to multimedia scored statistically significantly higher for Task Value and Self-Efficacy.

Table 4.6   Average Item Mean, Average Item Standard Deviation and Sex Difference (Effect Size and One-Way MANOVA Results) for Students Frequently Exposed to Multimedia for each Environment and Engagement Scale

Scale	Average Item Mean		Average Item Standard deviation		Difference Between Male and Female students exposed to multimedia	
	Male	Female	Male	Female	Effect Size	*F*
Learning Environment						
Student Cohesiveness	4.11	4.19	0.57	0.55	-0.14	0.97
Teacher Support	3.50	3.54	0.77	0.68	-0.06	0.12
Involvement	3.35	3.21	0.69	0.69	0.20	1.98
Task Orientation	4.02	4.01	0.53	0.60	0.02	0.00
Cooperation	3.72	3.75	0.61	0.63	-0.05	0.14
Equity	3.74	3.76	0.67	0.74	0.03	0.04
Engagement						
Learning Goal Orientation	4.29	4.18	0.51	0.47	0.22	2.47
Task Value	3.98	3.75	0.58	0.55	0.41	8.03**
Self-Efficacy	3.94	3.77	0.56	0.56	0.34	4.47*
Self-Regulation	3.90	3.81	0.61	0.63	0.14	1.09

N= 197 students in 9 classes of which 107 were males and 90 were females.
*p<0.05   **p<0.01
Effect size was calculated using the following formula: $d = M_1 - M_2 / \sqrt{[(\sigma_1^2 + \sigma_2^2)/2]}$, $r_{Y\lambda} = d/\sqrt{(d^2+4)}$

4.5   Differential Effectiveness of Exposure to Multimedia for Different Sex

Whereas Section 4.3 examined differences between students' perceptions of the learning environment and their engagement for those who were in classes frequently exposed to multimedia and those who were not, and Section 4.4 reported that male and female students in classes that were frequently exposed to multimedia held statistically significant differences in their perceptions of two of the 10 scales, this section examines whether exposure to multimedia was differentially effective for male and female students. To this end the fourth research objective was:

To examine whether exposure to multimedia in mathematics classes was differentially effective for male and female students in terms of: a) perceptions of the learning environment; and b) student engagement in mathematics.

Previously, Section 4.3 reported the use of a one-way MANOVA in exploring differences between classes that were frequently and not frequently exposed to multimedia in terms of the six learning environment scales and four engagement scales. In contrast, this section reports the use of a two-way MANOVA aimed at identifying the differential effectiveness of these classes according to student sex.

For the two-way MANOVA, the results for which are reported in Table 4.7, the independent variables were the type of class (frequently or not frequently exposed to multimedia) and sex, and the dependent variables were the six learning environment scales and the four engagement scales. The sample of 365 students (191 of whom were males and 174 of whom were females) in 16 classes was used for analysis. Because the two-way MANOVA, using Wilks' lambda criterion, yielded significant

differences for the three effects (exposure to multimedia, student sex, and exposure to multimedia-by-student sex), the univariate ANOVA was interpreted for each dependent variable for each of the three effects. The type of effect size used for reporting the strength of association between each effect for both the WIHIC and SALEM scales was the eta^2 statistic, which is an estimate of the proportion of variance accounted for. The results for the exposure to multimedia (Section 4.4.2.1), student sex (Section 4.4.2.2) and interaction between exposure to multimedia and sex (Section 4.4.2.3) are reported below.

Table 4.7   Two-Way MANOVA/ANOVA Results (F and Eta^2 statistic) for Exposure to Multimedia and Sex for each Scale of the WIHIC and SALEM

| | Two-Way ANOVA Results | | | | | |
| Scale | Exposure to Multimedia | | Sex | | Exposure to Multimedia x Sex | |
	F	Eta^2	F	Eta^2	F	Eta^2
Learning Environment						
Student Cohesiveness	30.81**	0.08	2.52	0.01	0.18	0.00
Teacher Support	82.95**	0.19	3.38	0.01	1.94	0.01
Involvement	85.68**	0.19	0.00	0.00	3.82*	0.01
Task Orientation	139.49**	0.28	4.40*	0.01	4.64*	0.01
Cooperation	55.79**	0.13	2.37	0.01	1.10	0.00
Equity	88.86**	0.20	8.62**	0.02	7.17**	0.02
Student Engagement						
Learning Goal						
Orientation	222.44**	0.38	1.67	0.01	8.72**	0.02
Task Value	223.49**	0.38	0.07	0.00	12.24**	0.03
Self-Efficacy	108.58**	0.23	0.06	0.00	8.18**	0.02
Self-Regulation	145.53**	0.29	0.06	0.00	2.28	0.01

*$p<0.05$ **$p<0.01$
N= 365 students in 16 classes
Eta^2 represents the proportion of variance in a dependent variable explained by an independent variable.

4.5.1   Exposure to Multimedia

The results reported in Table 4.7 for the two-way ANOVAs (with control for sex) reflect the results of the previous one-way ANOVAs ignoring sex (refer to Section 4.3). In both cases, statistically significant ($p<0.01$) differences were found between students frequently exposed to multimedia and those who were not for all six WIHIC scales (Student Cohesiveness, Teacher Support, Involvement, Task Orientation, Cooperation, and Equity) and four SALEM scales (Learning Goal Orientation, Task Value, Self-Efficacy, Self-Regulation). The eta² statistics show that the amount of variance in scores accounted for by exposure to multimedia ranged from 0.08 to 0.28 for the WIHIC scales and from 0.23 to 0.38 for the SALEM scales.

4.5.2   Sex

For the sample of 365 students, this portion of the MANOVA/ANOVA focused on whether differences exist between males and females regardless of their exposure to multimedia. As shown in Table 4.7, statistically significant differences exist between females and males for two WIHIC scales of Task Orientation ($p<0.05$) and Equity ($p<0.01$), with male students perceiving both scales more favourably than their female counterparts. The proportion of variance for these significant differences (eta²) was 0.01 to 0.02, respectively. Interactions exist between exposure to multimedia and sex for Involvement, Task Orientation, Equity and three of the four SALEM scales (the exception being Self-Regulation), as shown in Table 4.7, these differences are discussed separately in Section 4.5.3.

To better understand the differences between sexes, Table 4.8 shows the average item mean and average standard deviation for males and females for both the

learning environment scale and student engagement scale. Examination of the average item means in Table 4.8 clarifies the direction of the sex differences. Females scored statistically significantly higher for Task Orientation and Equity scales.

4.5.3   *Interaction between Exposure to Multimedia and Sex*

Information about the differential effectiveness of exposure to multimedia for male and female students was obtained by examining the interactions between exposure to multimedia and sex, identified through the two-way ANOVAs. The results for the interaction between exposure to multimedia and sex with respect to the learning environment and the interaction between exposure to multimedia and sex with respect to engagement are reported in Table 4.7. The average item mean, reported in Table 4.8, can be used in the interpretation of the statistically significant interactions between exposure to multimedia and sex. The section reports the statistically significant interactions between exposure to multimedia and sex scales (Section 4.5.3.1) and student engagement (Section 4.5.3.2)

Table 4.8   Average Item Mean, Average Standard Deviation for Males and Females Using the Individual as the Unit of Analysis.

Scale	Average Item Mean		Average Item Standard Deviation	
	Males	Females	Males	Females
Learning Environment				
Student Cohesiveness	3.93	4.02	0.66	0.68
Teacher Support	3.14	3.24	0.91	0.75
Involvement	3.00	2.96	0.81	0.71
Task Orientation	3.62	3.71	0.75	0.70
Cooperation	3.46	3.54	0.73	0.66
Equity	3.33	3.51	0.84	0.77
Student Engagement				
Learning Goal Orientation	3.77	3.80	0.88	0.72
Task Value	3.48	3.41	0.83	0.66
Self-Efficacy	3.56	3.53	0.75	0.66
Self-Regulation	3.46	3.43	0.85	0.80

N= 191 males and 174 females

4.5.3.1   Interaction between Exposure to Multimedia and Sex with Respect to the Learning Environment

The results, reported in Table 4.7, indicate that, with respect to the learning scales, a statistically significant interaction ($p<0.05$) between exposure to multimedia and sex emerged for three of the six WIHIC scales, namely, Involvement, Task Orientation, Equity. Therefore, the independent interpretations of exposure to multimedia differences and sex differences are valid for all other scales except these three. For the statistically significant interactions, Involvement, Task Orientation, Equity, the amount of variance accounted for was 0.01, 0.01 and 0.02, respectively.

The interpretation of the interaction ($p<0.05$) for the Involvement scale (Figure 4.2) is that males perceived more Involvement than their female counterparts in classes that were frequently exposed to multimedia. However, females perceived higher

levels of Involvement than their male counterparts in classes that were not frequently exposed to multimedia.
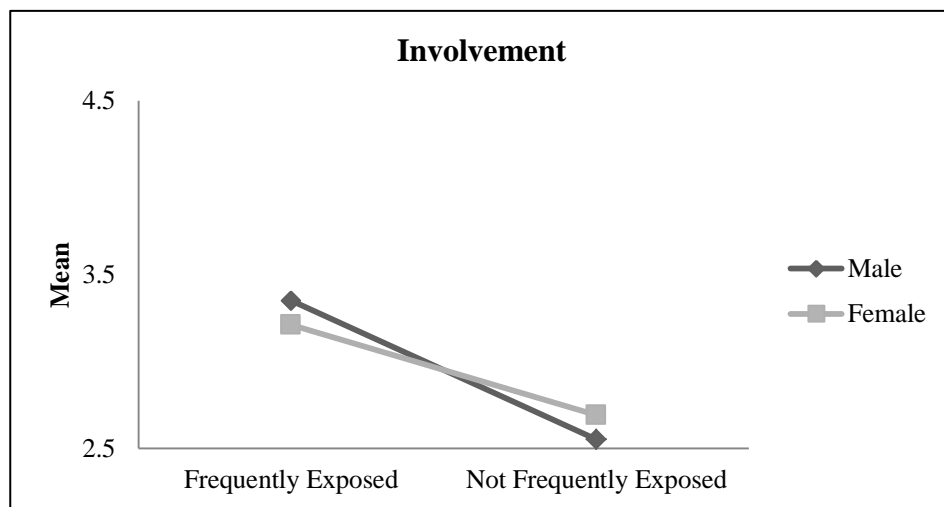
Figure 4.2   Interactions between Exposure to Multimedia and Sex for Involvement

The interpretation of the exposure to multimedia-by-sex interaction for Task Orientation ($p<0.05$, eta^2 = 0.01) and Equity ($p<0.01$, eta^2 = 0.02) suggests that both male and female students in classes that were frequently exposed to multimedia had similar perceptions for both of these scales. However, in classes that are not frequently exposed to multimedia, females perceived more Task Orientation (Figure 4.3) and more Equity (Figure 4.4) than their male counterparts.

Figure 4.3   Interactions between Exposure to Multimedia and Sex for Task Orientation
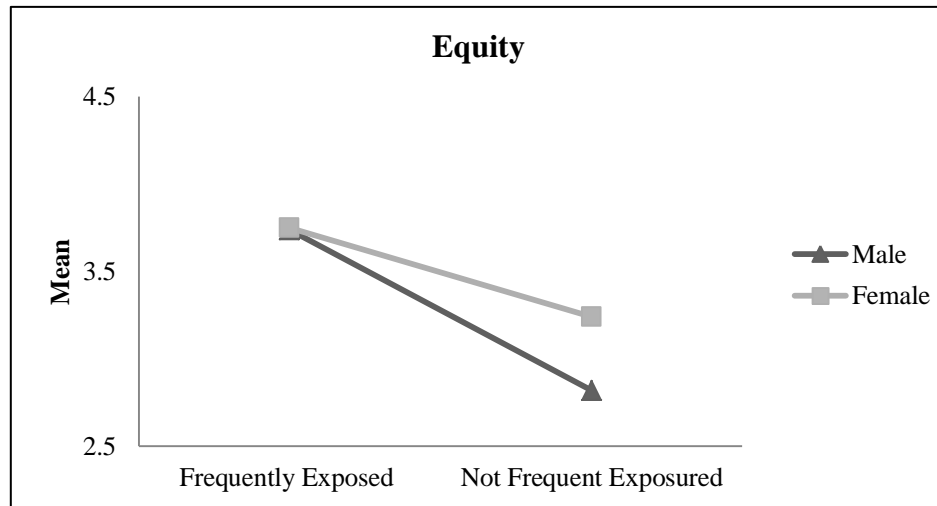
Figure 4.4   Interactions between Exposure to Multimedia and Sex for Equity

4.5.3.2   *Interaction between Exposure to Multimedia and Sex with Respect to Engagement*

The results reported in Table 4.7 indicate that a statistically significant interaction between exposure to multimedia-by-sex existed for three of the four SALEM scale, namely, Learning Goal Orientation ($p<0.01$), Task Value ($p<0.01$) and Self-efficacy ($p<0.01$). Therefore, independent interpretation of exposure to multimedia by sex differences was only valid for Self-Regulation. For the statistically significant interactions, Learning Goal Orientation, Task Value and Self-efficacy, the amount of variance accounted for was 0.02, 0.03 and 0.02, respectively.

Again, the average item means, reported in Table 4.8, were used in the interpretation of the statically significant interactions between exposure to multimedia and sex. For all three engagement scales, the interpretation for the interactions was similar. In classes that are frequently exposed to multimedia, males perceived a greater sense of Learning Goal Orientation (Figure 4.5), Task Value (figure 4.6), and Self-Efficacy

(Figure 4.7) than the females. However, in classes not frequently exposed to multimedia, female students perceived a greater sense of Learning Goal Orientation, Task Value and Self Efficacy than their male counterparts. Graphical representations of the exposure to multimedia-by-sex interactions for the three engagement scales of Learning Goal Orientation, Task Value and Self-efficacy are provided in Figure 4.5, 4.6 and 4.7, respectively.
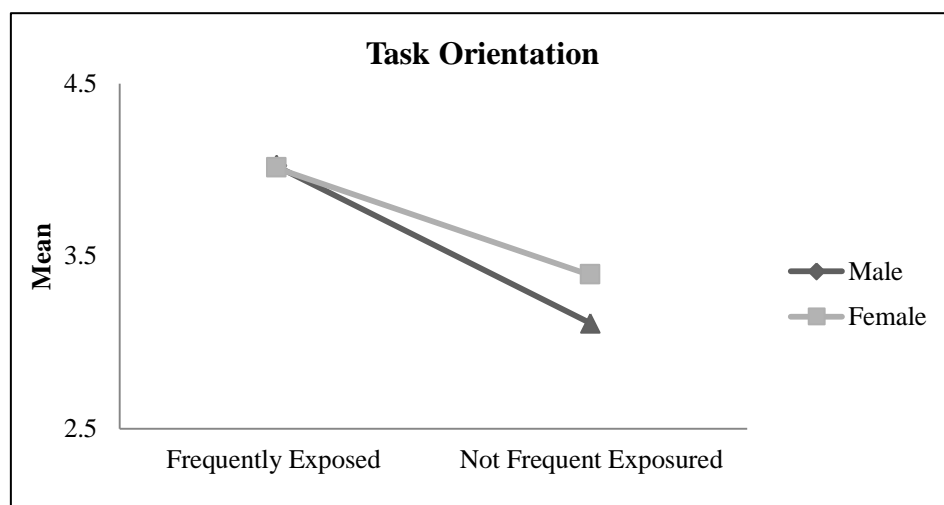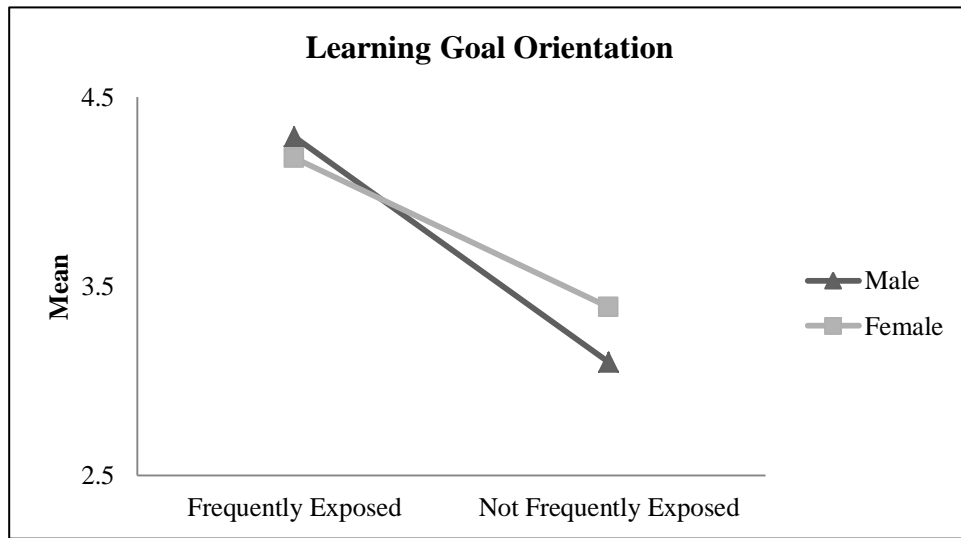

Figure 4.5   Interactions between Exposure to Multimedia and Sex for Learning Goal Orientation
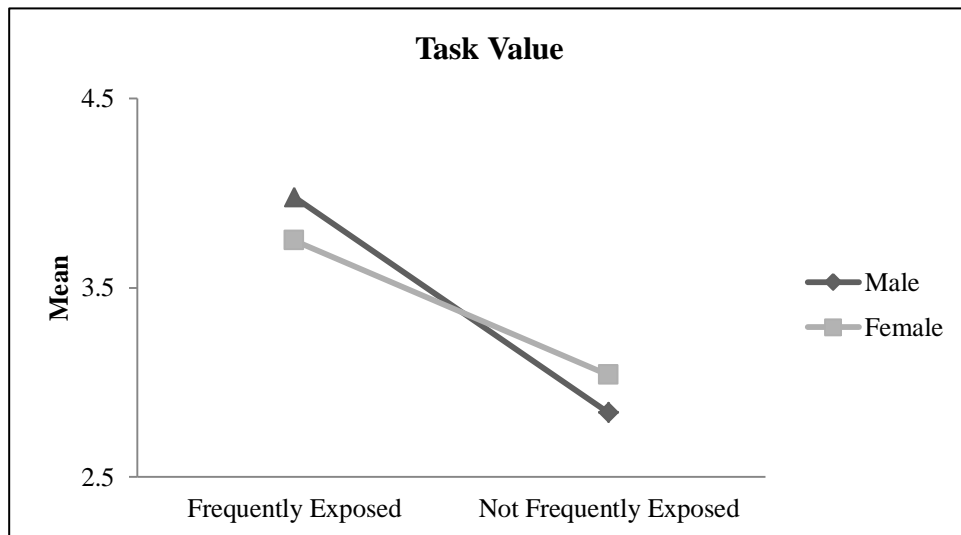
Figure 4.6   Interactions between Exposure to Multimedia and Sex for Task Value
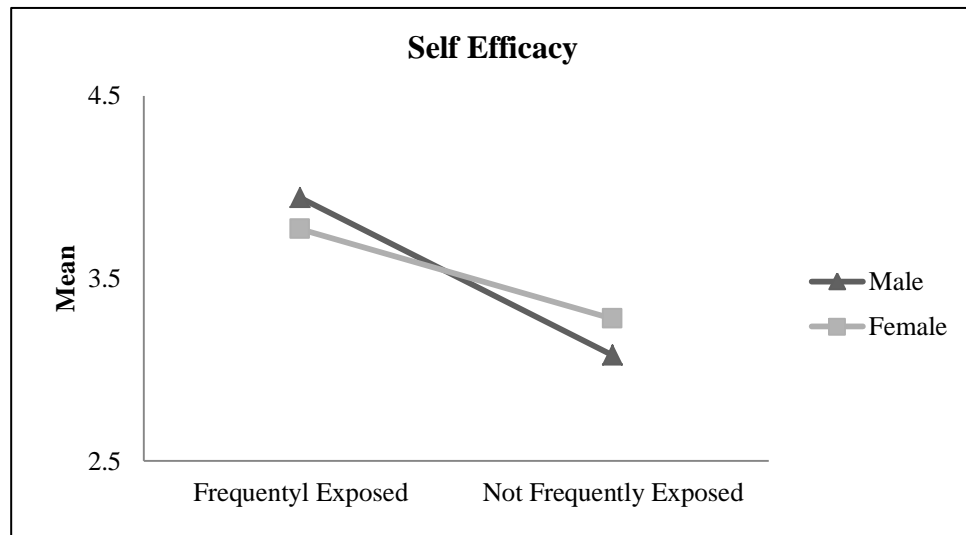
Self Efficacy

Figure 4.7   Interactions between Exposure to Multimedia and Sex for Self-Efficacy

4.6   Associations between the Learning Environment and Student Engagement for Students Frequently Exposed to Multimedia

Using data from a sub-sample of 197 students in 9 classes that were frequently exposed to multimedia, simple correlation and multiple regressions were used to examine whether relationships for students who were frequently exposed to multimedia existed between their perceptions of the learning environment and their engagement. These analyses were used to answer the fifth research objective which was:

To investigate whether, for students who were frequently exposed to multimedia, there was a relationship between students' perceptions of the learning environment and their engagement in mathematics.

Simple correlation analysis was used to examine the bivariate relationship between each engagement scale of the SALEM and the environment scale of the WIHIC

using the individual and class mean as the unit of analysis. Multiple regression analyses (R) were used to determine the joint influence of the set of modified WIHIC scales (as independent variables) and the individual SALEM scales (as dependent variables), using the individual and the class mean as the units of analysis. Multiple regression analysis provided a more parsimonious picture of the joint influence of correlated learning environment scales on engagement and reduced the Type I error rate. To identify which of the learning environment scales contributed uniquely and significantly to the explanation of the variance in students' engagement, standardised regression coefficients (β) were examined. The multiple regression analysis was carried out separately for reach SALEM scale and for the same two units of analysis. Simple correlations (r) and multiple regression analysis were calculated for two units of analysis, namely, the individual and the class mean.

The results of the simple correlation and multiple regression analysis are reported in Table 4.9 and expanded on under the following subheadings: Learning Goal Orientation (Section 4.5.1); Task Value (Section 4.5.2); Self-Efficacy (Section 4.5.3); and Self-Regulation (Section 4.5.4).

4.6.1 *Learning Goal Orientation*

The results of the simple correlation indicate that, with one exception (for the individual as the unit of analysis), there were statistically significant ($p<0.01$) and positive relationships between Learning Goal Orientation and all six scales of the WIHIC (Student Cohesiveness, Teacher Support, Involvement, Task Orientation, Cooperation and Equity, Task Orientation, and Equity) and for both the individual

191

and class mean as units of analysis. (The only exception was Equity when using the individual as the unit of analysis.)

Table 4.9   Simple Correlation and Multiple Regression Analysis for Associations between student Engagement and Classroom Environment for Two Units of Analysis

Scale	Unit of Analysis	Engagement-Environment Associations							
		Learning Goal Orientation		Task Value		Self-Efficacy		Self-Regulation	
		r	*β*	*r*	*β*	*r*	*β*	*r*	*β*
Student Cohesiveness	Individual	0.26**	0.02	0.18**	-0.04	0.21**	-0.03	0.19**	-0.04
	Class	0.78**	-0.45	0.74**	-0.52	0.81**	-0.23	0.80**	-0.41*
Teacher Support	Individual	0.42**	0.07	0.46**	0.17**	0.29**	-0.10	0.36**	0.06
	Class	0.88**	-0.21	0.88**	-0.18	0.83**	-0.08	0.85**	-0.43
Involvement	Individual	0.40**	0.03	0.44**	0.17**	0.43**	0.21**	0.33**	-0.02
	Class	0.93**	0.69	0.95**	1.24**	0.93**	0.93*	0.94**	1.02**
Task Orientation	Individual	0.67**	0.56**	0.58**	0.42**	0.54**	0.42**	0.72**	0.70**
	Class	0.92**	0.52	0.91**	0.57*	0.93**	0.79*	0.95**	0.92**
Cooperation	Individual	0.37**	0.03	0.32**	-0.02	0.35**	0.02	0.31	0.02
	Class	0.84**	0.20	0.80**	-0.01	0.85**	0.10	0.84**	-0.03
Equity	Individual	0.49	0.10	0.47**	0.03	0.40**	0.12	0.41	0.00
	Class	0.91**	0.17	0.89**	-0.21	0.86**	-0.57	0.89**	-0.17
Multiple Regression (R)	Individual		0.69**		0.62**		0.58**		0.72**
	Class		0.95**		0.98**		0.97**		0.99**

*p<0.05 **p<0.01
N=197 students in 9 classes

The multiple regressions (*R*) between the six environment scales of the WIHIC and Learning Goal Orientation (reported at the bottom of Table 4.9) was 0.69 with the individual as unit of analysis and 0.95 as the class mean as the unit of analysis. For both units of analyses, the multiple regression was statistically significant (*p<0.01*). To examine which scales were likely to contribute to variance in Learning Goal Orientation, the standardised regression coefficients (*β*) were examined. The results indicated that one scale, Task Orientation, was statistically significantly and positively related to Learning Goal Orientation at the individual level of analysis.

There were no statistically significant relationships between the environment and Learning Goal Orientation at the classroom level of analysis.

4.6.2   Task Value

The results of the simple correlation analysis, reported in Table 4.9, suggests that statistically significant ($p<0.01$) and positive relationships existed for all six scales of the WIHIC and Task Value for both the individual and class mean as the units of analysis.

The multiple regression (R) between Task Value and the set of the environment scales was statistically significant ($p<0.01$) for both units of analysis and was 0.62 for the individual as unit of analysis and 0.98 for the class mean as unit of analysis, suggesting associations between various learning environment scales and Task Value. With the individual as the unit of analysis, there were three WIHIC scales (Teacher Support, Involvement and Task Orientation) that were statistically significant ($p<0.01$) independent predictors of Task Value. For the class means as the unit of analysis two WIHIC scales (Task Orientation and Involvement) that were statistically significant ($p<0.01$) independent predictors of Task Value. The regression coefficient for those scales that were significant independent predictors of Task Value were all positive.

4.6.3   Self-Efficacy

Simple correlation analysis indicated that statistically significant ($p<0.01$) associations existed between the learning environment and Self-Efficacy. Table 4.9 shows that each of the six WIHIC scales (Student Cohesiveness, Teacher Support, Involvement, Task Orientation, Cooperation and Equity) were correlated positively and statistically significantly ($p<0.01$) with student Self-Efficacy with both the individual and the class mean as the unit of analysis.

The multiple regression (R) between the set of six environment scales and Self Efficacy are also shown in Table 4.9. The multiple correlations of the environment scales with Self-Efficacy was statistically significant ($p<0.01$) and 0.58 with the individual as the unit of analysis and 0.97 with the class mean as unit of analysis. With both the individual and class mean as the unit of analysis, two environment scales were statistically significant ($p<0.05$) and positive independent predictors of Self Efficacy, these being, Involvement and Task Orientation.

4.6.4   Self-Regulation

The results of the simple correlation indicated that, with the individual as the units of analysis, statistically significant ($p<0.01$) and positive correlations existed between four environment scales (Student Cohesiveness, Teacher Support, Involvement and Task Orientation) and Self-Regulation. With the class mean as the unit of analysis, statistically significant simple correlations ($p<0.01$) and positive relations existed

between all six environment scales (Student Cohesiveness, Teacher Support, Involvement, Task Orientation, Cooperation and Equity) and Self-Regulation.

The multiple correlation (R) between the set of six environment scales and Self-Regulation was statistically significant ($p<0.01$) for both units of analysis and was 0.72 for the individual unit of analysis and 0.99 with the class mean as the unit of analysis. The standardised regression coefficients showed that, with the individual as the unit of analysis, Task Orientation was a statistically significant ($p<0.01$) independent predictor of Self-Regulation and, with the class mean as the unit of analysis, Student Cohesiveness, Involvement and Task Orientation were statistically significant independent predictors of student Self-Regulation. With the exception of Student Cohesiveness, all other scales were positive predictors of Self-Regulation.

4.7   Chapter Summary

This chapter reported the results for each of the research objectives of the present study, including the validation of the instruments used, the analysis of the differences and interactions within the study and the relationships between the environment and student engagement.

Data collected from 365 students, using the six-scale WIHIC and SALEM, was analysed to provide evidence with respect to the factor structure, internal consistency reliability and ability of each scale to differentiate between classrooms. The factor structure of the WIHIC, after removing eight items during item analysis, provided strong support for the reliability and validity of the instrument when used with this

sample. The scale reliability was considered to be high ranging from 0.75 to 0.87 with the individual as the unit of analysis and from 0.91 to 0.98 with the class mean as the unit of analysis. The results also suggested that all six scales of the WIHIC were able to statistically significantly ($p<0.01$) differentiate between the perceptions of students in different classes.

For data collected using the SALEM, the results of the factor analysis (with six items removed during item analysis) supported the factorial validity of the four scales when used with the sample of 365 students in 16 classes. The internal consistency reliability (Cronbach alpha coefficient), for the four SALEM scales, ranged from 0.84 to 0.90 using the individual as the unit of analysis and from 0.98 to 0.99 using the class mean as the unit of analysis. These internal consistency indices suggest high reliability for the SALEM scales. The ANOVA results, used to determine ability the SALEM scales to differentiate between the perceptions of students in different classrooms were statistically significant ($p<0.01$) for all four SALEM scales.

The sample of 365 students (of which 197 were frequently exposed to multimedia and 168 were not) was used to investigate whether differences existed between students in classes that were frequently exposed to multimedia and those who were not (Research Question 2). The results indicated that the differences between the two groups (in terms of learning environment perceptions and student engagement) were statistically significant ($p<0.01$) for all six WIHIC scales and all four SALEM scales. The effect sizes (differences between means expressed in standard deviations) for all scales were large and of educational significance for Student Cohesiveness ($F=$ 30.31, effect size = 0.57 standard deviations), Teacher Support ($F=$ 82.22, effect size

= 0.94 standard deviations), Involvement (*F*= 87.09, effect size = 0.98 standard deviations), Task Orientation (*F*=137.60, effect size = 1.22 standard deviations), Cooperation (*F*= 55.48, effect size = 0.78 standard deviations), Equity (*F*= 85.95, effect size = 0.96 standard deviations), Learning Goal Orientation (*F*= 220.58, effect size = 1.53 standard deviations), Task Value (*F*= 222.70, effect size = 1.56 standard deviations), Self-Efficacy (*F*= 109.47, effect size = 1.08 standard deviations) and Self-Regulation (*F*= 147.23, effect size = 1.38 standard deviations). In all cases, students who were frequently exposed to multimedia scored consistently higher than their counterparts who were not.

To help to explain the differences in students' perceptions of the learning environment and engagement scales qualitative information, collected using observations and interviews with 10 students and three teachers, was analysed. During the analysis of the data, three overarching themes emerged that served to explain the differences in students' scores, namely: autonomy and flexibility; interpersonal (classroom) relationships and collaboration; and, engagement and involvement in learning. These differences were likely to have contributed to the differences in students' perceptions of the learning environment and there engagement in mathematics as reported on the WIHIC and SALEM.

To examine whether differences exist for males and females, in classes that were frequently exposed to multimedia, in terms of the learning environment and engagement, one-way MANOVA was used (Research Objective 3). The sample involved only those students (*n*=197) who were in classes that were frequently exposed to multimedia. The results indicated that, for students' perceptions of the

learning environment, there were no statistically significant differences. For the engagement scales, two scales, Task Value and Self-Efficacy, were reported to have statistically significant sex differences ($p<0.05$). In both cases, the average item mean was higher for males than for females.

Interactions between exposure to multimedia and sex were found using two-way MANOVA/ANOVA. Statistically significant interactions were found between the exposure to multimedia and sex for three of the six learning environment scales, namely, Involvement, Task Orientation and Equity. In classes that were frequently exposed to multimedia, male students perceived more Involvement than females and in classes that were not frequently exposed to multimedia, boys perceived less Involvement than females. The statistically significant interactions for Task Orientation and Equity indicated that, in classes frequently exposed to multimedia, males and females had similar perceptions. However, in classes not frequently exposed to multimedia, boys perceived less Task Orientation and less Equity than their female counterparts. Statistically significant interactions were also found between exposure to multimedia and sex for three of the four engagement scales (Learning Goal Orientation, Task Value and Self-Efficacy). In all cases, males were more engaged then females in classes that were frequently exposed to multimedia and less engaged than females in classes that were not frequently exposed to multimedia.

Relationships between the learning environment and the four student engagement scales were examined using simple correlation and multiple regression analyses for the 197 students (nine classes) who were frequently exposed to multimedia. The

results found Task Orientation scale contributed uniquely and significantly to the explanation of the variance in students' Learning Goal Orientation. Teacher Support, Involvement and Task Orientation scales were found to be significant independent predictors of Task Value. Involvement and Task Orientation scales were significant independent predictors of Self-Efficacy while Student Cohesiveness, Involvement and Task Orientation scales were significant independent predictors of Self-Regulation (Student Cohesiveness having a negative standardised regression coefficient).

The discussion of these results is presented in the following chapter. Also included in the subsequent chapter are the significance, limitations, and educational implications of the study.

CHAPTER 5

DISCUSSION AND CONCLUSIONS

5.1   Introduction

The study reported in this thesis was driven by a post-positivistic view and used an explanatory mixed-method design that was carried out in two phases. The first phase involved collecting quantitative data and the second phase involved gathering qualitative data to provide insights into the quantitative findings (Research Objective 2).

For the collection of quantitative data two modified instruments, namely, the What Is Happening In This Class (WIHIC) and the Students' Adaptive Learning Engagement in Mathematics (SALEM), were administrated to 365 high school students in 16 intact mathematics classes. Nine of the classes had access to an interactive whiteboard in their classrooms or had more than two class hours of mathematics instruction in the computer laboratory. These nine classes were considered to be frequently exposed to multimedia. Conversely, the students in the other seven classes did not have access to either interactive whiteboards or the computer laboratory and were considered to be not frequently exposed to multimedia environments.

In the second phase, qualitative information was gathered using classroom observations, narratives and interviews with a subsample of 10 students including both males and females and selected from both groups and three teachers. This data were collected for the purposes of explaining the general picture portrayed by the

quantitative data (which examined differences between the two groups) to address Research Objective 2.

This chapter summarises and concludes the thesis and is organised under the following headings; summary of major findings (Section 5.2); limitations of the study (Section 5.3); educational implications of the study (Section 5.4); summary of recommendations (Section 5.5); significance of the study (Section 5.6); and concluding remarks (Section 5.7).

5.2   Summary of Major Findings

To focus the discussion of the results, this section provides a summary of the major findings, structured around the five research objectives. The major findings of this study are summarised under the following sub-headings: validity and reliability of the WIHIC and SALEM questionnaires (Section 5.2.1); differences between students frequently exposed to multimedia and those who were not (Section 5.2.2); differences between male and female students in classes frequently exposed to multimedia (Section 5.2.3); differential effectiveness of exposure to multimedia for different sex (Section 5.2.4); and associations between student exposure to multimedia and student engagement (Section 5.2.5).

5.2.1   Research Question 1: Validity and Reliability of the Instruments

The first research objective was:

> To investigate whether the instrument used to assess students' perceptions
> of the learning environment and self-reports of adaptive learning
> engagement in mathematics were valid and reliable for use in a school
> located in regional Western Australia.

To provide confidence in subsequent results, the initial focus of this study was to validate the two instruments that were used to collect quantitative data. To assess students' perceptions of the learning environment, a 48-item, six-scale version of the WIHIC (Fraser, Fisher & McRobbie, 1996) was used. To assess student engagement the 32-item, four-scale SALEM (Velayutham, Aldridge & Fraser 2011) was used. Data collected from 365 students in 16 intact classes was used to check the reliability and validity of each the WIHIC and SALEM in terms of their factor structure, internal consistency reliability and ability to differentiate between scales.

To assess the reliability and validity of the instruments, first, the *a priori* factor structure of the WIHIC and SALEM items were checked using principal axis factoring with varimax rotation with the sample of 365 students in 16 classes. Second, the internal consistency (Cronbach alpha) reliability for each WIHIC and SALEM scale was used to assess the extent to which the items in a given scale assessed the same construct. Third, the ability of each WIHIC and SALEM scale to distinguish between different classes was assessed using an ANOVA with class

membership as the independent variable. Key findings for the validity and reliability of the instruments are summarised below.

- The 48-item, six-scale version of the WIHIC displayed satisfactory factorial validity after the removal of eight items. The total proportion of variance accounted for was 60.49%.

- The remaining 40 WIHIC items in six scales showed high reliability for two units of analysis (ranging from 0.75 to 0.87 for the individual as unit of analysis and from 0.91 to 0.98 for the class mean as the unit of analysis).

- The ANOVA results indicated that all six WIHIC scales were able to differentiate significantly between the perceptions of students in different classrooms.

- The 32-item, four-scale SALEM displayed satisfactory factorial validity after the removal of six items. The total proportion of variance accounted for was 61.67%.

- The remaining 26 SALEM items in four scales showed high reliability for two units of analysis (ranging from 0.84 to 0.90 for the individual as unit of analysis and from 0.98 to 0.99 for the class mean as the unit of analysis).

- The ANOVA results indicated that all four SALEM scales were able to differentiate significantly between the perceptions of students in different classrooms.

These results, related to the reliability and validity of the modified WIHIC, were comparable with past research that has involved the WIHIC in Australia (Aldridge, Fraser & Huang, 1999; Dorman 2003, 2008; Dorman, Fisher & Waldrip, 2006; Fraser, Aldridge & Adolphe, 2010; Velayutham, Aldridge & Fraser, 2011, 2013; Zandvliet & Fraser, 2004). In addition, my results compared favourably with the findings of other studies that have used versions of the WIHIC in the English language in other countries including Canada (Zandvliet & Fraser, 2005), New Zealand (Saunders & Fisher, 2006), Singapore (Chionh & Fraser, 2009; Khoo & Fraser, 2008), UAE (Afari, Aldridge & Fraser, 2013) and the US (Allen & Fraser, 2007; Gabler & Fraser, 2007; Martin-Dunlop & Fraser, 2008; Ogbuehi & Fraser, 2007; Wolf & Fraser, 2008). The results of this study add to numerous other studies that have found the WIHIC to be a reliable tool. However, it is recognised that the majority of these studies, including this one, have used exploratory factor analysis to examine the factor structure therefore it is recommended that future studies further establish the validity of the WIHIC by including the use of confirmatory factor analysis (*Recommendation 1*).

The results obtained in this study were similar to and supported the results obtained by Velayutham, Aldridge and Fraser (2011) when they developed the SALES using the Trochim and Donnelly's (2006) framework for construct validity. The SALES (from which SALEM originated) is a relatively new instrument, therefore there are

few reports with respect to the reliability of the instrument when used in past studies. To further examine the applicability and reliability of the SALEM (and SALES), both of which have only used students in Western Australia, it is recommended that future studies involve a sample that includes students from a wider population (*Recommendation 2*).

Overall, the reliability and validity of the WIHIC and SALEM questionnaires, in terms of the factor structure, scale internal consistency reliability and their ability to differentiate between classrooms support the validity and reliability of the WIHIC and SALEM questionnaires. These strong results served to establish that the data, collected using the two instruments, was valid and reliable. These findings suggested that the data could be used with confidence to answer subsequent research questions.

5.2.2   Research Objective 2: Differences for Frequent and Infrequent Exposure to Multimedia

The second research objective was:

To examine whether differences exist for students who are frequently exposed to multimedia in mathematics classes and those who are not (in terms of perceptions of the learning environment and engagement in mathematics) and, if so, investigate why.

To address this objective, a mixed method approach, involving the collection of qualitative and quantitative data, was used. As a first step, the quantitative sample,

involving 365 students in 16 classes, nine of which (*n*=197 students), were frequently exposed to multimedia and seven of which (*n*=168 students) were not frequently exposed to multimedia was used.

One-way MANOVA (using the student as the unit of analysis) was used to determine whether statistically significant differences existed between the students' scores on the WIHIC and SALEM for these two groups. To examine the magnitudes of the differences, effect sizes were calculated. The set of six WIHIC scales (Student cohesiveness, Teacher Support, Involvement, Task Orientation, Cooperation and Equity) and four SALEM scales (Learning Goal Orientation, Task Value, Self-Efficacy and Self-Regulation) constituted the dependent variables whilst frequency of exposure to multimedia (frequent and infrequent exposure to multimedia) was the independent variable. The results of the quantitative analysis are summarised below.

- The average item mean for all six WIHIC scales and all four SALEM scales for students in classes that were frequently exposed to multimedia were consistently higher than for students in classes that were not frequently exposed to multimedia.

- The scores for all six learning environment scales were statistically speaking, significantly ($p<0.01$) higher for students in classes that were frequently exposed to multimedia.

- The effect sizes for the differences all were large and can be considered educationally important, ranging from 0.57 standard deviations (for Student Cohesiveness) to 1.22 standard deviations (for Task Orientation).

- The scores for all four engagement scales were, statistically significantly ($p<0.01$) higher for students in classes that were frequently exposed to multimedia.

- The effect sizes for the difference were large and, therefore considered to be of educational importance, for Learning Goal Orientation (effect size = 1.53 standard deviations), Task Value (effect size = 1.56 standard deviations), Self-Efficacy (effect size = 1.08 standard deviations) and Self-Regulation (effect size = 1.38 standard deviations).

To provide insights into the differences in students' perceptions of the learning environment and engagement, and to add depth to the quantitative data, qualitative information, collected using classroom observations and interviews were analysed. Two narratives, one based on observations of classes that were frequently exposed to multimedia and the other based on observations of classes that were not frequently exposed to multimedia, were used to help to explain the results.

During the analysis of the data, three overlapping themes emerged (autonomy and flexibility, interpersonal relationships and collaboration; and engagement and involvement in learning activities) that served to explain differences in students'

scores (quantitative results). The explanations of the differences in student scores are summarised below.

Theme 1: Autonomy and Flexibility

- Whereas students who were frequently exposed to multimedia had the freedom and independence to associate with the students of their choice during the various activities, students who were not frequently exposed to multimedia were required, on the whole, to adhere to a fixed seating plan, decided on by the teacher.

- In classes that were not frequently exposed to multimedia, the pace of the progress was determined largely by the teacher and the speed at which the other students in the class progressed. In contrast, the pace and progress of students in the classes that were frequently exposed to multimedia were not determined by either the teacher or the pace of other students but, rather, it was set by the students themselves.

- Students who were frequently exposed to multimedia were able to receive real-time feedback about their work. In contrast, students in classes not frequently exposed to multimedia were reliant on the teachers' presence for feedback either orally or written on the whiteboard.

Theme 2: Interpersonal (Classroom) Relationships and Collaboration

- Students in classes that were frequently exposed to multimedia had better interpersonal relationships than those in the classes that were not.

- The relationships between the students and the teachers in classes frequently exposed to multimedia were more respectful than in the classes that were not.

- Students in classes that were frequently exposed to multimedia were more likely to collaborate on tasks and to discuss their ideas during classroom activities as opposed to students in the classes that were not, who were less likely to show camaraderie towards their classmates.

Theme 3: Student Engagement and Involvement in Activities and Tasks

- Students in classes that were frequently exposed to multimedia generally appeared to be more interested in what they were doing and had more opportunities for discussions than in the classes that were not.

- Students in classes that were not frequently exposed to multimedia tended to be more disruptive than those in the classes that were frequently exposed to multimedia. In contrast, students in the classes frequently exposed to multimedia were generally more enthusiastic about their learning, often going beyond what the teacher would have instructed.

- Students in classes that were frequently exposed to multimedia were more likely to be forthcoming with ideas, suggestions and answers to questions than students in the classes that were not frequently exposed to multimedia, who were generally more reluctant to discuss their ideas openly and were less willing to engage in class discussions.

Overall, my results indicated that differences do exist for students who are in classes frequently exposed to multimedia in mathematics classes when compared to those who are not, for both their perceptions of the learning environment and engagement in mathematics. The results suggest that the students in classes exposed frequently to multimedia in their learning environment were more likely to be tasked focused and to know what is expected of them (*Task Orientation*), feel socially accepted by their peers (*Student Cohesiveness*), be involved in the learning process (*Involvement and Cooperation*) and feel that their teacher treats them fairly (*Equity*). In terms of engagement, the students in classes that were frequently exposed to multimedia were more likely to perceive their learning activities as important, useful, and interesting (*Task Value*), more likely to feel that they would succeed in mathematics (*Self-Efficacy*) and were prepared to spend more time, effort and persist longer towards completing their activities (*Self-Regulation*). These results suggest that students' exposure to multimedia could provide the means to nurture more goal-oriented behaviours (*Learning Goal Orientation*) and exert sustained intense effort and concentration in the implementation of their learning tasks (*Self-Regulation*) in mathematics.

The results of my study, which found statistically significant differences for all of the learning environment and engagement scales, corroborated numerous other studies that have examined multimedia in educational settings and found positive impacts that multimedia had on students' engagement. For example, Lajoie, (1993) and Afari, Aldridge and Fraser (2012) reported that the use of computers in the classroom increased student motivation and interest. Passey, Rogers, Machell, McHugh and Allaway (2003) concluded that, rather than just completing tasks and being more committed to learn, ICT impacted on students' motivation positively, their attitude towards their school work and their behaviour in class. Lee, Brescia and Kissinger (2009) found that, those students who used computers in mathematics classes displayed more positive classroom behaviours and had higher test scores in mathematics.

The findings of the present study highlight the possibilities of using multimedia in mathematics classes, particularly for promoting students' engagement in mathematics learning. Although it was beyond the scope of the present study, it is possible that students' engagement could be further enhanced by exposing students to different types of multimedia-involving tasks and activities. Therefore it is recommended that future research examine whether different types of multimedia-involving tasks and activities enhance students' engagement in mathematics to differing degrees (*Recommendation 3*).

The results of the study reported in this thesis were generally consistent with the findings of past studies. These past studies, that have examined learning in settings that involve multimedia, have also reported improved: student cooperation and

involvement (Owens, 2005); student enjoyment and engagement (Afari, Aldridge & Fraser, 2012); student attentiveness and achievement (Lajoie, 1993; Mayer, 2001); autonomy, in terms of students progressing without limiting (or being limited by) other students (Squire, 2005); curriculum differentiation to meet the needs of students of diverse backgrounds and learning styles (Papastergiou, 2009); classroom relationships and collaboration in groups and the comparison of results–both of which are necessary in the development of communication and team skills (Lipponen, 2002; Schellens & Valcke, 2005); and teacher-student interaction and motivation (Alexander & McKenzie, 1998). Therefore it is recommended that government education reform efforts consider interventions targeted specifically at engaging students by improving the availability of multimedia in all mathematics classrooms (*Recommendation 4*).

5.2.3   *Research Objective 3: Male-Female Differences in Multimedia Classes*

The third research objective was:

> To examine whether differences exist for male and female students who were frequently exposed to multimedia in mathematics classes in terms of: a) perceptions of the learning environment; and b) engagement in mathematics.

MANOVA, involving the sample of 197 students (107 male and 90 female) who were in classes that were frequently exposed to multimedia was used to examine whether differences in perceptions of the learning environment and engagement

existed between male and female students exposed to multimedia. The set of six WIHIC scales and four SALEM scales constituted the dependent variables whilst sex was the independent variable. The key findings are summarised below.

- For all learning environment scales, the differences were not statistically significant.

- The scores for two of the four engagement scales, Task Value and Self-Efficacy, were statistically significantly ($p<0.05$) greater for boys than for girls.

- Modest effect sizes were found for the scales with statistically significant differences between girls and boys, these being, Task Value (effect size = 0.42 standard deviations) and Self-Efficacy (effect size = 0.34 standard deviations).

Many studies in the field of learning environments have examined the perceptions of girls and boys (Aldridge & Fraser, 2008; Henderson & Fisher, 2008; Huang, 2003; Majeed et al., 2002; Margianti, Fraser & Aldridge, 2004; Telli, den Brok, Tekkaya & Cakiroglu, 2009; Waxman & Huang, 1998). The picture portrayed by past research is that female students, in general, perceive a more positive classroom environment than male students (den Brok, Fisher, Rickards & Bull, 2006; Goh & Fraser, 1998; Huang, 2003; Kaya, Ozay & Sezek, 2008; Wahyudi and Treagust, 2004). The finding of this study did not show statistically significant differences for any of the learning environment scales, thereby, contradicting the results of these past studies. Given

that these findings of past studies were not carried out in classrooms exposed to multimedia, it is possible that my results could be related to the influence of multimedia. If this is the case, then there would be a strong argument for the inclusion of multimedia in mathematics classrooms, therefore it is recommended that further research be carried out to examine why, in multimedia learning environments, males and females reported similar perceptions (*Recommendation 5*).

The results indicated that male students in classes that were frequently exposed to multimedia were more likely to value the activities provided to them in class than their female counterparts, who were also frequently exposed to multimedia. The results for the Task Value scale are consistent with the views of Darragh (1996) who reported that multimedia makes learning activities for male students more interesting and more importantly, male students tend to be more cognitively engaged in trying to learn and comprehend the materials presented to them. The results suggest that male (not female) students in classes that were frequently exposed to multimedia were more inclined to believe in their abilities to succeed (Self-Efficacy scale). This result suggests that, whilst the use of multimedia could be good for the education of males, further research might open new ground in exploring how the use of multimedia can be used in ways that also benefit females (*Recommendation 6*).

5.2.4   Research Objective 4: Differential Effectiveness for Male and Female Students

The fourth research objective was:

> To examine whether exposure to multimedia in mathematics classes was differentially effective for male and female students in terms of: a) perceptions of the learning environment; and b) student engagement in mathematics.

The interactions between exposure to multimedia and sex were examined using a two-way MANOVA for the set of learning environment and engagement scales with the sample of 365 students (174 females and 191 males) in 16 classes. The multivariate test using Wilks' lambda criterion yielded significant differences, and so the univariate ANOVA was interpreted for each scale.

A key finding for differences between sex regardless of instructional method was that:

- Statistically significant differences were found between females and males for two WIHIC scales of Task Orientation ($p<0.05$) and Equity ($p<0.01$), with female students perceiving both scales more favourably than their male counterparts.

My findings, that significant differences in perceptions of Task Orientation and Equity, both in favour of females, were consistent with Telli, den Brok, Tekkaya and

Cakiroglu's (2009) and Wahyudi and Treagust (2004), all of whom explored sex differences in students' perceptions of their classroom learning environment and found that female students held more positive perceptions of both actual and preferred learning environments than their male counterparts.

Key findings for interactions between exposure to and sex are summarised below.

- Statistically significant interactions existed for six of the 10 dependent variables, namely, Involvement, Task Orientation, Equity, Learning Goal Orientation, Task Value and Self-Efficacy. Therefore, the independent interpretations of exposure to multimedia differences and sex differences were valid for all scales except these.

- The interpretation of the interactions for the Involvement, Learning Goal Orientation, Task Value and Self-Efficacy scales was that, in classes frequently exposed to multimedia, males scored higher than their female counterparts; however in classes not frequently exposed to multimedia female students scored higher than their male counterparts.

- The interpretation of the interactions for the Task Orientation and Equity scales was that, in classes frequently exposed to multimedia, the views of males and females were similar. However, in classes that were not frequently exposed to multimedia, females scored higher than males.

These results indicate that in classes that were not exposed to multimedia, females had more positive perceptions (of both the environment and a greater sense of engagement) than males. However, in classes exposed to multimedia, there was little difference between the ways that males and females perceived the environments (see earlier section) and in their sense of engagement. However, there are some instances in which the males had slightly more positive views (such as for Task Value and Self-Efficacy). For sex, the learning environment scores and engagement scores were more positive for both sex in classes exposed to multimedia.

It is interesting to note that, despite these interactions, exposure to multimedia appeared to increase student motivation regardless of sex. These results are consistent with the observations by Mayer, (2001) who noted that multimedia encourages participation and improves engagement in mathematics.

My findings, that males in classes that were frequently exposed to multimedia scored higher than their female counterparts in Learning Goal Orientation, Task Value and Self-efficacy, is consistent with the findings of Forgasz and Leder (1996), who noted that males hold more functional beliefs about themselves as learners of mathematics than females do, and that female confidence in mathematics and in setting themselves goals remains a critical variable with respect to mathematics achievement levels and participation in mathematics. Australian statistics continue to reveal that differences between male and female students tend to be more marked at high school, and manifest themselves more clearly, in the middle school years with boys consistently maintaining a higher intrinsic value for mathematics than girls (Forgasz & Rivera, 2012; Wolf & Fraser, 2008). Therefore, examining the differential

effectiveness of exposure to multimedia in terms of differences perceived by different sex, make it possible for policy makers to address these perceived differences in classes by using multimedia. Given that both boys and girls in classes exposed to multimedia had consistently higher perceptions than their counterparts who were not, it is recommended that government policy makers consider the benefits of introducing multimedia to classes that are not currently exposed to multimedia on a frequent basis as a means of encouraging both boys and girls to participate in the learning process and to improve their engagement in mathematics (*Recommendation 7*).

5.2.5 Research Objective 5: Environment-Engagement Associations for Students Exposed to Multimedia

The fifth research objective was:

> To investigate whether, for students who were frequently exposed to multimedia, there was a relationship between students' perceptions of the learning environment and their engagement in mathematics.

Simple correlation and multiple regressions were used to examine whether relationships existed between students' perceptions of the learning environment and their engagement. The sub-sample of 197 students in nine classes that were frequently exposed to multimedia was used. The results, used to address the fifth research question are summarised below:

- The results of the simple correlation analysis shows that all six WIHIC scales correlated significantly and positively with the four SALEM scales at both the individual and class levels, with three exceptions at the individual level of analysis. The three exceptions, for which there was a non-statistically significant simple correlation, with the individual as the unit of analysis, were Learning Goal Orientation with Equity, Self-Regulation with Equity and Self-Regulation with Cooperation.

- The multiple correlation of the set of WIHIC scales with each SALEM scale was statistically significant for both the individual and class means as the unit of analysis.

- There were statistically significant ($p<0.01$) multiple correlations between each engagement scale (Learning Goal Orientation, Task Value, Self-Efficacy and Self-Regulation) and the set of six learning environment scales with both the individual and class mean as the unit of analyses. These statistically significant independent predictors, all of which were positive in direction, are outlined below.

  o Task Orientation contributed uniquely and significantly to the explanation of the variance in students' Learning Goal Orientation.

  o Teacher Support, Involvement and Task Orientation contributed uniquely and significantly to the explanation of the variance in students' Task Value.

- o Involvement and Task Orientation scales contributed uniquely and significantly to the explanation of the variance in students' Self-Efficacy.

- o Student Cohesiveness, Involvement and Task Orientation scales being unique predictors of and significant contributors to students' Self-Regulation. However, Student Cohesiveness was negatively correlated to Self-Regulation.

This pattern of associations replicates many studies that have investigated relationships between students' learning environment and student outcomes (Afari et al., 2013; Helding & Fraser, 2013; Ogbuehi & Fraser, 2007; Opolot-Okurut, 2010; Velayutham & Aldridge, 2013; Wei, den Brok & Zhou, 2009; Wolf & Fraser, 2008; Zandvliet & Fraser, 2005). My study was similar to and supported the results found by Schraw, Crippen and Hartley (2006), who concluded that multimedia-based learning (as a form of inquiry-based learning) was an essential instructional strategy for improving engagement in science and mathematics classrooms.

The findings of this study suggest a strong and positive association between the learning environment and student engagement in mathematics lessons. These results are similar to those found by Opolot-Okurut (2010) and Velayutham et al. (2013), both of whom reported positive and significant relationships between the learning environment and students' motivation and self-regulation for most scales. These associations suggest practical ways in which the learning environment might be changed to enhance student engagement. While Opolot-Okurut (2010) suggested that teachers who wished to improve students' motivation in mathematics should

consider emphasising student involvement and task organisation, Velayutham et al. (2012) emphasised that improving student learning environment would improve students' motivation and self-regulation. With more positive engagement towards mathematics classes, it is possible that more students might choose to pursue mathematics-oriented classes in high school, university, and mathematics-related careers.

The results of this study indicate that, four out of six learning environment scales (Student Cohesiveness, Teacher support, Involvement, and Task Orientation) were significant independent predictors to the variance of student engagement. Numerous past researchers have indicated that dimensions of the learning environment contribute to the variance of specific student outcomes (Helding & Fraser, 2013; Opolot-Okurut, 2010; Velayutham & Aldridge, 2013; Wolf & Fraser, 2008). The four learning environment scales (Student Cohesiveness, Teacher support, Involvement, and Task Orientation) suggest that, in a multimedia learning environment, students are more likely to have clear and meaningful goals which in turn, influence their urge to acquire new information in order to improve their competence. Evidence from past research has indicated that students' engagement is likely to influence a range of positive learning outcomes including: student achievement and problem solving strategies (Brookhart, Walsh & Zientarski, 2006; Kaplan & Maehr, 1999, 2007); positive emotions and persistence (Elliott & Dweck, 1988); students' interest, (Cury, Elliot, Da Fonseca & Moller, 2006); effort and persistence (Elliot, McGregor & Gable, 1999); employment of deep learning strategies (Elliot et al., 1999; Kaplan & Midgley, 1997); retention of information learned (Elliot & McGregor, 1999) and self-efficacy (Kaplan & Maehr,

1999).Therefore, on the basis of the findings of this study, it is recommended that schools provide the resources (in terms of equipment and professional development) to enable mathematics teachers to create multimedia learning environments in a bid to improve student engagement (*Recommendation 8*).

5.3   Limitations of the Study

Research can never be free of limitations and biases, especially when working with human subjects. This section acknowledges their existence in this research and reports the actions that were taken to minimise their effects.

Whilst the original sample size of 365 students in 16 classes was considered to be satisfactory. The use of sub-groups within the sample (e.g. males and females), the size of the sample decreased. Also, given that the data for the present study was collected from only one site, generalising the results to other schools should be done with caution. It is recommended that future research, which replicates this study, involves a larger and wider sample of students (*Recommendation 9*).

Patton (1990), states that the interpretation of interview data can never be free from the personal interpretations and biases of the researcher conducting the interview or analysing the data. Whilst every effort was made to view the data through the eyes of the participants who were interviewed, possible biases should not be ignored. However, during the course of this study, every effort was made, on my part, to acknowledge my bias and avoid placing my own expectations on the data. For

example, the interview protocol and scripting of the questions was used to reduce the effects of the researcher on the analysis.

Another limitation of the present study was the threat to internal validity. I was not only the primary researcher but also a teacher at the research site (having taught four of the 16 classes involved in the sample). One disadvantage of being a researcher-teacher is that it is difficult to 'refrain from teaching' (Martin-Dunlop & Fraser, 2008). In fact, data from all classes could be subject to biased influences, such as 'demand characteristics' (Hersen & Ballow, 1976) as the questionnaires were administered by me.

One characteristic of educational research is the close and often long-term relationship between the participants and the researcher (Einarsdottir, 2007). Where adolescents are involved, as it is in this case, these relationships can become complicated. Adolescents are potentially more susceptible to unequal power relationships with their teachers. Unequal power, in this case, exists in terms of age, status, competency and experience. They could have perceived their teachers as authority figures and, consequently, tried to please them for fear of the reaction if they did not (Flewitt, 2005). This could have led to biased results in my research and was considered a threat to the quality of the research. To address this limitation, it was made clear to students that involvement in the research was voluntary and that they were free to withdraw at any time without giving a reason. In addition, the verbal reminders and information letters sent to parents, prior to administering questionnaires and interviews, were used to ensure that students understood the confidential nature of the research. At the time of administration, students were

urged to respond honestly and not to consider the expectations of the research and their teachers. The students (and teachers) were informed that this research was not aimed at an individual teacher's classroom, but at a more holistic picture of the mathematics classrooms at this site. They were informed that no data, or analysis of that data, would be based on individual classrooms.

This research was undertaken to examine students' perceptions of the environment and the impact that this had on students' engagement in mathematics. A limitation of the present study was that the sample was confined only to the exposure to multimedia in mathematics classes and only examined only student engagement as the outcome variable. Therefore, it is recommended that further, similar research be carried out to examine whether the findings of the present study can be replicated to other student outcomes (such as student achievement) and to other subjects (such as science or English) (*Recommendation 10*).

Due to the cross-sectional nature of this study, another limitation was that changes in students' engagement, over time, were not tracked. The snapshot of information used in the present study has the potential to fluctuate as students' progress in their schooling years. However, the employment of a longitudinal study was beyond the scope of the present study. Therefore, it is recommended that in the future, longitudinal studies be carried out to identify patterns of student engagement over time and at different stages in high school (*Recommendation 11*).

Whilst the results of my study indicate that students in classes exposed to multimedia were more engaged and perceived a more positive environment, my selection of

groups was based on the amount of time that they had access to multimedia and did not take into consideration the quality of the activities (in terms of whether it was construction-oriented or otherwise). Therefore, it is recommended that future studies examine whether exposure to different types of multimedia and the quality of the programmes and activities provided through multimedia impacts on students' learning environment perceptions and engagement (*Recommendation 12*).

5.4   Educational Implications of the Study

The current study contributes to wider research related to the field of learning environment and its impact on student engagement. The context of learning has been viewed as an important element that strongly influences the success of education (Dumont & Instance, 2010). The study reported in this thesis has contributed to this research area by identifying relationships between the learning environment and student engagement.

An important implication of the present study is that, in classes that were frequently exposed to multimedia, students held remarkably improved perceptions of their learning environment and significantly higher levels of engagement in mathematics learning than the students in classes that were not frequently exposed to multimedia. These findings provide educators with better understanding of students' views of their mathematics learning environment that could cultivate fertile ground for schools and mathematics teachers to implement intervention programmes and strategies using multimedia which, in turn would increase students engagement in mathematics learning.

The overall result for the environment-engagement associations for students exposed to multimedia is that the learning environment significantly contributes and predicts the variance of student engagement. Given that a student's level of engagement (shaped by the learning environment and school experiences) is likely to impact on his or her achievement (Velayutham et al. 2013), it is important to consider the types of learning environments that are used. In my study, the view that student exposure to multimedia led to higher students' perception scores of the learning environment and improved engagement, implies that schools and mathematics teachers wishing to improve students' engagement should consider exposing students to and using multimedia in their day to day activities.

These findings provide a starting point from which practical attempts, involving the use of multimedia, can be used to enhance students' engagement in mathematics. In many classrooms, the school's willingness for teachers to incorporate and use multimedia in their lessons could be a key to success in improving the classroom environment and students' engagement in mathematics. In Western Australia, there is a push for teachers to shift their focus from more traditional education and delivery methods to contemporary approaches including the use of ICT (Curriculum Council, 2006). The results of my study suggest that it could be useful for mathematics teachers to use multimedia as a means of improving the classroom environment and hence students' engagement in mathematics. Given these findings, it is recommended that schools consider the need to provide professional development to help teachers improve their use of multimedia (*Recommendation 13*).

Involvement and Task Orientation scales were unique positive predictors of students' Self-Regulation. These results suggest that, if students in classes that are frequently exposed to multimedia value their tasks and are involved in class activities and discussions then they are more likely to be able to regulate their effort and handle the numerous distractions that they confront. In contrast, Student Cohesiveness was found to be an independent and negative predictor of Self-Regulation suggesting that Student Cohesiveness negatively impacts on students' ability to controls and regulate their effort in mathematics learning tasks. An explanation of this anomaly was beyond the scope of this study and, therefore, it is recommended that further research should establish why the standardised regression coefficient between Student Cohesive and Self-Regulation was negative (*Recommendation 14*).

A statistically significant interaction was found for three of the four SALEM scales, these being, Learning Goal Orientation, Task Value and Self-efficacy. An interesting observation is that, although the engagement scores for female students exposed to multimedia for these three scales were lower than that of their male counterparts, each female engagement scale score was higher than that for male and female students who were not frequently exposed to multimedia. In line with this observation, the implication is that, schools and teachers are encouraged to use multimedia in classes not frequently exposed to multimedia to raise their engagement levels. However, it is recommended that future studies investigate why males have higher engagement levels than their female counterparts in classes exposed to multimedia (*Recommendation 15*).

5.5   Significance of the Study

The study reported in this thesis is significant to the field of learning environment as well as mathematics education because it is the first study within the field of learning environment research that has examined student exposure to multimedia in mathematics learning as perceived by students. A distinctive and major contribution of this study to the field of mathematics education is the knowledge that exposure to multimedia in mathematics has the potential to improve the way that students view their learning environment and, importantly, promote their engagement in mathematics learning.

The gap in literature, related to the influence of the students' perceptions of the learning environment and students' engagement in mathematics learning, was bridged through this study. The findings that the learning environment constructs were strong predictors of and significant contributors to students' engagement in mathematics learning add to the literature on secondary school students who undergo a critical developmental period during the transition from primary to secondary school.

Further, to add to the literature on sex differences with respect to student exposure to multimedia, this study revealed that, in classes exposed to multimedia, males and females viewed the learning environment in similar ways. In terms of engagement, males were found to sense more Task Value and Self-Efficacy in classes exposed to multimedia than females. This contribution is significant because, understanding what drives differential student engagement in males and females, and the aspects of

the learning environment that each sex prefers, can promote the design of targeted intervention programs to tackle equity issues. It is important for mathematics educators to be aware of the pivotal role that multimedia could play in facilitating students' (both male and female) engagement in mathematics learning, particularly in high school when shifts in students' engagement are most likely to occur (Britner, 2008). The findings of this study recommend that school mathematics reform efforts involve the use of multimedia as an integral component of interventions targeting student engagement (*Recommendation 16*).

The information obtained from this study can be used to design such intervention programmes that may differ in terms of orientation and application for girls and boys. In particular, the emphasis would be to target and boost girls' engagement in mathematics. In line with the findings of this study, the strategies targeted towards improving girls' Learning Goal Orientation, Task Value and Self-Efficacy in mathematics learning should be intensified so that existing sex imbalances might be overcome.

This study is distinctive because it used multiple research methods, from the students' perspective, to examine different aspects of multimedia learning environments and to understand the effect this had on students' engagement in mathematics. The findings offer potentially important insights into how exposure to multimedia in the learning environments could promote high school students' engagement towards mathematics learning and, in turn, encourage them to proactively regulate their own learning progress.

5.6   Summary of Recommendations

Recommendation 1:   Future studies involve the use of confirmatory factor analysis (in addition to exploratory factor analysis) to further establish the validity of the WIHIC and SALEM.

Recommendation 2:   To further establish the reliability and applicability of the SALEM future studies should involve a wider sample.

Recommendation 3:   Future research should examine whether exposing students to different multimedia-involving tasks and activities would enhance students' engagement in mathematics.

Recommendation 4:   Government education reform efforts should consider interventions targeted specifically at engaging students by introducing multimedia in mathematics classrooms.

Recommendation 5:   Further research needs to be carried out to examine why, in classes exposed frequently to multimedia, males and females generally reported similar perceptions of the environment and engagement.

Recommendation 6:   Future studies need to explore how multimedia tasks can be designed to better suit girls, particularly in terms of task value and self-efficacy.

Recommendation 7:   Government policy makers should consider the benefits of introducing multimedia to classes that are currently not exposed to multimedia on a frequent basis as a means to improving student engagement in mathematics.

Recommendation 8:   Schools needs to provide the resources (in terms of equipment and professional development) to encourage teachers to create multimedia learning environments.

Recommendation 9:   Further research should be conducted with a wider sample, both nationally and internationally, to improve the external validity of the study.

Recommendation 10:   Further studies should examine the impact of exposure to multimedia on other outcomes, such as academic achievement, and in other subject areas.

Recommendation 11:   Longitudinal studies should be carried out to identify changes in patterns of student engagement over time and at different points in their schooling years.

Recommendation 12:   Future studies should examine whether exposure to different types of multimedia and the quality of the programmes and

activities provided through multimedia, impacts on students' learning environment perceptions and engagement.

Recommendation 13: Since multimedia improves engagement, schools should consider the need to provide professional development to help teachers to improve their use of multimedia in mathematics.

Recommendation 14: Future research needs to establish why the standardised regression coefficient between Student Cohesive and Self-Regulation was negative.

Recommendation 15: Future studies should investigate why males have higher engagement levels in multimedia learning environments.

Recommendation 16: School mathematics reform needs to involve the use of multimedia as an integral component of interventions targeting student engagement.

5.7   Concluding Remarks

An integral role of the teacher today is to increase students' motivation and develop the skills or strategies that help to make the student become a life-long self-regulated learner. Fundamentally, schools and teachers are required to structure the students' learning environment so that students are engaged and are able to take ownership of

their own learning. The confluence of the field of multimedia learning environment with the field of student engagement provided the impetus for this research.

This is the first study conducted in Western Australia that examined whether students' perceptions of the learning environment and engagement differ for classes exposed to multimedia when compared to those that are not. Additionally, it is the first study that has provided a comprehensive validation of data for the revised version of the SALES. This study achieved all of its research objectives, engendered possible future research directions and provided important contributions of this study to the field of learning environments and mathematics education. Although the focus of this research is on multimedia in mathematics learning, it is likely that the findings could help educators to understand and improve student engagement in other subject areas.

The findings of this study suggest that student exposure to multimedia is likely to engage students in mathematic classes. In addition, the findings of my study have implications for schools and mathematics teachers who are interested in improving not only the learning environments for their students but also their engagement in mathematics learning.

Perhaps, as suggested by Fisher and Fraser (1992), teacher training programs might benefit from incorporating and modelling multimedia learning environments as a means of ensuring that teachers become aware of the alternatives that exist in modifying their classroom environment for the benefit of students. It is hoped that

the research presented here would generate valuable information that could transform future mathematics classrooms so that they are filled with engaged learners.

REFERENCES

Abbott, C., & Cribb, A. (2001). Special schools, inclusion and the world wide web: The emerging research agenda. *British Journal of Educational Technology*, *32*(3), 331-342.

ACARA. (2012). *Myschool*. Retrieved May 27, 2012, from http://www.myschool.edu.au

Afari, E., Aldridge, J. M., & Fraser, B. J. (2012). Effectiveness of using games in tertiary-level mathematics classrooms. *International Journal of Science and Mathematics Education, 10,*1369-1392.

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

Aldridge, J.M., Afari, E., & Fraser, B.J. (2013). Influence of teacher support and personal relevance on academic self-efficacy and enjoyment of mathematics lessons: A structural equation modeling approach. *Alberta Journal of Educational Research, 58,* 614-633.

Alderman, M. K. (1999). *Motivation for achievement: Possibilities for teaching and learning.* Mahwah, NJ: Lawrence Erlbaum.

Aldrich, C. (2005). *Learning by doing.* Chichester, UK: Wiley.

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

Aldridge, J. M., & Fraser, B. J. (2008). *Outcomes-focused learning environments: Determinants and effects.* The Netherlands: Sense Publishers.

Aldridge, J. M., & Fraser, B. J. (2011). Monitoring an outcomes-focused learning environment: A case study. *Curriculum Perspectives, 31*, 25-41.

Aldridge, J. M., Fraser, B. J., & Fisher, D. L. (2003). Investigating students outcomes in an outcomes-based, technology-rich learning environment. In D. Fisher, & T. Marsh (Eds.), *Science, mathematics and technology education for all: Proceedings of the Third International Conference on Science, Mathematics and Technology Education* (pp. 167-178). Perth, Australia: Curtin University of Technology.

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

Aldridge, J. M., Fraser, B. J., & Laugksch, R. C. (2011). Relationship between the school-level and classroom-level environments in secondary schools in South Africa. *South African Journal of Education, 31*, 127-144.

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

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

Aldridge, J. M., Fraser, B. J., Bell, L., & Dorman, J. (2012). Using a new learning environment questionnaire for reflection in teacher action research. *Journal of Science Teacher Education, 23*, 259-290.

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

Aldridge, J.M., Laugksch, R.C., Seopa, M.A., & Fraser, B.J. (2006). Development and validation of an instrument to monitor the implementation of outcomes-based learning environments in science classrooms in South Africa. *International Journal of Science Education, 9,* 123-147.

Alexakos, K., & Antoine, W. (2003). The gender gap in science education. *Science Teacher, 70*, 30-33.

Alexander, S., & McKenzie, J. (1998). *An evaluation of information technology projects in university learning.* DEETYA: Canberra.

Al-Hmouz, H., Wilma, V., & Rose, D. (2010). *A comparison of three levels of achievers.* Lambert: Academic Publishing.

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

Ames, C. (1992). Classrooms: Goals, structures, and student motivation. *Journal of Educational Psychology, 84*, 261-271.

Ames, C., & Archer, J. (1988). Achievement goal in the classroom: Students' learning strategies and motivation processes. *Journal of Educational Psychology, 80*, 260-267.

Amory, A. (2001). Building an educational adventure game: Theory, design, and lessons. *Journal of Interactive Learning Research, 12(2)*, 249-263.

Anderman, E. M., & Young, A. J. (1994). Motivation and strategy use in science: Individual differences and classroom effects. *Journal of Research in Science Teaching, 31*, 811-831.

Anderson, A., Hamilton, R. J., & Hatie, J. (2004). Classroom climate and motivated behaviour in secondary schools. *Learning Environments Research, 7*, 211-225.

Anderson, J. R. (1982). Acquisition of cognitive skill. *Psychological Review, 89*, 369-406.

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

Australian Education Union. (2008). *Policy on gender equity.* Southbank: Australian Education Union.

Baker, D. (2002). Editorial: Where is gender and equity in science education? *Journal of Research in Science Education, 39*, 659-664.

Baker, S., Chard, D., Kettlerlin-Geller, L., Apichatabutra, C., & Doabler, C. (2009). Teaching writing to at-risk students: The quality of evidence for self-regulated strategy development. *Exceptional Children, 75*, 303-318.

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review, 84*, 191-215.

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

Bandura, A. (1993). Perceived self-efficacy in cognitive development and functioning. *Educational Psychologist, 28*, 117-148.

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

Bandura, A. (2006). Guide for constructing self-efficacy scales. In F. Pajares, & T. Urdan (Eds.), *Self-efficacy beliefs of adolescents* (pp. 307-337). Greenwich, CT: Information Age.

Bandura, A., & Schunk, D. H. (1981). Cultivating competency, self-efficacy and intrinsic interest through proximal self-motivation. *Journal of Personality and Social Psychology, 41*, 586-598.

Banes, D., & Walter, R. (2002). *Internet for all (2nd edition).* London: David Fulton.

Beckman. (1996). The language of prosody. *Language and Cognitive Processes, 11*, 17-67.

Bell, L.M., & Aldridge, J.M. (2014). *Student voice, teacher action research and classroom improvement.* (Advances in Learning Environments Research series). Rotterdam, The Netherlands: Sense Publishers.

Bitter, G., & Pierson, M. (2002). Educational software types. In G. Bitter, & M. Pierson (Eds.), *Using technology in the classroom* (pp. 145-160). Boston, MA: Allyn & Bacon.

Blechman, E. A. (1996). Coping, competence, and aggression prevention: Part 2. Universal, school-based prevention. *Applied and Preventive Psychology, 5*, 19-35.

Boeije, H. (2002). A Purposeful Approach to the Constant Comparative Method in the Analysis of Qualitative Interviews. *Quality & Quantity, 36*, 391-409.

Boekaerts, M., & Cascallar, E. (2006). How far have we moved toward the integration of theory and practice in self-regulation? *Educational Psychology Review, 18*, 199-210.

Boekaerts, M., & Corno, L. (2005). Self-regulation in the classroom: A perspective on assessment and intervention. *Applied Psychology: An International Review, 54*, 199-231.

Bogdan, R., & Biklen, S. (1998). *Qualitative research for education: An introduction to theory and methods.* Needham Heights, MA: Ally & Bacon.

Bong, M. (2001). Role of self-efficacy and task value in predicting college student's course enrolments and intentions. *Contemporary Educational Psychology, 26*, 553-570.

Bork, A. (1980). New directions for adult and continuing education. *Computers in Continuing Education*, *5*, 79-84.

Bouffard-Bouchard, T. (1990). Influence of self-efficacy on performance in a cognitive task. *Journal of Social Psychology, 130*(3), 353-363.

Bouffard-Bouchard, T., Parent, S., & Larivèe, S. (1991). Influence of self-efficacy on self-regulation and performance among junior and senior high-school aged students. *International Journal of Behavioral Development, 14*, 153-164.

Bransford, J. D., Brown, A. L., & Cocking, R. C. (2000). *How people learn: Brain, mind, experience, and school.* Washington, DC: The National Academies Press.

Britner, S. L. (2008). Motivation in high school science students: A comparison of gender differences in life, physical, and earth science classes. *Journal of Research in Science Teaching*, *45*, 955-970.

Britner, S. L., & Pajares, F. (2001). Self-efficacy beliefs, motivation, race and gender in middle school science. *Journal of Women and Minorities in Science and Engineering*, *7*, 271-285.

Brookhart, S. M., Walsh, J. M., & Zientarski, W. A. (2006). The dynamics of motivation and effort for classroom assessments in middle school science and social studies. *Applied Measurement in Education, 19*, 151-184.

Carmichael, C., & Taylor, J. A. (2005). Analysis of student beliefs in a tertiary preparatory mathematics course. *International Journal of Mathematical Education in Science and Technology*, *36*(7), 713-719.

Carnegie Commission on Higher Education. (1977). *The fourth revolution: Instructional technology in higher education.* New York, NY: McGraw-Hill.

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

Clandinin, D. J., & Connelly, F. M. (2000). *Narrative inquiry: Experience and story in qualitative research.* San Francisco, CA: Jossey Bass.

Clark, R. E. (1983). Reconsidering research on learning from media. *Review of Educational Research*, *43*(4), 445-459.

Cleary, T., Platten, P., & Nelson, A. (2008). Effectiveness of the self-regulation empowerment program with urban high school students. *Journal of Advanced Academics, 20*, 70-107.

Coakes, S., & Ong, C. (2010). *SPSS: Analysis without anguish: Using SPSS version 18.0 for Windows.* Milton, Queensland: John Wiley.

Cohen, J. (1992). Quantitative methods in psychology: A power primer. *Psychological Bulletin, 112*, 155-159.

Cohen, L., Marion, L., & Morrison, K. (2000). *Research methods in education* (5th ed.). London: Routledge Falmer.

Collins, A., Brown, J. S., & Holum, A. (1991). Cognitive Apprenticeship: Making Thinking Visible. *American Educator*, *6*, 38-46.

Corno, L. (1994). Student volition and education: Outcomes, influences and practices. In B. J. Zimmerman, & D. H. Schunk (Eds.), *Self-regulation of*

learning and performance (pp. 229-254). Hillsdale, NJ: Lawrence Erlbaum Associates.

Creswell, J. W. (2008). *Educational research: Planning, conducting and evaluating quantitative and qualitative research* (3rd ed.). Upper Saddle River, NJ: Pearson.

Creswell, J. W., & Plano Clark, V. L. (2007). *Designing and conducting mixed method research.* Thousand Oaks, CA: Sage.

Creswell, J. W., Goodchild, L. F., & Turner, P. (1996). Integrated qualitative and quantitative research: Epistemology, history, and designs. In J. Smart (Ed.), *Higher education: Handbook of theory and research* (pp. 455-471). New York: Agathon Press.

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

Cronbach, D. J. (1951). Coefficient alpha and internal structure of tests. *Psychometrika, 16(3)*, 297-334.

Curriculum Council. (2006). *Curriculum framework.* Perth: Curriculum Council of Western Australia.

Cury, F., Elliot, A. J., Da Fonseca, D., & Moller, A. C. (2006). The social-cognitive model of achievement motivation and the 2×2 achievement goal framework. *Journal of Personality and Social Psychology, 90*, 666-679.

D'Amico, M., Baron, I. J., & Sissons, M. E. (1995). Gender differences in attributions about microcomputer learning in elementary school. *Gender Roles, 33*, 353-385.

Darragh, L. D. (1996). *Multimedia in the mathematics classroom.* Long Beach, CA: AMATYC .

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

den Brok, P., Telli, S., Cakiroglu, J., Taconis, R., & Tekkaya, C. (2010). Learning environment profiles of Turkish secondary biology classrooms. *Learning Environments Research, 13*, 187-204.

Denissen, J. J., Zarrett, N. R., & Eccles, J. S. (2007). I like to do it, I'm able, and I know I am: Longitudinal couplings between domain specific achievement, self-concept, and interest. *Child Development, 78*, 430-447.

Denzin, N. K., & Lincoln, Y. S. (1994). Introduction: Entering the field of qualitative research. In N. K. Denzin, & Y. S. Lincoln (Eds.), *Handbook of qualitative research* (pp. 1-7). Newbury Park, CA: Sage.

Denzin, N., & Lincoln, Y. (2000). The discipline and practice of qualitative research. In N. Denzin, & Y. Lincoln (Eds.), *Handbook of qualitative research* (pp. 1-28). Thousand Oaks, CA: Sage Publications.

DeVellis, R. F. (1991). *Scale development: Theory and applications, 26.* Newbury Park: SAGE Publications.

Dignath, C., Buettner, G., & Langfeldt, H. (2008). How can primary school students learn self-regulated learning strategies most effectively? A meta-analysis on self-regulation training programmes. *Educational Psychology Review, 3*, 101-129.

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

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

Dorman, J. P. (2008). Use of multitrait-multimethod modelling to validate actual and preferred forms of the What Is Happening In this Class? (WIHIC) questionnaire. *Learning Environments Research, 11*, 179-193.

Dorman, J. P., & Adams, J. (2004). Associations between students' perceptions of classroom environment and academic efficacy in Australian and British secondary schools. *International Journal of Research and Method in Education, 27*, 69-85.

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

Dorman, J. P., Aldridge, J. M., & Fraser, B. J. (2006). Using students' assessment of classroom environment to develop a typology of secondary school classrooms. *International Education Journal, 7*, 906-915.

Dorman, J. P., Fisher, D. L., & Waldrip, B. G. (2006). Learning environments, attitudes, efficacy and perceptions of assessment: A LISREL analysis. In D. L. Fisher, & M. S. Khine (Eds.), *Contemporary approaches to research on learning environments* (pp. 1-28). Singapore: World Scientific.

Dorman, J., Fraser, B. J., & McRobbie, C. J. (1994). *Rhetoric and reality: A study of classroom environment in Catholic and government secondary schools.* New Orleans, LA: Paper presented at the annual meeting of the American Educational Research Association.

Dreyden, J., & Gallagher, S. (1989). The effects of time and direction changes on the SAT performance of academically talented adolescents. *Journal for the Education of the Gifted, 12*, 187-204.

Drudy, S., & Chathain, M. U. (2002). Gender effects in classroom interaction: Data collection, self-analysis and reflection. *Evaluation and Research in Education, 16(1)*, 34-50.

Duffy, J., Warren, K., & Walsh, M. (2001). Classroom interactions: Gender of teacher, gender of student, and classroom subject. *Sex Roles*, *45*(9), 579-593.

Dumont, H., & Instance, D. (2010). Analysing and designing learning environments for the 21st century. In H. Dumont, D. Instance, & F. Benavides (Eds.), *The nature of learning. Using research to inspire practice* (pp. 19-34). Paris, France: OECD.

Duncan, T. G., & McKeachie, W. J. (2005). The making of the Motivated Strategies for Learning Questionnaire. *Educational Psychologist, 40*, 117-128.

Durik, A. M., Vida, M., & Eccles, J. S. (2006). Task values and ability beliefs as predictors of high school literacy choices: A developmental analysis. *Journal of Educational Psychology, 98*, 382-393.

Dweck, C. S. (1986). Motivational process affecting learning. *American Psychologist, 41*, 1040-1048.

Dweck, C. S., & Leggett, E. L. (1988). A social-cognitive approach to motivation and personality. *Psychological Review, 95*, 256-273.

Eccles, J. (1983). Expectancies, values, and academic behaviors. In J. T. Spence (Ed.), Achievement and achievement motives: Psychological and sociological approaches (pp. 75-146). San Francisco, CA: W. H. Freeman.

Eccles, J. S. (1993). School and family effects on the ontogeny of children's interests, self-perceptions, and activity choice. In J. Jacobs (Ed.), *Nebraska symposium on motivation, 1992: Developmental perspectives on motivation* (pp. 145-208). Lincoln, NB: University of Nebraska.

Eccles, J. S., & Wigfield, A. (2002). Motivational beliefs, values, and goals. *Annual Review of Psychology, 53*, 109-132.

Edwards, J. R. (2008). Person-environment fit in organizations: An assessment of theoretical progress. *The Academy of Management Annals*, *2*(1), 167-230.

Einarsdóttir, J. (2007). Research with children: Methodological and ethical challenges. *European early childhood education research journal*, *15*(2), 197-211.

Einarsson, C., & Granström, K. (2002). Gender-biased interaction in the classroom: The influence of gender and age in the relationship between teacher and pupil. *Scandinavian Journal of Educational Research*, *46*(2), 117-127.

Eisenberg, N., Martin, C. L., & Fabes, R. A. (1996). Gender development and gender effects. In D. C. Berliner, & R. C. Calfee (Eds.), *Handbook of educational psychology* (pp. 358-396). New York: Simon & Schuster Macmillan.

Eisenhart, M., & Finkel, E. (1998). *Women's science: Learning and succeeding from the margins.* Chicago: University of Chicago Press.

Eisner, E. (1981). On differences between scientific and artistic approaches to qualitative research. *Educational Researcher*, *10*(4), 5-9.

Elliot, A. J., & McGreger, H. A. (1999). Test anxiety and the hierarchical model of approach and avoidance achievement motivation. *Journal of Personality and Social Psychology, 76*, 628-644.

Elliot, A. J., McGregor, H., & Gable, S. (1999). Achievement goals, study strategies, and exam performance: A mediational analysis. *Journal of Educational Psychology, 91*, 549-563.

Elliott, E. S., & Dweck, C. S. (1988). Goals: An approach to motivation and achievement. *Journal of Personality and Social Psychology, 54*, 5-12.

Ferguson, P. D., & Fraser, B. J. (1998). Changes in learning environment during the transition from primary to secondary school. *Learning Environments Research, 1*, 369-383.

Fetterman, D. M. (1997). Ethanography. In L. Bickman, & D. Rog (Eds.), *Handbook of applied social science research* (pp. 473-507). Thousand Oakes, CA: Sage.

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

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

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

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

Flewitt, R. (2005). Conducting research with young children: Some ethical considerations. *Early Child Development and Care, 175*(6), 553-566.

Florian, L. (2004). Uses of technology that support pupils with special educational needs. In L. Florian, & J. Hegarty (Eds.), *ICT and special educational needs: A tool for inclusion* (pp. 7-20). London, England: Open University Press.

Forgasz, H. J., & Leder, G. C. (1995). Learning mathematics in mixed-sex small group settings: Three case studies. In R. P. Hunting, G. E. Fitzsimons, P. C. Clarkson, & A. Bishop (Eds.), *Regional collaboration in mathematics education* (pp. 261-270). Melbourne, Australia: International Commission on Mathematics Instruction.

Forgasz, H. J., & Leder, G. C. (1996). Mathematics classrooms, gender and affect. *Mathematics Education Research Journal*, *8*(1), 153-173.

Forgasz, H. J., & Leder, G. C. (1997). Single-sex classes in a coeducational high school: Highlighting parents' perspectives. *Mathematics Education Research Journal, 9*, 274-291.

Forgasz, H., & Rivera, F. (2012). *Towards equity in mathematics education: Gender, culture, and diversity.* London: Springer Heidelberg.

Forgasz, H., & Tan, H. (2010). Does CAS use disadvantage girls in VCE mathematics? *Australian Senior Mathematics Journal*, *24*(1), 25-36.

Forman, G. (1998). Constructive play. In D. Fromberg, & D. Bergen (Eds.), *Play from birth to twelve and beyond: Contexts, perspectives, and meanings* (pp. 392-400). New York: Garland.

Fraser, B. J. (1979). *Test of Enquiry Skills handbook.* Hawthorn, Australia: Australian Council for Educational Research Limited.

Fraser, B. J. (1986). *Classroom environment.* London: Croom Helm.

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

Fraser, B. J. (1991). Two decades of classroom environment research. In B. J. Fraser, & H. J. Walberg (Eds.), *Educational environments: Evaluation, antecedents and consequences* (pp. 3-27). Oxford: Pergamon Press.

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

Fraser, B. J. (1999). "Grain sizes" in learning environment research: Combining qualitative and quantitative methods. In H. C. Waxman, & H. J. Walberg (Eds.), *New directions for teaching practice and research* (pp. 285-296). Berckeley, CA: McCutchan.

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

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

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

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

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

Fraser, B. J., & Kahle, J. B. (2007). Classroom, home and peer environment influence on student outcomes in science and mathematics: An analysis of

systemic reform data. *International Journal of Science Education, 29*, 1891-1909.

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

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

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

Fraser, B. J., & Tobin, K. (1991). Combining qualitative and quantitative methods in classroom environment research. In B. J. Fraser, & H. J. Walberg (Eds.), *Educational environments: Evaluation, antecedents and consequences* (pp. 271-291). London: Pergamon Press.

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

Fraser, B. J., & Walberg (Eds.), H. (1991). *Educational environments: Evaluation, antecedents and consequences.* Oxford, UK: Pergamon.

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

Fraser, B. J., Aldridge, J. M., & Soerjaningsih, W. (2010). Instructor-student interpersonal interaction and student outcomes at the university level in Indonesia. *The Open Education Journal, 3*, 21-33.

Fraser, B. J., Anderson, G. J., & Walberg, H. J. (1982). *Assessment of learning environments: Manual for Learning Environment Inventory (LEI) and My Class Inventory (MCI) (3rd version).* Perth: Western Australian Institute of Technology.

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

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

Fraser, B. J., Treagust, D. F., & Dennis, N. C. (1986). Development of an instrument for assessing classroom psychosocial environment at universities and colleges. *Studies in Higher Education, 11*, 43-54.

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

Gabler, C. T., & Fraser, B. J. (2007). *Sustained, job embedded professional development and the learning environment of middle-school mathematics*

classrooms. Paper presented at the annual meeting of the American Educational Research Association: Chicago.

Gaskell, G. (2000). Individual and group interviewing. In M. L. Bauer, & G. Gaskell (Eds.), *Qualitative researching with text, image and sound: A practical handbook* (pp. 38-56). London: SAGE.

Gee, J. (2003). *What video games have to teach us about learning and literacy.* New York, NY: Palgrave Macmillan.

Geelan, D. R. (1997). Weaving narrative nets to capture school science classrooms. *Research in Science Education, 27(4)*, 553-563.

Glaser, B. G., & Strauss, A. L. (1967). *The discovery of grounded theory: Strategies for qualitative research.* Hawthorne, Chicago: Aldine Publishing Company.

Glynn, S. M., Taasoobshirazi, G., & Brickman, P. (2007). Nonscience majors learning science: A theoretical model of motivation. *Journal of Research in Science Teaching, 44*, 1088-1107.

Glynn, S. M., Taasoobshirazi, G., & Brickman, P. (2009). Science motivation questionnaire: Construct validation with nonscience majors. *Journal of Research in Science Teaching, 46*, 127-146.

Goh, S. C., & Fraser, B. J. (1996). Validation of an elementary school version of the questionnaire on teacher interaction. *Psychological Reports, 79*, 512-522.

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

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

Gonski, D., Boston, K., Greiner, K., Lawrence, C., Scales, B., & Tannock, P. (2011). *Review of Funding for Schooling.* Canberra: Department of Education, Employment and Workplace Relations.

Gottfried, A. W., Gottfried, A. E., Cook, C. R., & Morris, P. E. (2005). Educational characteristics of adolescents with gifted academic intrinsic motivation: A longitudinal investigation from school entry through early adulthood. *Gifted Child Quarterly*, *49*(2), 172-186.

Greene, J. C., & Caracelli (Eds.), V. (1997). *Advances in mixed-method evaluation: The challenges and benefits of integrating diverse paradigms.* (New Directions for Evaluation, No. 74). San Francisco: Jossey-Bass.

Gros, B. (2007). Digital games in education: The design of games-based learning environments. *Journal of Research on Technology in Education*, *40*(1), 23-38.

Gurer, D., & Camp, T. (2002). An ACM-W literature review on women in computing. *ACM SIGCSE Bulletin, 34*, 121-127.

Guthrie, J., McRae, A., & Klauda, L. (2007). Contributions of concept-oriented reading instruction to knowledge about interventions for motivations in reading. *Educational Psychologist, 42(4)*, 237-250.

Haladyna, T., Oslen, R., & Shaughnessy, J. (1982). Relations of student, teacher and learning environment variables to attitudes towards science. *Science Education, 66*, 671-687.

Hammersley, M., & Atkinson, P. (1995). *Ethnography: Principles in practice* (2nd ed.). New York: Routledge.

Hanrahan, M. (2002). *Learning science: Revisiting humanist dimensions of intellectual engagement.* Paper presented at the annual meeting of the Australasian Science Education Research Association: Townsville, Australia.

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

Henderson, D. G., & Fisher, D. L. (2008). Interpersonal behaviour and student outcomes in vocational education classes. *Learning Environments Research, 11*, 19-29.

Henderson, D., Fisher, D., & Fraser, B. J. (2000). Interpersonal behaviour, learning environments and student outcomes in senior biology classes. *Journal of Research in Science Teaching, 37*, 26-43.

Hersen, M., & Barlow, D. H. (1976). *Single case experimental designs: Strategies for studying behavior change.* Oxford: Pergamon.

Hijzen, D., Boekaerts, M., & Vedder, P. (2007). Exploring the links between students' engagement in cooperative learning, their goal preferences and appraisals of instructional conditions in the classroom. *Learning and Instruction, 17*, 673-687.

Hirata, S., & Sako, T. (1998). Perceptions of school environment among Japanese junior high school, non-attendant, and juvenile delinquent students. *Learning Environment Research, 1*, 321-331.

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

Howitt, C. (2008). *A guide to preparing your application for ethics approval at SMEC (Rev. ed).* Perth: Western Australia: Curtin University of Technology.

Huang, S. L. (2003). Antecedents to psychosocial environments in middle school classrooms in Taiwan. *Learning Environments Research, 6*, 119-135.

Humphrey, L. L. (1984). Children's self-control in relation to perceived social environment. *Journal of Personality and Social Psychology, 46*, 178-188.

Jegede, O. J., Fraser, B. J., & Okebukola, P. A. (1994). Altering socio-cultural beliefs hindering the learning of science. *Instructional Science, 22*, 137-152.

Johnson, D. W., Johnson, R. T., & Smith, K. (2007). The state of cooperative learning in postsecondary and professional settings. *Educational Psychology Review, 19*, 15-29.

Joiner, K. F., Malone, J. A., & Haimes, D. H. (2002). Assessment of classroom environments in reformed calculus education. *Learning Environments Research, 5*, 51-76.

Jones, E. (2011). The technology-boom. *School Matters*, *2*, 18-20.

Jones, J. W. (1989). Personality and epistemology: Cognitive social learning theory as a philosophy of science. *Journal of Religion and Science*, *24*(1), 23-38.

Joyce, B. A., & Farenga, S. J. (1999). Informal science experience, attitudes, future interest in science, and gender of high ability students: An exploratory study . *School Science and Mathematics, 99*, 431-437.

Kaiser, H. F. (1960). The application of electronic computers to factor analysis. *Educational and Psychological Measurement, 20*, 141-151.

Kaplan, A. (2004). Achievement goals and intergroup relations. In P. R. Pintrich, & M. L. Maehr (Eds.), *Advances in research on motivation and achievement, 13: Motivating students, improving schools: The legacy of Carol Midgley* (pp. 97-136). United Kingdom: Elsevier.

Kaplan, A., & Maehr, M. (1999). Achievement goals and student well-being. *Contemporary Educational Psychology, 24*, 330-358.

Kaplan, A., & Maehr, M. L. (2007). The contribution and prospects of goal orientation theory. *Educational Psychology Review, 19*, 141-187.

Kaplan, A., & Midgley, C. (1997). The effect of achievement goals: Does level of perceived academic competence make a difference? *Contemporary Educational Psychology, 22*, 415-435.

Kaplan, A., & Midgley, C. (1999). The relationship between perceptions of the classroom goal structure and early adolescents' affect in school: The mediating role of coping strategies. *Learning and Individual Differences, 11*, 187-212.

Kaplan, A., Lichtinger, E., & Gorodetsky, M. (2009). Achievement goal orientations and self-regulation in writing: An integrative perspective. *Journal of Educational Psychology, 101*, 51–69.

Karp, K., & Shakeshaft, C. (1997). Restructuring school to be maths-friendly to females. *NASSP Bulletin, 81(586)*, 84-93.

Kaya, E., Özay, E., & Sezek, F. (2008). Application of a Questionnaire to Describe Teacher-Students Communication Behaviour in a University in Turkey. *International Journal of Environmental & Science Education*, *3*(1), 26-29.

Kember, D., Lai, T., Murphy, D., Siaw, L., Wong, J., & Yuen, K. (1990). Naturalistic evaluation of courses. *Journal of Distance Education*, *5*(1), 38-52.

Kerlinger, F. N. (1986). *Foundations of behavioral research (3rd ed).* New York, NY: Holt, Rinehart & Winston.

Kerr, S. J., Neale, H. R., & Cobb, S. V. (2002). Virtual environments for social skills training: the importance of scaffolding in practice. *Assets 2002: Proceedings of the Fifth International ACM SIGCAPH Conference on Assistive Technologies, 8-10 July, 2002, Crowne Plaza Hotel* (pp. 104-110). Edinburgh, Scotland: ACM Press.

Khoo, H. S., & Fraser, B. J. (2008). Using classroom psychosocial environment in the evaluation of adult computer application courses in Singapore. *Technology, Pedagogy and Education, 17*, 53-67.

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

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

Kline, B. (2010). *Principles and practice of structural equation modelling.* New York, NY: Guilford Press.

Kolb, S. M. (2012). Grounded theory and the constant comparative method: Valid research strategies for educators. *Journal of Emerging Trends in Educational Research and Policy Studies*, *3*(1), 83-86.

Koul, R. B., & Fisher, D. L. (2005). Cultural background and students' perspectives of science classroom learning environment and teacher interpersonal behaviour in Jammu, India. *Learning Environment Research: An International Journal, 8*, 195-211.

Koul, R. B., & Fisher, D. L. (2006). A contemporary study of learning environments in Jammu, India. In D. L. Fisher, & M. S. Khine (Eds.), *Contemporary approaches to research on learning environments* (pp. 273-296). Singapore: World Scientific.

Kuehn, S. A. (1994). Computer-mediated communication in instructional settings: A research agenda. *Communication Education, (43)*, 171-183.

Kuo, F. R., Hwang, G. J., & Lee, C. C. (2012). A hybrid approach to promoting students' web-based problem solving competence and learning attitude. *Computers & Education, 58(1)*, 351-364.

Kupermintz, H. (2002). Affective and cognitive factors as aptitude resources in high school science achievement. *Educational Assessment, 8*, 123-137.

Kuyper, H., van der Werf, M. P., & Lubbers, M. J. (2000). Motivation, meta-cognition and self-regulation as predictors of long term educational attainment. *Educational Research and Evaluation, 6*, 181-201.

Lajoie, S. P. (1993). Computer environments as cognitive tools for enhancing learning. In S. Lajoie, & S. J. Derry (Eds.), *Computers as cognitive tools* (pp. 261-288). Hillsdale, NJ: Lawrence Erlbaum.

Lane, J., Lane, A., & Kyprianou, A. (2004). Self-efficacy, self-esteem and their impact on academic performance. *Social Behaviour and Personality, 32*, 247-256.

Lansford, J. E., & Parker, J. G. (1999). Children's interactions in triads: Behavioral profiles and effects of gender and patterns of friendships among members. *Developmental Psychology, 35*, 80-93.

Lau, S., & Roeser, R. W. (2002). Cognitive abilities and motivational processes in high school students' situational engagement and achievement in science. *Educational Assessment, 8*, 139-162.

Lawrenz, F. (1976). The prediction of student attitude towards science from student perception of the classroom learning environment. *Journal of Research in Science Teaching, 13*, 509-515.

Leary, T. (1957). *An interpersonal diagnosis of personality.* New York: Ronald-Press Company.

Leder, G. C. (1992). Mathematics and gender: Changing perspectives. In D. A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 597-622). New York: Macmillan.

Leder, G. C. (1993). Teacher/student interactions in the mathematics classroom: A different perspective. In E. Fennema, & G. C. Leder (Eds.), *Mathematics and gender* (pp. 149-168). St Lucia, Queensland: Queensland University Press.

Lee, O., & Brophy, J. (1996). Motivational patterns observed in sixth-grade science classrooms. *Journal of Research in Science Teaching, 33*, 585-610.

Lee, S. M., Brescia, W., & Kissinger, D. (2009). Computer use and academic development in secondary schools. *Computers in the Schools, 26*(3), 224-235.

Lent, R. W., Brown, S. D., & Hackett, G. (2002). Social cognitive career theory. In D. Brown (Ed.), *Career choice and development* (pp. 255-311). San Francisco: Jossey-Bass.

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

Lewin, K. (1951). *Field theory in social science.* New York: Harper.

Lewin, K. (Ed.). (1952). *Field theory in social science.* London: Tavistock.

Lichtenstein, S., & Blackorby, J. (1995). Who drops out and what happens to them? *Journal of Vocational Special Needs Education*, *18*(1), 6-11.

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

Lipponen, L. (2002). Exploring foundations for computer-supported collaborative learning. In G. Stahl (Ed.), *4th CSCL: Foundations for a CSCL Community* (pp. 72-81). NJ, USA: Colorado, LEA.

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

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

Lovat, T. J., & Smith, D. L. (1991). *Curriculum: Action on reflection.* Pennsylvania State University: Social Science Press.

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

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

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

Margianti, E. S., Fraser, B. J., & Aldridge, J. M. (2004). *Investigating the learning environment and students' outcomes at the university level in Indonesia.* Paper presented at the annual meeting of the American Educational Research Association: New Orleans.

Margolis, J., Fisher, A., & Miller, F. (2000). The anatomy of interest: Women in undergraduate computer science. *Women's Studies Quarterly, 28*, 104-127.

Marsh, H. W., Köller, O., Trautwein, U., Lüdtke, O., & Baumert, J. (2005). Academic self-concept, interest, grades, and standardized test scores: Reciprocal effects models of causal ordering. *Child Development, 76*, 397-416.

Martin, B., & Newcomer, S. (2002). A descriptive study of gender equity in rural secondary classroom situations. *Rural Educator, 23*, 37-46.

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

Mayer, R. E. (2001). *Multi-media learning.* New York: Cambridge University Press.

Mayer, R. E., Moutone, P., & Prothero, W. (2002). Pictorial aids for learning by doing in a multimedia geology simulation game. *Journal of Educational Psychology, 94*, 171-185.

McInerney, C. (2002). Knowledge management and the dynamic nature of knowledge. *Journal of the American Society for Information Science and Technology*, *53*(12), 1009-1018.

Meece, J. L., Glienke, B. B., & Burg, S. (2006). Gender and motivation. *Journal of School Psychology, 44*, 351-373.

Meece, J. L., Wigfield, A., & Eccles, J. S. (1990). Predictors of math anxiety and its consequences for young adolescents' course enrolment intentions and performances in mathematics. *Journal of Educational Psychology, 82*, 60-70.

Merriam, S. (1988). *Case study research in education: A qualitative approach.* San Francisco: Jossey-Bass Publishers.

Michael, D., & Chen, S. (2006). *Serious games: Games that educate, train and inform.* Boston: Thomson Course Technology.

Midgley, C. (2002). *Goals, goal structures, and patterns of adaptive learning.* Mahwah, NJ: Lawrence Erlbaum.

Midgley, C., Kaplan, A., & Middleton, M. (2001). Performance-approach goals: Good for what, for whom, under what circumstances, and at what cost? *Journal of Educational Psychology, 93*, 77-86.

Midgley, C., Maehr, M. L., Hicks, L., Roeser, R., Urdan, T., & Anderman, E. (1996). *The Patterns of Adaptive Learning Survey (PALS).* Ann Arbor, MI: The University of Michigan.

Mitchell, A., & Savill-Smith, C. (2004). *The use of computer and video games for learning: A review of literature.* London: Learning and Skills Development Agency.

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

Moos, R. H. (1978). A typology of junior high and high school classrooms. *American Educational Research Journal, 15*, 53-66.

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

Moos, R. H. (1991). Connections between school, work, and family settings. In B. J. Fraser, & H. J. Walberg (Eds.), *Educational environments: Evaluation, antecedents and consequences* (pp. 29-53). London, UK: Pergamon Press.

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

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

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

Morse, J. M. (2003). Principles of mixed and multi-method method research design. In A. Tashakkori, & C. Teddlie (Eds.), *Handbook of mixed method* (pp. 189-208). Thousand Oaks, CA: Sage.

Muir-Herzig, R. G. (2004). Technology and its impact in the classroom. *Computers & Education, 42*, 111-131.

Murphy, P. K., & Alexander, P. A. (2000). A motivated exploration of motivation terminology. *Contemporary Educational Psychology, 25*, 3-53.

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

Murray, H.A. (1951). Toward a classification of interaction. In T. Parsons & E.A. Shils (Eds.), *Toward a general theory of action* (pp. 434–464). Cambridge, MA: Harvard University Press.

Nair, C. S., & Fisher, D. (2000). Transition from senior secondary to higher education: A learning environment perspective. *Research in Science Education, 30*, 435-450.

Neo, M., & Neo, T. K. (2009). Engaging students in multimedia-mediated constructivist learning – Students' perceptions. *Educational Technology & Society*, *12*(2), 254-266.

Newman, R. S. (1998). Students' help seeking during problem solving: Influences of personal and contextual achievement goals. *Journal of Educational Psychology*, *90*, 644-658.

Nicholls, J., Cobb, P., Wood, T., Yackel, E., & Patashnick, M. (1990). Assessing students' theories of success in mathematics: individual and classroom differences. *Journal of Research in Mathematics Education, 21*, 109-122.

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

Nolan, J., & Short, E. (1985). Combining qualitative and quantitative modes of inquiry to inform curriculum deliberation: A proposed framework. *Curriculum Perspectives, 5(1)*, 15-23.

Nolen, S. (1988). Reasons for studying: motivational orientations and study strategies. *Cognition and Instruction, 5*, 269-287.

Oakes, J. (1990). Opportunities, achievement and choice: Women and minority students in science and maths. *Review of Research in Education, 16*, 153-223.

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

Okan, Z. (2008). Computing laboratory classes as language learning environments. *Learning Environments Research, 11*, 31-48.

Opolot-Okurut, C. (2010). Classroom learning environment and motivation towards mathematics among secondary school students in Uganda. *Learning Environments Research, 13*, 267-277.

Osborne, J., & Dillon, J. (2008). *Science education in Europe: Critical reflections.* London: The Nuffield Foundation.

Owens, K. (2005). Substantive communication of space mathematics in upper primary school. In H. L. Chick, & J. I. Vincent (Eds.), *Proceedings of the 29th annual conference of the International Group for the Psychology of Mathematics Education, 4* (pp. 33-40). Melbourne: Psychology of Mathematics Education.

Pace, C. R., & Stern, G. G. (1958). An approach to the measurement of psychological characteristics of college environments. *Journal of Educational Psychology, 49(5)*, 269-277.

Paivio, A. (1971). *Imagery and verbal processes.* New York: Holt, Rinehart and Winston.

Pajares, F. (1996). Self-efficacy beliefs in academic settings. *Review of Educational Research, 66*, 543-578.

Pajares, F. (2001). Toward a positive psychology of academic motivation. *Journal of Educational Research, 95*, 27-35.

Pajares, F. (2002). Gender and perceived self-efficacy in self-regulated learning. *Theory into Practice, 41*, 116-125.

Pajares, F., & Miller, M. D. (1994). Role of self-efficacy and self-concept beliefs in mathematical problem solving: A path analysis. *Journal of Educational Psychology*, *86*(2), 193-203.

Pajares, F., & Schunk, D. H. (2001). Self-beliefs and school success: Self-efficacy, self-concept, and school achievement. In R. Riding, & S. Rayner (Eds.), *Self-perception* (pp. 239-266). London: Ablex Publishing.

Pajares, F., Britner, S. L., & Valiante, G. (2000). Relation between achievement goals and self beliefs of middle school students in writing and science. *Contemporary Educational Psychology, 25*, 406-422.

Papastergiou, M. (2009). Digital game-based learning in high school computer science education: Impact on educational effectiveness and student motivation. *Computers and Education, 52*, 1-12.

Papert, S. (1980). *Mindstorms: Children, computers, and powerful ideas.* New York: Basic Books.

Passey, D., Rogers, C., Machell, J., McHugh, G., & Allaway, D. (2003). *The motivational effect of ICT on students.* Nottingham: DfES Publications.

Patton, M. Q. (1990). *Qualitative evaluation and research methods* (2nd ed.). Newbury Park, CA: Sage Publications.

Pekrun, R. (1993). Facets of adolescents' academic motivation: A longitudinal expectancy-value approach. In P. Pintrich, & M. L. Maehr (Eds.), *Advances in motivation and achievement* (pp. 139-189). Greenwich, CT: JAI.

Pekrun, R. (2009). Emotions at school. In K. R. Wentzel, & A. Wigfield (Eds.), *Handbook of motivation in school* (pp. 575-604). New York: Taylor Francis.

Perels, F., Gurtler, T., & Schmitz, B. (2005). Training of self-regulatory and problem-solving competence. *Learning and Instruction, 15*, 123-139.

Peterson, P., & Fennema, E. (1985). Effective teaching, students' engagement in classroom activities, and sex-related differences in learning mathematics. *American Educational Research Journal, 22*, 309-335.

Phillips, N., & Lindsay, G. (2006). Motivation in gifted students. *High Ability Studies, 17(1)*, 57-73.

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

Piero, M. M., & Fraser, B. J. (2009). Assessment and investigation of science learning environments in the early childhood grades. In M. Ortiz, & C. Rubio (Eds), *Educational evaluation: 21st century issues and challenges* (pp. 349-365). New York: Nova Science Publishers.

Pintrich, P. R. (2000). The role of goal orientation in self-regulated learning. In M. Boekaerts, P. R. Pintrich, & M. Zeidner (Eds.), *Handbook of self-regulation* (pp. 451-502). San Diego, CA: Academic.

Pintrich, P. R. (2003). A motivational science perspective on the role of student motivation in learning and teaching contexts. *Journal of Educational Psychology, 95*, 667-686.

Pintrich, P. R., & De Groot, V. E. (1990). Motivational and self-regulated learning components of classroom academic performance. *Journal of Educational Psychology, 82*, 33-40.

Pintrich, P. R., & Schrauben, B. (1992). Students' motivational beliefs and their cognitive engagement in classroom tasks. In D. Schunk, & J. Meece (Eds.), *Student perceptions in the classroom: Causes and consequences* (pp. 149-183). Hillsdale, NJ: Lawrence Erlbaum.

Pintrich, P. R., Marx, R. W., & Boyle, R. A. (1993). Beyond cold conceptual change: The role of motivational beliefs and classroom contextual factors in the process of conceptual change. *Review of Educational Research, 63*, 167-199.

Pintrich, P. R., Smith, D. A., Garcia, T., & McKeachie, W. J. (1991). Reliability and predictive validity of the Motivated Strategies for Learning Questionnaire (MSLQ). *Educational and Psychological Measurement, 53*, 801- 813.

Polkinghorne, D. E. (1995). Narrative configuration in qualitative analysis. In J. A. Hatch, & R. Wisniewski (Eds.), *Life history as narrative* (pp. 5-23). London, England: The Falmer Press.

Pope, C., Ziebland, S., & Mays, N. (2000). Qualitative research in health care: analysing qualitative data. *British Medical Journal, 320*, 114-116.

Prensky, M. (2000). *Digital game-based learning.* New York: MaGraw-Hill.

Pryor, J. (1995). Gender issues in group work- A case study involving work with computers. *British Educational Research Journal, 21*, 277-288.

Raaflaub, C. A., & Fraser, B. J. (2002). *Investigating the learning environment in Canadian mathematics and science classrooms in which laptop computers are used.* Paper presented at the annual meeting of the American Educational Research Association: New Orleans, LA.

Randel, J. M., Morris, B. A., Wetsel, C. D., & Whitehill, B. V. (1992). The effectiveness of games for educational purposes: A review of recent research. *Simulations and Gaming*, *23*(3), 261-276.

Reeves, T. C., & Harmon, S. W. (1994). Systematic evaluation procedures for interactive multimedia for education and training. In S. Reisman (Ed.), *Multimedia computing: Preparing for the 21st century* (pp. 472-303). Idea Group Publishing.

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

Riah, H., & Fraser, B. J. (1998). *The learning environment of high school chemistry classes.* Paper presented at the annual meeting of the National Association for research in science teaching: San Diego, CA.

Rickards, T., den Brok, P., & Fisher, D. (2005). The Australian science teacher: Typology of teacher-student interpersonal behaviour in Australian science classes. *Learning Environments Research, 8*, 267-287.

Ritchie, L. (2013). Understanding the changing role of women in society. *Women in Leadership: Understanding the gender gap*, 89-98.

Robinson, E., & Fraser, B. J. (2013). Kindergarten students' and parents' perceptions of science classroom environments: Achievement and attitudes. *Learning Environments Research*, *16*(2), 151-167.

Rosser, S. (1997). *Re-engineering female-friendly science.* New York: Teachers College Press.

Ryan, A. M., Gheen, M. H., & Midgley, C. (1998). Why do some students avoid asking for help? An examination of the interplay among students' academic efficacy, teachers' social-emotional role, and the classroom goal structure. *Journal of Educational Psychology*, *90*, 528-535.

Ryan, R. M., & Deci, E. L. (2000). Intrinsic and extrinsic motivations: Classic definitions and new directions. *Contemporary Educational Psychology, 25*, 54-67.

Sadker, M., & Sadker, D. (1994). *Failing at fairness: How America's schools cheat girls.* New York: Macmillan.

Sanders, J., Koch, J., & Urso, J. (1997). *Gender equity right from the start.* Mahwah, NJ: Lawrence Erlbaum.

Saunders, K. J., & Fisher, D. L. (2006). An action research approach with primary pre-service teachers to improve university and primary school classroom environments. In D. L. Fisher, & M. S. Khine (Eds.), *Contemporary approaches to research on learning environments* (pp. 247-272). Singapore: World Scientific.

Schellens, T., & Valcke, M. (2005). Collaborative learning in asynchronous discussion groups: What about the impact on cognitive processing? *Computers in Human Behavior, 21*, 957-975.

Schraw, G., Crippen, K. J., & Hartley, K. (2006). Promoting Self-Regulation in Science Education: Metacognition as Part of a Broader Perspective on Learning. *Research in Science Education, 36*, 111-139.

Schunk, D. H. (1984). Self-efficacy perspective on achievement behavior. *Educational Psychologist, 19*, 48-58.

Schunk, D. H. (1985). Self-efficacy and classroom learning. *Psychology in the Schools, 22*, 208-223.

Schunk, D. H. (2003). Self-efficacy for reading and writing: Influence of modeling, goal setting and self-evaluation. *Reading and Writing Quarterly: Overcoming Learning Difficulties, 19(2)*, 159-172.

Schunk, D. H. (2004). *Learning theories: An educational perspective.* Upper Saddle River, NJ: Pearson Prentice Hall.

Schunk, D. H. (2005). Commentary on self-regulation in school contexts. *Learning and Instruction, 15*, 173-177.

Schunk, D. H., & Ertmer, P. A. (2000). Self-regulation and academic learning: Self-efficacy enhancing interventions. In M. M. Boekaerts, P. R. Pintrich, & M. Zeidner (Eds.), *Handbook of self-regulation* (pp. 631-649). San Diego, CA: Academic Press.

Schunk, D. H., & Pajares, F. (2001). The development of academic self-efficacy. In A. Wigfield, & J. S. Eccles (Eds.), *Development of achievement motivation* (pp. 15-32). San Diego, CA: Academic Press.

Schunk, D. H., & Pajares, F. (2005). Competence beliefs in academic functioning. In A. J. Elliot, & C. Dweck (Eds.), *Handbook of competence and motivation* (pp. 85-104). New York: Guilford Press.

Schunk, D. H., & Zimmerman, B. J. (2007). Influencing children's self-efficacy and self-regulation of reading and writing through modeling. *Reading & Writing Quarterly, 23*, 7-25.

Schunk, D. H., Pintrich, P. R., & Meece, J. L. (2008). *Motivation in education (3rd ed.).* Upper Saddle River, NJ: Pearson.

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

Seifert, T. L. (1995). Characteristics of ego- and task-oriented students: A comparison of two methodologies. *British Journal of Educational Psychology, 65*, 125-138.

Seifert, T. L. (1997). Academic goals and emotions: results of a structural equation model and cluster analysis. *British Journal of Educational Psychology, 67*, 323-338.

Seifert, T. L. (2004). Understanding student motivation. *Educational Research, 46*, 137-149.

Seifert, T. L., & O'Keefe, B. (2001). The relationship of work avoidance and learning goals to perceived competency, externality and meaning. *British Journal of Educational Psychology, 71*, 81-92.

Seymour, E., & Hewitt, N. M. (1997). *Talking about leaving: Why undergraduates leave the sciences.* Boulder, CO: Westview Press.

Sharp, J., & Byrne, J. (2002). *Using ICT in Primary Science Teaching.* Learning matters: Exeter.

Simpkins, S. D., Davis-Kean, P. E., & Eccles, J. S. (2006). Maths and science motivation: A longitudinal examination of the links between choices and beliefs. *Developmental Psychology, 42*, 70-83.

Sink, C. A., & Spencer, L. R. (2005). My Class Inventory - Short Form as an accountability tool for elementary school counsellors to measure classroom climate. *Professional School Counseling, 9*, 37-48.

Sjøberg, S., & Schreiner, C. (2010). *The ROSE project: An overview and key findings.* Oslo: University of Oslo.

Snyder, S. J., & Vaughan, M. J. (1998). Multimedia and student expectations. *Developments in Business Simulation and Experiential Learning, 25*.

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

Spady, W. (1994). *Outcome-based education: Critical issues and answers.* Arlington, VA: American Association of School Administrators.

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

Squire, K. (2005). *Game-based learning: Present and future state of the field.* Madison, WI: University of Wisconsin-Madison Press.

Stacey, J. (1988). Can there be feminist ethnography? *Women's Studies International Forum, 11,* 21-27.

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

Stevens, J. P. (1992). *Applied multivariate statistics for the social sciences* (2nd ed.). Hillsdale, NJ: Lawrence Erlbaum.

Stevens, J. P. (2002). *Applied multivariate statics for the social sciences (4th ed.).* Mahwah, NJ: Lawrence Erlbaum.

Streiner, D. L., & Norman, G. R. (2003). Short, homogeneous version of the Marlowe-Crowne Social Desirability Scale. *Journal of Clinical Psychology, 28*, 191-193.

Taboada, A., Tonks, S., Wigfield, A., & Guthrie, J. (2009). Effects of motivational and cognitive variables on reading comprehension. *Reading and Writing, 22*, 85-106.

Tan, I. G., Sharan, S., & Lee, C. K. (2007). Group investigation effects on achievement, motivation, and perceptions of students in Singapore. *Journal of Educational Research, 100*, 142-154.

Tashakkori, A., & Teddlie, C. (1998). *Mixed methodology: Combining qualitative and quantitative approaches.* Thousand Oaks, CA: Sage.

Taylor, P. C., & Campbell-Williams, M. (1993). Discourse toward balanced rationality in the high school mathematics classroom: Ideas from Habermas's critical theory. In J. A. Malone, & P. C. Taylor (Eds.), *Constructivist interpretations of teaching and learning mathematics* (pp. 135-148). (Proceeding of Topic Group 10 at the Seventh International Congress on Mathematical Education) Perth, Western Australia: Curtin University of Technology.

Taylor, P. C., Fraser, B. J., & Fisher, D. L. (1997). Monitoring constructivist classroom learning environments. *International Journal of Educational Research, 27*, 293-302.

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

Telli, S., Cakiroglu, J., & den Brok, P. (2006). Turkish secondary education students' perceptions of their classroom learning environment and their attitude towards biology. In D. L. Fisher, & M. S. Khine (Eds.), *Contemporary approaches to research on learning environments* (pp. 517-542). Singapore: World Scientific.

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

Telli, S., den Brok, P., Tekkaya, C., & Cakiroglu, J. (2009). Turkish students' perceptions of their biology learning environments: The effects of gender and grade level. *Asian Journal of Educational Research and Synergy, 1*, 110-124.

The National Centre for Education Statistics (NCES). (2000). *The NAEP science scale*. Retrieved June 29, 2005, from http://nces.ed.gov/nationalreportcard/science/scale.asp

Theobald, M. A. (2006). *Increasing student motivation: Strategies for middle and high school teachers.* Thousand Oaks, CA: Corwin.

Thompson, B. (1998a). Review of 'What if there were no significance tests?' *Educational and Psychological Measurement, 58*, 334-346.

Thompson, B. (1998b). *Five methodology errors in educational research: The pantheon of statistical significance and other faux pas.* Address presented at

the annual meeting of the American Educational Research Association, San Diego, CA.

Tobin, K., & Fraser, B. (1998). Qualitative and quantitative landscapes of classroom learning environments. In B. J. Fraser, & K. G. Tobin (Eds.), *The international handbook of science education* (pp. 623-640). Dordrecht, The Netherlands: Kluwer Academic Publishers.

Trickett, E. J., & Moos, R. H. (1973). Social environment of junior high and high school classrooms. *Journal of Educational Psychology, 65*, 93-102.

Trochim, W. M., & Donnelly, J. P. (2006). *The research methods knowledge base* (3rd ed.). Cincinnati, OH: Atomic Dog.

Tuan, J., Chin, C., & Shieh, S. (2005). The development of a questionnaire to measure students' motivation towards science learning. *international Journal of Science Education, 27*, 639-654.

Tytler, R. (2007). *Re-imagining science education: Engaging students in science for Australia's future.* Camberwell, Victoria: ACER Press.

Urdan, T., & Midgley, C. (2003). Changes in the perceived classroom goal structure and pattern of adaptive learning during early adolescence. *Contemporary Educational Psychology, 28*, 524-551.

Urdan, T., & Schoenfelder, E. (2006). Classroom effects on student motivation: Goal structures, social relationships, and competence beliefs. *Journal of School Psychology, 44*, 331-349.

Vallerand, R. J., Pelletier, L. G., Blais, M., Briére, N. M., Senècal, C., & Valliéres, E. F. (1992). The academic motivation scale: A measure of intrinsic, extrinsic and motivation in education. *Educational and Psychological Measurement*, *52*, 1003-1019.

VanderStoep, S., Pintrich, P. R., & Fagerlin, A. (1996). Disciplinary differences in self-regulated learning in college students. *Contemporary Educational Psychology*, *21*, 345-362.

Velayutham, S. (2012). *The influence of classroom environment on students' motivation and self-regulation.* Unpublished doctoral thesis, Curtin University, Perth, Australia.

Velayutham, S., & Aldridge, J. M. (2013). Influence of psychosocial classroom environment on students' motivation and self-regulation in science learning: A structural equation modeling approach. *Research in Science Education*, *43*, 507-527.

Velayutham, S., Aldridge, J. M., & Fraser, B. J. (2011). Development and validation of an instrument to measure students' motivation and self-regulation in science learning. *International Journal of Science Education*, *33*(15), 2159-2179.

Velayutham, S., Aldridge, J., & Fraser, B. J. (2013). Gender differences in student motivation and self-regulation in science learning: A multi-group structural equation modelling analysis. *International Journal of Science and Mathematics Education, 10*, 1347-1368.

Vos, T., Astbury, J., Piers, L. S., Magnus, A., Heenan, M., & Stanley, L. (2006). Measuring the impact of intimate partner violence on the health of women in Victoria, Australia. *Bulletin of the World Health Organisation, 84(9)*, 739-744.

Wahyudi, & Treagust, D. (2004). An investigation of science teaching practices in Indonesian rural secondary school. *Research in Science Education*, *34*(4), 455-467 .

Walberg (Ed.), H. J. (1979). *Educational environments and effects: Evaluation, policy and productivity.* Berkeley, CA: McCutchan.

Walberg, H. J. (1968). Structural and affective aspects of classroom climate. *Psychology in the Schools*, *5*, 247-253.

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

Walker, J. C., & Evers, C. W. (1988). The epistemological unit of educational research. In J. P. Keeves (Ed.), *Educational research, methodology, and measurement: An international handbook.* New York: Pergamon Press.

Watt, H. M. (2004). Development of adolescents' self perceptions, values and task perceptions according to gender and domain in 7th through 11th grade Australian students. *Child Development*, *75*, 1556-1574.

Watt, H. M. (2006). The role of motivation in gendered educational and occupational trajectories related to maths. *Educational Research and Evaluation*, *12*, 305-322.

Watt, H. M. (2008). Gender and occupational outcomes: An introduction. In H. M. Watt & J. S. Eccles (Eds.), *Gender and occupational outcomes: Longitudinal assessments of individual, social, and cultural influences* (pp. 3-24). Washington, DC: APA books.

Watt, H. M. (2010). Gender and occupational choice. In D. R. McCreary & J. C. Chrisler (Eds.), *Handbook of gender research in psychology* (pp. 379-400). New York, NY: Springer.

Waxman, H. C., & Huang, S. L. (1998). Classroom learning environments in urban elementary, middle, and high school. *Learning Environment Research, 1*, 95-113.

Wei, M., den Brok, P., & Zhou, Y. (2009). Teacher interpersonal behaviour and student achievement in English as a foreign language classrooms in China. *Learning Environments Research, 12*, 157-174.

Weinstein, C. E., Schulte, A., & Palmer, D. R. (2002). *The learning and study strategies in inventory (2nd ed.).* Clearwater, FL: H and H Publishing.

Wiburg, K. (1995). Learning from mistakes: Research in special education and technology. *Learning and Leading with Technology*, 64-67.

Wigfield, A., & Cambria, J. (2010). Students' achievement values, goal orientations, and interest: Definitions, development, and relations to achievement outcomes. *Developmental Review, 30*, 1-35.

Wigfield, A., Guthrie, J., Perencevich, K., Taboada, A., Klauda, S., McRae, A., et al. (2008). Role of reading engagement in mediating effects of reading

comprehension instruction on reading outcomes. *Psychology in the Schools, 45*, 432-445.

Wikipedia. (2013). *The Free Encyclopedia*. Retrieved August 31, 2013, from States and Territories of Australia: http://en.wikipedia.org.wiki.States_and_territories_of_Australia

Williams, J. B., & Jacobs, J. (2004). Exploring the use of blogs as learning spaces in the higher education sector. *Australasian Journal of Educational Technology*, *20*(2), 232-247.

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

Wolters, C. A. (1999). The relation between high school students' motivational regulation and their use of learning strategies, effort, and classroom performance. *Learning and Individual Differences, 11*, 281-300.

Wolters, C. A. (2010). *Self-regulated learning and the 21st century competencies*. Retrieved November, 2012, from http://www.hewlett.org/library/grantee-publication/self-regulated-learning-and-21st-century-competencies

Wolters, C. A., & Pintrich, P. R. (1998). Contextual differences in student motivation and self-regulated learning in mathematics, English and social studies classrooms. *Instructional Science*, *26*, 27-47.

Wolters, C. A., & Rosenthal, H. (2000). The relation between students' motivational beliefs and their use of motivational regulation strategies. *International Journal of Educational Research*, *33*, 801-820.

Wolters, C. A., Yu, S. L., & Pintrich, P. R. (1996). The relation between goal orientation and students' motivational beliefs and self-regulated learning. *Learning and Individual Differences*, *8*, 211-238.

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

Wong, A. F., & Fraser, B. J. (1996). Environment-attitude associations in the chemistry laboratory classroom. *Research in Science and Technological Education*, *64*, 29-40.

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

Wubbels, T., & Brekelmans, M. (2005). Two decades of research on teacher- Student relationships in class. *International Journal of Educational Research*, *43*(1), 6-24.

Wubbels, T., Brekelmans, M., & Hooymayers, H. (1991). Interpersonal teacher behavior in the classroom. In B. J. Fraser & H. J. Walberg (Eds.), *Educational environments* (pp. 141-160). Oxford: Pergamon Press.

Wubbels, T., Creton, H. A., & Hooymayers, H. P. (1992). Review of research on teacher communication styles with use of the Leary model. *Journal of Classroom Interaction*, *27*, 1-12.

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

Xiang, P., McBride, R. E., & Bruene, A. (2004). Fourth graders' motivation in an elementary physical education running program. *Elementary School Journal*, *104*, 253-266.

Yarrow, A., Millwater, J., & Fraser, B. J. (1997). Improving university and primary school classroom environments through preservice teachers' action research. *International Journal of Practical Experiences in Professional Education*, *1*, 68-93.

Yelland, N. (1999). Technology as play. *Early Childhood Education Journal, 26*(4), 217-220.

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

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

Zeldin, A. L., & Pajares, F. (2000). Against the Odds: Self-efficacy Beliefs of women in mathematical, scientific and technological careers. *American Educational Research Journal*, *37*(1), 215-246.

Zimmerman, B. J. (2000). Self-efficacy: An essential motive to learn. *Contemporary Educational Psychology*, *25*, 82-91.

Zimmerman, B. J. (2002). Becoming a self-regulated learner: An overview. *Theory into Practice*, *41*, 64-70.

Zimmerman, B. J. (2008). Investigating self-regulation and motivation: Historical background, methodological developments, and future prospects. *American Educational Research Journal*, *45*, 166-183.

Zimmerman, B. J., & Martinez-Ponz. (1990). Student differences in self-regulated learning: Relating grade, sex, and giftedness to self-efficacy and strategy use. *Journal of Educational Psychology*, *82*, 51-59.

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

APPENDIX A

What Is Happening In this Class?

(WIHIC)

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. Thank you.

Year Group ………………   **Sex** …………………

		Almost Never	Seldom	Sometimes	Often	Almost always
1	I make friendship among students in this class.	1	2	3	4	5
2	The teacher takes a personal interest in me.	1	2	3	4	5
3	I discuss ideas in class.	1	2	3	4	5
4	Getting a certain amount of work done is important to me.	1	2	3	4	5
5	I cooperate with other students when doing assignment work.	1	2	3	4	5
6	The teacher gives as much attention to my questions as to other students' questions.	1	2	3	4	5
7	I know other students in this class.	1	2	3	4	5
8	The teacher goes out of his/her way to help me.	1	2	3	4	5
9	I give my opinions during class discussions.	1	2	3	4	5
10	I do as much as I set out to do.	1	2	3	4	5
11	I share my books and other resources with other students when doing assignments	1	2	3	4	5
12	I get the same amount of help from the teacher as do other students.	1	2	3	4	5
13	I am friendly to members of this class.	1	2	3	4	5
14	The teacher considers my feeling.	1	2	3	4	5
15	The teacher asks me questions.	1	2	3	4	5
16	I know the goals of this class.	1	2	3	4	5

		Almost Never	Seldom	Someti mes	Often	Almost always
17	When I work in groups in this class, there is teamwork.	1	2	3	4	5
18	I have the same amount of say in this class as other students.	1	2	3	4	5
19	Members of the class are my friends.	1	2	3	4	5
20	The teacher helps me when I have trouble with my work.	1	2	3	4	5
21	My ideas and suggestions are used during class discussions.	1	2	3	4	5
22	I am ready to start this class on time.	1	2	3	4	5
23	I work with other students on projects in this class.	1	2	3	4	5
24	I am treated the same as other students in this class.	1	2	3	4	5
25	I work well with other class members.	1	2	3	4	5
26	The teacher talks to me.	1	2	3	4	5
27	I ask the teacher questions.	1	2	3	4	5
28	I know what I am trying to accomplish in this class.	1	2	3	4	5
29	I learn from other students in this class.	1	2	3	4	5
30	I receive the same encouragement from the teacher as other student.	1	2	3	4	5
31	I help other class members who are having trouble with their work.	1	2	3	4	5
32	The teacher is interested in my problems.	1	2	3	4	5
33	I explain my ideas to other students.	1	2	3	4	5
34	I pay attention during this class.	1	2	3	4	5
35	I work with other students in this class	1	2	3	4	5
36	I get the same opportunity to contribute to class discussions as other students.	1	2	3	4	5
37	Students in this class like me.	1	2	3	4	5
38	The teacher moves about the class to talk to me.	1	2	3	4	5
39	Students discuss with me how to go about solving problems.	1	2	3	4	5
40	I try to understand the work in this class.	1	2	3	4	5
41	I cooperate with other students on class activities.	1	2	3	4	5
42	My work receives as much praise as other students' work.	1	2	3	4	5
43	In this class, I get help from other students.	1	2	3	4	5
44	The teacher's questions help me to understand.	1	2	3	4	5
45	I am asked to explain how I solve problems.	1	2	3	4	5
46	I know how much work I have to do.	1	2	3	4	5
47	Students work with me to achieve class goals.	1	2	3	4	5
48	I get the same opportunity to answer questions as other students.	1	2	3	4	5

APPENDIX B

Student Adaptive Learning Engagement in Mathematics

(SALEM)

Student Adaptive Learning Engagement in Mathematics Questionnaire

Directions for Students

Here are some statements about you as a student in this class. Please read each statement carefully. Circle the number that best describes what you think about those statements.

There are no 'right' or 'wrong 'answers. Your opinion is what is wanted.

For each statement, draw a circle around

1	if you *Strongly disagree* with the statement
2	if you *Disagree* with the statement
3	if you *Are not sure* about the statement
4	if you *Agree with the statement*
5	if you *Strongly agree* with the statement

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. Thank you.

Year Group   ………………   **Sex**   ………………

		Strongly disagree	Disagree	Not sure	Agree	Strongly agree
In this maths class………						
1	One of my goals is to learn as much as I can.	1	2	3	4	5
2	What I learn can be used in my daily life.	1	2	3	4	5
3	I can master the skills that are taught.	1	2	3	4	5
4	Even when tasks are uninteresting, I keep working.	1	2	3	4	5
5	One of my goals is to learn new mathematics content.	1	2	3	4	5
6	What I learn is interesting.	1	2	3	4	5
7	I can figure out how to do difficult work.	1	2	3	4	5
8	I work hard even if I do not like what I am doing.	1	2	3	4	5
9	One of my goals is to master new mathematics skills.	1	2	3	4	5
10	What I learn is useful for me to know.	1	2	3	4	5
11	Even if the maths work is hard, I can learn it.	1	2	3	4	5
12	I continue working even if there are better things to do.	1	2	3	4	5

		Strongly disagree	Disagree	Not sure	Agree	Strongly Agree
In this maths class………						
13	It is important that I understand my work.	1	2	3	4	5
14	What I learn is helpful to me.	1	2	3	4	5
15	I can complete work if I try.	1	2	3	4	5
16	I concentrate so that I will not miss important points.	1	2	3	4	5
17	It is important for me to learn the maths content that is taught.	1	2	3	4	5
18	What I learn is relevant to me.	1	2	3	4	5
19	I will receive good grades.	1	2	3	4	5
20	I finish my work and assignments on time.	1	2	3	4	5
21	It is important to me that I improve my mathematical skills.	1	2	3	4	5
22	What I learn is of practical value.	1	2	3	4	5
23	I can learn the work we do.	1	2	3	4	5
24	I do not give up even when the work is difficult.	1	2	3	4	5
25	It is important that I understand what is being taught to me.	1	2	3	4	5
26	What I learn satisfies my curiosity.	1	2	3	4	5
27	I can understand the contents taught.	1	2	3	4	5
28	I concentrate in class.	1	2	3	4	5
29	Understanding maths ideas is important to me.	1	2	3	4	5
30	What I learn encourages me to think.	1	2	3	4	5
31	I am good at mathematics.	1	2	3	4	5
32	I keep working until I finish what I am supposed to do.	1	2	3	4	5

APPENDIX C

Student Interview Protocol

Sample Interview Protocol

Introduction (Interviewer)

Hello! How are you? Thanks for agreeing to speak to me. You may be aware; I am investigating mathematics students' views of a learning environment that integrates multimedia into the learning process. Do you remember those surveys you filled out a few weeks ago? That was the beginning of the project and now I am trying to double check what those questionnaires came up with. I observed some mathematics lesson and am also making a follow-up to this as well. Are you ready so we can begin?

Scale	Question
Student Cohesiveness	1. Do you make friends with other students in your class?
	2. Do students in your class like you?
	3. Do you get help from other students in your class?
Teacher Support	1. Does the teacher go out of his/her way to help you?
	2. Is the teacher interested in your problems?
	3. Do the teacher's questions help to understand the topic?
Involvement	1. Do you give your opinion during class discussions?
	2. Are your ideas and suggestions used during class discussions?
	3. Do other students discuss with you how to go about solving problems?
Task Orientation	1. Do you know the purpose of studying in this class?
	2. Are you always ready to study in this class?
	3. Do you know how much work you have to do?
Cooperation	1. Do you cooperate with other students when doing assignment work?
	2. Do you share your books and resources?
	3. Do you cooperate with other students on class activities?
Equity	1. Does the teacher give you as much attention as to other student?
	2. Are you given the same opportunity in the class?
	3. Do you receive the same encouragement from the teacher?

Scale	Question
Goal Orientation	1. Do you think it is important for you to understand your work?
	2. Is it important for you that you understand mathematics?
	3. Do you think that learning mathematics is one of your goals?
Task Value	1. Is what you learn interesting, helpful and relevant to you?
	2. Is what you learn of practical value to you?
	3. Does what you learn encourage you to think and satisfy your curiosity?
Self-Efficacy	1. Are you good at mathematics and do you understand what you are being taught?
	2. Do you think you master the skills that are taught and do you think you will receive good grades this year?
	3. Do you think you can master the skills that are taught in class?
Self-Regulation	1. Even if tasks are not interesting, do you persevere in your work?
	2. Do you think you work hard even if you do not like what you are doing?
	3. Do you concentrate in class so that you do not miss important things?
Other	1. Do you think the presence / lack of whiteboards/computers in your lessons affect the way you learn mathematics?
	2. What do you think of the whiteboards/computers in your class? Are they necessary in your maths lessons? Why?
	3. How often do you do mathematics on the computer?
	4. If your teacher has not given you H/work, do you ever do mathematics on your own at school or home?
	5. Using an analogue describe how you have found your lessons to be?

APPENDIX D

Information Sheet and Consent Form:

Teachers

Maths Department

Teachers Information Sheet

Investigating students' perceptions of the learning environment of mathematics classrooms that use multimedia, and their motivation and self-regulation in mathematics

Dear Colleague,

You are invited to participate in the research project identified above. This research project is part of my PhD degree with Curtin University of Technology, which is being supervised by Dr Jill Aldridge.

Why is the research being done?

The purpose of the research is to investigate mathematics students' perceptions of a learning environment that integrates multimedia into their learning process. The study further investigates the impact that this learning environment has on students' motivation towards and self-regulation in mathematics. It is expected that the study will provide important information about whether the use of multimedia is likely to improve students' motivation towards and self-regulation in mathematics.

Who can participate in the research?

I invite all mathematics teachers at ▇▇▇▇▇▇▇▇▇ to participate in this research.

What choice do you have?

Participation in this research is entirely your choice. Whether or not you decide to participate, your decision will not disadvantage you in any way. Only those who give their informed consent will be included in the project. If you give informed consent to participate, you may still withdraw from the project at any time without giving a reason.

What would you be asked to do?

I am seeking permission to administer questionnaires to your students during your lesson. It will take about 25 minutes to complete. I also seek your permission to observe one of your classes for the purposes of seeing your students' reactions to their learning environments. I will also need to interview you about the various actions that would have taken place in your observed class. Your view and thoughts about multimedia learning environment will be sought during this interview. The interview will take place at a time that is convenient to both of us.

What are the risks and benefits of participating?

Some teachers find it beneficial to think or talk about how they perceive and approach their lessons. Of course, there is always a risk that you might feel upset by thinking or talking about your experiences. If this should happen you are free to

withdraw from the project. In the unlikely event that participation in this project causes you distress, you could also withdraw from participating immediately. This study has the potential to inform us the degree of impact a multimedia learning environment have on our students' engagement in mathematics classrooms.

How will your privacy be protected?

The information you will provide will be used for the sole purposes of the study and only myself and my supervisor will have access to this data. The interview transcript will not have your name or any other identifying information on it and will be in adherence to university and Department of Education policy. Electronic data will be retained in a secure, password-protected computer for a minimum of 5 years at Curtin University before a decision is made as to whether it will be destroyed.

How will the information collected be used?

At the conclusion of the project, a summary of the results and associated reports will be available in the maths office. The results will also be reported in a thesis to be submitted for my degree, and as appropriate, in papers for presentation at conferences or for publication in scientific journals.

What do you need to do to participate?

Please read this Information Statement and be sure you understand its contents before you consent to participate. If there is anything you do not understand, or you have questions, please see me and I will be happy to discuss these issues with you. At your convenience, you could leave the consent form in my pigeonhole or on my desk.

Further information

Should you have concerns about your rights as a participant in this research, or you have a complaint about the manner in which the research is conducted, it may be given to me in person or by email, Addwell.Chipangura@education.wa.edu.au If an independent person is preferred, you could contact my supervisor, Dr Jill Aldridge at J.Aldridge@curtin.edu.au or by telephone (08) 92663592.

This study has been approved by the Curtin University Human Research Ethics Committee (Approval Number SMEC-108-11) and the Department of Education (Approval number D12/0110395). If needed, verification of approval can be obtained either by writing to the Curtin University Human Research Ethics Committee, c/- Office of Research and Development, Curtin University of Technology, GPO Box U 1987, Perth, WA, 6845 or by telephoning (08) 92662784 or hrec@curtin.edu.au

Thank you,

Addwell Chipangura

Teachers Consent Form

Investigating students' perceptions of the learning environment of mathematics classrooms that use multimedia, and their motivation and self-regulation in mathematics.

I understand that the project will be conducted as described in the Information Statement, a copy of which I have retained.

I understand that I can withdraw from the project at any time and do not have to give any reason for withdrawing.

I understand that my personal information will be de-identified and will remain anonymous to the research team,

I have the right to contact the researcher and have any questions answered to my satisfaction.

I understand that the procedure itself may not benefit me.

I understand that my involvement is voluntary and I can withdraw anytime without problem.

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

I understand that no personal identifying information like my name and address will be used in any published material.

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

_____

Name: _____

Signature: _____

Date: _____

APPENDIX E

Information Sheet and Consent Form:

Caregivers

Curtin University

Information Sheet for Parents/Caregivers

Dear Parent/Caregiver,

My name is Addwell Chipangura. I am a teacher at ▬▬▬▬▬ SHS and am currently completing a piece of research for my doctoral degree at Curtin University of Technology.

Purpose of Research

I am investigating students' views of a learning environment in mathematics classrooms. I am also keen to find out if there is any relationship between this learning environment and their engagement in mathematics lessons.

Your role

I am interested in finding out the mathematics students' views of a learning environment in mathematics classrooms at ▬▬▬▬. I will ask your child to complete a questionnaire on his/her views of that learning environment. There will be minimal disruption to students, as the questionnaire requires about 25 minutes of class time for the students to complete. The observations and informal interviews will be conducted by me. This will occur during normal lesson/school time.

Consent to participate

Your child's involvement in the research is entirely voluntary. You or your child has the right to withdraw at any stage without it affecting your rights or my responsibilities. If you consent to your child participating in the study you do not need to do anything. If I have not heard from you by Friday 8 June, then I will assume that you have agreed to have your child participate and allow me to use your child's data in this research. However, if you do not want your child to participate in this study, please fill in and return the tear off form below to me or your child's maths teacher by Friday 8 June. With feedback collected from this study, we can be guided to improve our teaching and learning and make our mathematics classrooms a more pleasant, positive and engaging environment. This can lead to an improvement in our students' long term outcomes.

Confidentiality

The information your child will provide will be used for the sole purposes of this study and only myself and my supervisor will have access to this data. The questionnaire or interview transcript will not have your child's name or any other identifying information on it and will be in adherence to university and Department of Education policy. The interview transcript will be kept in a locked cabinet for at least five years before a decision is made as to whether it should be destroyed.

Further information

This research has been reviewed and given approval by Curtin University of Technology, Human Research Ethics Committee (Approval Number SMEC-███) and Department of Education (Approval number ██████). If you would like further information about the study, please feel free to contact me on (08) 98920690 or by email addwell.chipangura@education.wa.edu.au . Alternatively, you can contact my supervisor Dr Jill Aldridge on (08) 92663592 or by email J.Aldridge@curtin.edu.au

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

Kind Regards,

Addwell Chipangura

Parent/Caregiver Consent Form

Investigating students' perceptions of the learning environment of mathematics classrooms that use multimedia, and their motivation and self-regulation in mathematics.

• I understand the purpose and procedures of the study.

• I have been provided with the participation information sheet.

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

• I understand that my child's involvement is voluntary and he/ she can withdraw anytime without problem.

• I understand that no personal identifying information like his/her name and address will be used in any published material.

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

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

• However, **I do/do not give consent** for my child to participate in the study outlined to me.

_____

Name of Child: _____

Parent/Caregiver Name: _____

Signature: _____

Date: _____

APPENDIX F

Information Sheet and Consent Form:

Students

Curtin University

Information Sheet: Students

Dear Maths Student,

I am currently completing a piece of research for my doctoral degree of Philosophy at Curtin University of Technology.

Purpose of Research

I am investigating students' views of a learning environment in mathematics classrooms at ███████. I am also keen to find out if there is any relationship between this learning environment and students' attention and focus in mathematics lessons.

Your role

I will ask you to complete a questionnaire on your views of your learning environment. I will not take more than is necessary to complete the questionnaires so that there is minimal disruption to lesson time.

Consent to participate

Your involvement in the research is entirely voluntary. You can withdraw at any stage without it affecting your rights or my responsibilities. I am therefore asking you to read and sign the consent form if you wish to participate. Please read and return your signed and dated consent form to me. When you have signed the consent form I will assume that you have agreed to participate and allow me to use your data in this research. With feedback collected from this study, we can be guided to improve our teaching and learning and make our mathematics classrooms a more pleasant, positive and engaging environment. This can lead to an improvement in your long term outcomes.

Confidentiality

The information you will provide will be used for the sole purpose of this study and only myself and my supervisor will have access to this data. The questionnaire will not have your name or any other identifying information on it and will be in adherence to university and Department of Education policy. Electronic data generated from the questionnaires will be kept in a password protected computer at Curtin University for at least five years, before a decision is made as to whether it should be destroyed.

Further information

Should you have concerns about your rights as a participant in this research, it may be given to me in person or on (08) 98920690 or by email Addwell.Chipangura@education.wa.edu.au If an independent person is preferred, you could contact my supervisor, Dr Jill Aldridge at J.Aldridge@curtin.edu.au or by telephone (08) 92663592. This study has been approved by

the Curtin University Human Research Ethics Committee (Approval Number SMEC-108-11) and the Department of Education (Approval number D12/0110395). If needed, verification of approval can be obtained either by writing to the Curtin University Human Research Ethics Committee, c/- Office of Research and Development, Curtin University of Technology, GPO Box U 1987, Perth, WA, 6845 or by telephoning (08) 92662784 or hrec@curtin.edu.au

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

Kind regards,

Addwell Chipangura.

Student Consent Form

Investigating students' perceptions of the learning environment of mathematics classrooms that use multimedia, and their motivation and self-regulation in mathematics.

•   I understand the purpose and procedures of the study.

•   I have been provided with the participation information sheet.

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

•   I understand that my involvement is voluntary and I can withdraw anytime without problem.

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

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

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

•   I **consent/do not consent** to participate in the study outlined to me *(please delete inapplicable)*.

_____

Name: _____

Signature: _____

Date: _____

APPENDIX G

Ethics Approval:
Department of Education

Government of **Western Australia**
Department of **Education**

Your ref   :
Our ref   :   D12/0110395
Enquiries   :

Mr Addwell Chipangura
North Albany Senior High School
47 Anson St
ALBANY   WA   6330

Dear Mr Chipangura

Thank you for your completed application received 7 February 2012 to conduct research on Department of Education sites.

The focus and outcomes of your research project, *Investigating students' perceptions of the learning environment of mathematics classrooms that use multimedia, and their motivation and self regulation in mathematics,* are of interest to the Department. I give permission for you to approach site managers to invite their participation in the project as outlined in your application. It is a condition of approval, however, that upon conclusion the results of this study are forwarded to the Department at the email address below.

Consistent with Department policy, participation in your research project will be the decision of the schools invited to participate, individual staff members, the children in those schools and their parents. A copy of this letter must be provided to site managers when requesting their participation in the research. Researchers are required to sign a confidential declaration and provide a current Working with Children Check upon arrival at the Department of Education site.

Responsibility for quality control of ethics and methodology of the proposed research resides with the institution supervising the research. The Department notes a copy of a letter confirming that you have received ethical approval of your research protocol from the Curtin University Human Research Ethics Committee.

Any proposed changes to the research project will need to be submitted for Department approval prior to implementation.

Please contact Ms Allison McLaren, A/Evaluation Officer, on (08) 9264 5512 or researchandpolicy@det.wa.edu.au if you have further enquiries.

Very best wishes for the successful completion of your project.

Yours sincerely

ALAN DODSON
DIRECTOR
EVALUATION AND ACCOUNTABILITY

21 February 2012

151 Royal Street, East Perth Western Australia 6004

APPENDIX H

Ethics Approval:
Curtin University

Curtin University

Memorandum

To	Addwell Chipangura, SMEC
From	Pauline Howat, Administrator, Human Research Ethics Science and Mathematics Education Centre
Subject	Protocol Approval **SMEC-108-11**
Date	11 January 2012
Copy	Jill Aldridge, SMEC

Office of Research and Development

Human Research Ethics Committee

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

Thank you for your "Form C Application for Approval of Research with Low Risk (Ethical Requirements)" for the project titled *"Investigating students' perceptions of the learning environment of mathematics classrooms that use multimedia, and their motivation and self-regulation in mathematics"*. On behalf of the Human Research Ethics Committee, I am authorised to inform you that the project is approved.

Approval of this project is for a period of twelve months **19th December 2011** to **18th December 2012**.

The approval number for your project is **SMEC-108-11**. *Please quote this number in any future correspondence*. If at any time during the twelve months changes/amendments occur, or if a serious or unexpected adverse event occurs, please advise me immediately.

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 by the Curtin University Human Research Ethics Committee (Approval Number SMEC-108-11). If needed, verification of approval can be obtained either by writing to the Curtin University Human Research Ethics Committee, c/- Office of Research and Development, Curtin University of Technology, GPO Box U1987, Perth, 6845 or by telephoning 9266 2784 or hrec@curtin.edu.au

J:\SAE\SMEC\office\Pauline\ETHICS\Ethics Approval Letter 2011\Chipangura.docx   CRICOS Provider Code 00301J

APPENDIX I

Principal's Letter to Parents/Caregivers

Principal's Information letter in school newsletter

Research Studies

From time to time schools are approached by individuals (often teachers) wanting to undertake research as part of their post graduate studies. These research studies benefit education by providing valuable feedback from parents, students and staff. All research studies in schools are required to fit within very strict ethical guidelines, including minimal disruption, and permission has to be granted by the Department of Education central office. ██████ Mathematics teacher, Mr Addwell Chipangura, is currently undertaking studies towards his doctoral degree and permission has been granted for Mr Chipangura to undertake his research at ██████. Enclosed in this newsletter is information relating to this. I am quite excited about Mr Chipangura's research as it relates to the use of multimedia and technologies. As parents are aware we are constantly exploring the use of technologies as a way to provide relevant and engaging teaching and learning programs for our students. If you do not wish your child to be participate in this survey, then please complete the enclosed form and return to ██████ by next Friday, 11 May.

██████ Newsletter Issue No 3/12

30 April 2012