School of Education

Gender Differences in the Relationships between the Learning Environment and Student Outcomes

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DECLARATION

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

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

The research presented and reported in this thesis was conducted in accordance with the National Health and Medical Research Council National Statement on Ethical Conduct in Human Research (2007)-updated 2014. The proposed research study received human research ethics approval from the Curtin University Human Ethics Research Committee (ECOO262), Approval Number # RDSE-70-15.

Signature [redacted]

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ABSTRACT

It is widely acknowledged that the context in which learning takes place, or the psychosocial learning environment, supports the learning process. Further, research evidence suggests that the learning environment is related to a range of student outcomes. Given the malleable nature of the learning environment, examining how it can be modified to better suit learners' needs provides educators with the opportunity to create a learning environment that optimises the learning of all students.

The overarching aim of this research was to examine the interactions between the learning environment and outcomes that support or inhibit to the learning process (including motivation, self-regulation, mathematics anxiety and mathematics achievement). Importantly, the study examined whether and how these interactions differ for male and female students.

The study drew on the post-positive paradigm using a combined explanatory correlational and causal comparative design. The collection of data involved a sample of 426 students, 287 female and 139 male students, studying in 27 single-sex university-level mathematics classes in the United Arab Emirates (UAE). All students were in their first year of studying mathematics as part of an engineering degree program.

Data collection involved the administration of three surveys to assess (1) the students' perceptions of the mathematics learning environment; (2) their reported levels of motivation and self-regulation; and (3) their degree of mathematics anxiety. All three instruments were developed in previous studies, but for this study, they were translated into Arabic and presented in a dual English/Arabic format. In addition to the survey data, the students' final course grades were used as a measure of mathematics achievement. Analysis of the data indicated that all three instruments displayed satisfactory factor analysis, internal consistency reliability, discriminant validity and the ability to differentiate between classes. The results, which supported the validity of the instruments for use at the university level in the UAE, provided confidence in the results of subsequent analysis.

A hypothetical model, based on prior research and theorising was developed to examine the relationships between the variables (mathematics learning environment, motivation, self-regulation, mathematics anxiety and mathematics achievement). Given the complexity of the model, it was necessary to examine the relationships of five simple three-construct models. Using the results of these simple models, the final model included only those paths shown to be statistically significant. Analysis of both the measurement and structural models using structural equation modelling (SEM) with maximum likelihood estimation (MLE) confirmed the final research model. Psychometric equivalence (measurement invariance) was established using multi-group confirmatory factor analysis (MGCFA) across gender. Following confirmation of psychometric equivalence, differences in students' perceptions of the learning environment, their reported levels of motivation, self-regulation and mathematics anxiety, and their level of mathematics achievement for both male and female students were investigated using independent sample t-tests and effect size. Finally, differences in the relationships included in the final structural model were examined across gender using multi-group structural equation modelling (MGSEM).

The measurement model displayed satisfactory construct validity (convergent and discriminant validity) and model fit indices, which confirmed that the indicator variables provided a good measure of associated latent variables. Evaluation of the five simple three-construct models indicated that 28 of the 53 possible relationships were statistically significant. The statistically significant relationships found in the five three-construct models were combined to form a five-construct model, which underwent a second round of SEM. Following this analysis, 24 relationships remained statistically significant and were retained in the final structural model. The results of the final structural model indicated that mathematics learning environment was a key determinant of motivation, self-regulation, mathematics anxiety and mathematics achievement. All seven learning environment indicator variables were either directly or indirectly (i.e. mediated through either motivation, self-regulation or mathematics anxiety) related to mathematics achievement. The significant relationships in the final structural model supported all hypothesised relationships.

The MGCFA results supported psychometric equivalence across gender, which suggests that male and female students interpreted the survey statements in a similar manner. Differences in means for the 13 indicator variables suggest that female students perceived a more positive learning environment and higher levels of motivation than male students. The differences between means for self-regulation, mathematics anxiety and mathematics achievement were not statistically significant. For both male and female students, the highest scale mean was for learning goal orientation, whereas the lowest was for mathematics anxiety.

MGSEM results indicated that of the 24 relationships, 21 were significant for female students and 11 for male students. Task orientation was the most influential learning environment variable for both male and female students, as it was positively associated for both genders with motivation (learning goal orientation, task value and self-efficacy) and self-regulation.

The 10 relationships that were significant for female students but not for male students emphasised that social aspects of the learning environment were important to female students. The statistically significant interactions between female students' perceptions of the learning environment and the different outcomes suggest that, for female students, positive relationships with the instructor and with peers as well as opportunities to collaborate in class could optimise their learning success. In contrast, these relationships were not significant for male students, which suggests that social relationships could be less important for improved outcomes of male students.

This research has made a number of contributions to the field of learning environments. The development and testing of a complex model that explains the influence of the learning environment on student outcomes provides a theoretical contribution. Given the lack of research in the UAE at the tertiary level, this contribution helps to explain how the mathematics learning environment might be optimised for both male and female students.

The methodological contributions included (1) support for using dual English/Arabic versions of the instruments to support the reliability of instruments in settings where the medium of instruction is in English but English is the students' second language; and (2) the availability of validated instruments to assess students' perceptions of their learning environment and their reported levels of motivation, self-regulation and mathematics anxiety for use by practitioners and researchers.

The current research makes a practical contribution by providing important information to educational planners in the UAE. This information could aid their decision making, particularly when considering the transition from the traditional single-sex system to a co-educational system. In addition, the implications of the findings provide information on interventions that instructors can use to improve the learning environment in ways that will influence students' motivation, self-regulation and mathematics anxiety and, ultimately, improve achievement.

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LIST OF ACRONYMS

Acronym	Meaning
χ^2	chi-squared
χ^2/df	normed chi-squared
AMOS	Analysis of a Moment Structures
AMS	Academic Motivation Scale
ANOVA	analysis of variance
AVE	average variance extracted
CES	Classroom Environment Survey
CFA	confirmatory factor analysis
CFI	comparative fit index
CI	confidence interval
CLES	Constructivist Learning Environment Survey
COLES	Constructivist Orientated Learning Environment Scale
CR	composite reliability
CUCEI	College and University Classroom Environment Inventory
EELLS	Engagement in English Language Learning and Self-Regulation
ESL	English as a Second Language
HCT	Higher Colleges of Technology
HEI	Higher Education Institutes
ICEQ	Individualised Classroom Environment Questionnaire
ICR	internal consistency reliability
IELTS	International English Language Testing System
IFI	incremental fit index
KMO	Kaiser-Meyer-Olkin
LASSI	Learning and Study Strategies Inventory
LEI	Learning Environment Instrument
LGO	Learning Goal Orientation
MARS	Mathematics Anxiety Rating Scale
MAS	Mathematics Attitude Scale
MENA	Middle East and North Africa
MGCFA	multi-group confirmatory factor analysis

Acronym	**Meaning**
MGSEM	multi-group structural equations modelling
MLE	minimum likelyhood estimation
MMI	Multi-dimensional Motivation Instrument
MSLQ	Motivated Strategies for Learning Questionnaire
OECD	Organisation for Economic Co-operation and Development
PALS	Patterns of Adaptive Learning Survey
PISA	Programme for International Student Assessment
PLS	partial least squares
QTI	Questionnaire for Teacher Interaction
R^2	coefficient of determination
R-MANX	Revised Mathematics Anxiety Scale
RMARS	Revised Mathematics Anxiety Rating Scale
RMSEA	Root Mean Square Error of Approximation
SALEM	Students' Adaptive Learning Engagement for Mathematics
SALES	Students'Adaptive Learning Engagement for Science
SEM	structural equations modelling
SREP	Self-Regulation Empowerment Programme
SRMR	standardised root-mean-square residual
STEM	science, technology, engineering and mathematics
SPSS	statistical package for social sciences
TIMSS	Trends in International Mathematics and Science Study
TLI	Tucker-Lewis index
UAE	United Arab Emirates
US	United States
WIHIC	What is Happening in this Class?

Chapter 1

INTRODUCTION

1.1 Introduction

It is recognised that to optimise learning, students need to have both the will (motivation) and the skill (self-regulation) to learn. Numerous research suggests that these attributes do not develop in isolation, but rather with the influence of the learning environment. The learning environment, which includes social, psychological and pedagogical contexts where learning occurs (Lim & Fraser, 2018), has been shown to have a positive relationship with achievement (Afari & Eksail, 2022; Cohn & Fraser, 2016; Fraser et al., 2010). The learning environment has also been shown to have positive relationships with motivation (Alzubaidi et al., 2016; Gilbert et al., 2013) and self-regulation (Wentzel et al., 2017), as well as indirect relationships with achievement when mediated by motivation (Winheller et al., 2013) or self-regulation (McMinn & Aldridge, 2020). In addition to these relationships, the learning environment has also been reported to have a negative relationship with mathematics anxiety (Deieso & Fraser, 2018; McMinn & Aldridge, 2020). These relationships emphasise the importance of the learning environment as a determinant of the factors that contribute to the learning process and learning outcomes.

As a major participant in the development of a positive learning environment, the instructor needs to examine ways to ensure that students feel capable of being successful, appreciate the value of the content, have goals to provide direction, and have the necessary practical skills to facilitate the learning process (Winheller et al., 2013). To achieve this goal, instructors have a number of strategies at their disposal, including setting classroom structures (Aldridge & Rowntree, 2021), inter-personal behaviour (Tosto et al., 2016), expectations and support (Gilbert et al., 2013), teaching style (Ashcraft, 2002) and use of feedback (Wentzel et al., 2017). However, given the needs of students varies between contexts and between student groups, examining ways to optimise learning for different groups to best meet the needs of their students is imperative.

The overarching aim of the study reported in this thesis was to examine how instructors can leverage important elements of the learning environment to meet the needs of university-level mathematics students in the United Arab Emirates (UAE). Given that tertiary education in the UAE is transitioning from single-sex to co-educational, an important focus of the study was to examine how the learning environment of the mathematics classes can be developed to be beneficial to both male and female students. To this end, the study examined the interactions between students' perceptions of the mathematics learning environment, the factors that support or hinder the learning process (motivation, anxiety and self-regulation) and student achievement, and how these interactions differ for males and females. Examining these differences was pivotal to understanding how efforts to optimise learning outcomes for both genders might become a reality. Establishing gender differences in these interactions means that each gender can be treated as a separate entity, thereby becoming the focus of its own directed solutions aimed at optimal learning outcomes.

This chapter introduces the study using the following headings:

- Context of the study (Section 1.2)
- Problem statement (Section 1.3)
- Theoretical framework (Section 1.4)
- Operationalising the constructs (Section 1.5)
- Conceptual Framework (Section 1.6)
- Research objectives (Section 1.7)
- Significance of the study (Section 1.8)
- Overview of the thesis (Section 1.9).

1.2 Context of the Study

The research reported in this thesis was carried out at university level in the UAE. This section provides background information that describes the context of the study in the UAE. Section 1.2.1 provides a brief history of the region prior to the formation of the UAE in 1971 and then concentrates more specifically on the federation from that point and the challenges it faces into the future. Section 1.2.2 focuses on the history of education in the region and the development of a modern education system in the relatively short time since the formation of the federation. Finally, Section 1.2.3 describes the educational context of the research.

1.2.1 History of the UAE

The UAE consists of seven emirates (Abu Dhabi, Dubai, Sharjah, Ajman, Fujairah, Umm Al Quwain and Ras Al Khaimah). Initially a federation of six emirates was formed in December 1971, with Ras al Khaimah joining in February the following year. The land area totals 83,600 square kilometres in the eastern Arabian Peninsula, bordered in the north by the Arabian Gulf, the south and west by Saudi Arabia and the east by Oman, and sharing sea borders with Qatar and Iran. Following early conflicts between the local tribes and the British, the region then known as the Trucial States became a British protectorate in 1820 and remained as such until 1971.

Traditional agriculture in the region consisted of camel herding and date farming. Pearl diving was the predominant source of income. This industry had a long history and was originally centred in Bahrain and Julfar (Ras Al Khaimah), which had water sources and agriculture to sustain growing populations. Abu Dhabi and Dubai were temporary settlements that only came to life each year during the pearling season. The industry grew rapidly following the eighteenth-century pearl boom, reaching its peak in the early twentieth century when it involved as many as 4,500 boats and 74,000 men. The invention of the Japanese cultured pearl during the 1920s and the 1930s Great Depression saw a rapid decline in the demand for the region's pearls, which had a major impact on the communities that relied on the industry as a major source of employment and revenue.

Offshore oil was discovered in 1958 and onshore fields were found in 1960. Exports began in 1962 and the rapidly increasing revenue allowed for a massive construction program to build homes, schools, hospitals and roads. Within a decade, Dubai was following Abu Dhabi's lead. In 1971, the British government decided that it could no longer afford to offer protectorate status to the Trucial States; this encouraged the seven emirates to form an alliance known as the United Arab Emirates for both defence and economic prosperity. In the fifty years that followed, the UAE has undergone massive growth and modernisation.

The official language of the UAE is Arabic, but other languages such as English, Hindi and Urdu are widely spoken. English is the mode of instruction in tertiary education. Islam is the official religion of the country; however, religious tolerance is promoted. In 2019, the UAE became the first Muslim country to receive an official visit from the head of the Catholic Church.

According to World Bank figures, the population of the UAE was 9.77 million in 2019, of which only 11.48% were Emiratis. Indians made up 27.49%, Pakistanis 12.69%, Filipinos 5.56%, Egyptians 4.23% and others 38.55%. The large number of male expatriate workers has led to a population imbalance, with only 2.65 million or 28% of the population being female. A conservative culture means that females only have a 42% labour participation rate, compared to 91% for males. Males find it easier to find employment in well-paid government jobs directly from school, whereas females are encouraged to continue their education.

For the past fifty years the economy of the UAE has been oil based, but its goal now is to transition into a sustainable knowledge-based economy. In 2017, the nation fund Sandooq Al Watan was established with the intention of developing human capital, fostering innovation and supporting research and development. In 2015, the Gender Balance Council was established to address the country’s gender equity issues, which are grounded in its culture and religion. The Gender Balance Guide was prepared based on recommendations from the Organisation for Economic Co-operation and Development (OECD) and looks to integrate gender into policies and programs; promote gender sensitive engagement of personnel; and improve gender balance in leadership. The UAE’s 2018 gender inequality index ranking of 121 out of 149 countries reflects the long-term nature of the council’s work.

1.2.2 Education System in the UAE

In 1962 when the UAE first began to export oil, the country had only 20 schools with a total of 4,000 students, most of which were males. By the time it became a federation in 1971, the number of students enrolled in educational institutions was still less than 28,000 and education was still only available in the cities. In 1972, primary school education was made compulsory for all Emiratis and was free at all levels in public schools; since this time education has continued to be a priority. In 2012, the age of compulsory instruction was increased to eighteen years (or grade 12).

Education in the UAE has developed over a relatively short time when compared to most other countries. The public system, which is taught in Arabic and has a strong Islamic influence, was designed for Emiratis and only in the 2006/2007 school year were fee-paying expat students admitted. Public schools have also, traditionally, been single-sex. However, in a more recent change, in the 2018/2019 school year, grade 1 became coeducational. This change was to progress through the grades until the 2021/2022 school year, when grades 1 to 4 would be included.

Private school alternatives were originally established to cater for the various religious, cultural and educational needs of the children of expatriates. By the 2017/2018 school year, public and private school students totalled 287,725 and 793,295, respectively. Public schools were 81% Emirati and private schools 83% expatriate.

Higher education institutes (HEIs) in the UAE are classified as either federal, private or foreign private/international branch. Federal institutions include UAE University, which was the first university in the UAE when it opened in Al Ain in 1976, and Higher Colleges of Technology (HCT), which opened in 1988 to provide Emiratis with education geared towards employment, with diplomas, higher diplomas and applied degrees. Today HCT is the largest HEI in the UAE, with over 23,000 students spread over with 17 colleges, including nine for women and eight for men. At the time of writing, 63% of these students are female. Other federal universities include Zayed University (est. 1998) and Khalifa University (est. 2007).

At the time of writing, there are both public and private HEIs in the UAE; however, the vast majority are private, which generally means they are for-profit institutions. Included in this category are Al Khawarizmi International College (est. 1985), Ajman University of Science and Technology (est. 1990), American College of Dubai (est. 1990), American University of Dubai (est. 1995), University of Sharjah (est. 1997) and University of Dubai (est. 1997). Foreign private/international branch universities include University of Woolongong (est. 1993), University of Bradford (est. 2009, Sarbonne Université (est. 2006) and New York University (est. 2011). In 2016, 7.1%

of the country's tertiary students studied offshore. These students were predominantly male and the preferred destinations included the United Kingdom (UK) and the United States (US). The UAE also has more than 77,000 foreign students at degree level, with many studying on scholarships. Today there are over 70 HEIs in the UAE. This number is constantly changing with new institutions opening and others closing. Private and public HEIs have a 98% and 92% expatriate teaching faculty, respectively. From the information provided above, it can be seen that the UAE provides a number of educational options, including at university level. The research reported in this study has focused on single-sex federal university-level education as it is the path followed by the majority of Emirati students.

During the last ten years, it has become apparent that gender inequality exists in UAE education (Ridge, 2009), notably in the federal sector. These inequalities not only concern performance, where female students graduate from secondary school at a ratio of 3:2 compared to male students, but also participation rates. More than 80% of students enrolled in federal HEIs are female and 70% of all university graduates are female, including 58% of all STEM graduates (Farah, 2012). Although male students are more likely to attend university overseas, the numbers are relatively small and do not begin to account for the disparities mentioned above. The purpose of this study was to determine whether differences exist in male and female university students' perceptions of the mathematics learning environment; their reported levels of motivation, self-regulation and mathematics anxiety; and their level of mathematics achievement. This information could assist in understanding the different experiences of each gender and explaining, in part, the low participation and success rates of male students.

1.2.3 Educational Context

The sample for the present study was drawn from a single university in the UAE. The university was operated by a nationally owned company and was undergoing a merger with a larger, public university. Students were taught in single-sex classes in adjacent campuses. The students were almost exclusively Emirati and Muslim, and two-thirds were female, as is the case for most tertiary institutions in the country. The university was predominantly for students studying engineering. Entry was determined by school grades and was sought after due to the substantial stipend provided. To determine the course entry level, students were required to sit an entrance test. Despite school grades indicating that most students should be capable of entering into the first year of the degree program, few were successful in passing the entrance test and were required to spend time in the foundation program.

A proficient level of English (IELTS 6.0) was required by students prior to entry into the course, which meant most students had to take an intensive course in the foundation program. The foundation program also required students to meet minimum standards in mathematics, chemistry and physics. On entry into the program, a student would major in either chemical, mechanical, electrical or petroleum engineering, or geo-sciences. All majors were required to study mathematics (Calculus 1, 2 and 3, Linear Algebra and Differential Equations, and for some majors, Statistics and Probability) as well as their major subject.

The majority of students would take considerably longer than the minimum period of four years to complete their degree. The additional time was due to spending time in the foundation program to achieve the required minimum level in English, mathematics, chemistry and physics, as well as repeating failed courses. The spring and fall semesters run from August to May; however, most students would enrol in the summer semester, which runs for six weeks over May and June.

1.3 Problem Statement

Many students enrolling at university in the UAE lack the necessary level of English and the content knowledge in mathematics, chemistry and physics. Universities have had to use a considerable amount of their higher education resources to bring students up to the required standard for entry into the degree program. In 2014, only 20% of students were gaining direct entry into the degree program and funding of remedial studies via foundation programs was eating up one-third of the higher education budget (Underwood & Alhameli, 2014). Despite these figures, the government announced that the foundation program would be scrapped by 2018 (Underwood & Alhameli, 2014). However, today the foundation program still exists in UAE universities, but as the UAE looks to transition into a prosperous post-oil economy, the need for efficient use of the educational funding is greater than ever.

Universities could reduce the funding required per student by optimising the learning process and student success, thereby minimising the time taken for students to complete the program. To achieve this, it is first necessary to understand the needs of both the male and female students. Do male and female students require the focus to be on different aspects of the learning environment to maximise their levels of success? This study hoped to answer this question.

1.4 Theoretical Framework

According to Willis (2007, p.8) a paradigm is “a comprehensive belief system, world view or frame work that guides research and practice in a field”. Although there are numerous paradigms that guide research, positivism is one such paradigm that has been widely accepted (Guba, 1990) as it is the foundation of the basic tenets of behavioural science (Willis, 2007). Hessler (1992) articulated that the positivist’s fundamental belief is that any scientific concept or idea can be measured or observed. Therefore, positivists are interested in the discovery of a universal truth that can be applied to all (Guba, 1990).

The focus of this research was to create an understanding of the measurable and observable aspects of the classroom learning environment that influence students’ motivation, self-regulation, mathematics anxiety and mathematics achievement, as well as gender differences in these relationships. This exploratory study adopted the positivist assumption that all meaningful problems can be framed in clear-cut frameworks, characterised by precise hypotheses and well-defined methods. The ontological position of this study is that reality is objective and can be found. Therefore, this research takes the positivist approach to build a conceptual model grounded on theory and which subsequently tests the effectiveness of the research model.

1.5 Operationalising the Constructs

This section operationalises the constructs included in the hypothesised research model (see Section 1.6). These constructs include learning environment (Section 1.5.1), motivation (Section 1.5.2), mathematics anxiety (Section 1.5.3) and mathematics achievement (Section 1.5.4). The components used to measure each of the constructs are also introduced here.

1.5.1 Learning Environment

A learning environment includes social, psychological and pedagogical contexts where learning occurs (Lim & Fraser, 2018), and is usually, but not exclusively, found in formal settings such as a classrooms. In the current study, this construct is represented by seven aspects:

- student cohesiveness (students help and support each other)
- teacher support (teacher helps and is interested in students)
- investigations (enquiry process, problem solving and investigations are emphasised)
- involvement (students are interested, participate and do additional work)
- task orientation (students stay on task and complete planned work)
- collaboration (students collaborate rather than compete)
- equity (students are treated equally) (Fraser, McRobbie, & Fisher, 1996).

1.5.2 Motivation

According to Pintrich and Schunk (2002, p.405), motivation is “the process whereby goal-oriented activity is instigated and sustained”. It is commonly accepted that this process includes a combination of expectancies, beliefs, goals and values (Eccles & Wigfield, 2002). The definition of motivation used in the current study included three aspects:

- learning goal orientation (students develop competencies by mastering tasks)
- task value (value students place on a required task)

- self-efficacy (level of self-belief about ability to perform a task).

1.5.3 Self-Regulation

Self-regulation is a multi-faceted, iterative, self-steering process that targets a person's cognition, feelings and actions as well as features of the environment for modulation in the service of one's own goals (Boekaerts, Maes, & Karoly, 2005; Cleary, Callan, & Zimmerman, 2012). Self-regulation in learning requires the learner to show personal initiative to set goals, use cognitive and meta-cognitive strategies, monitor progress, and display perseverance and adaptive skill to make changes in their approach to continue along the mastery pathway (Zimmerman, 2015).

1.5.4 Mathematics Anxiety

Mathematics anxiety is a feeling of tension that interferes with manipulating numbers and solving mathematical problems (Richardson & Suinn, 1972). Mathematics anxiety brings a feeling of helplessness, tension or panic when performing mathematics operations (Gresham, 2007).

1.5.5 Mathematics Achievement

In the current study, the level of mathematics achievement measured a student's ability to complete the learning outcomes of the course. This was measured by the final grade for the mathematics course.

1.6 Conceptual Framework

The following sections provide the background for the development of the hypothesised research model. Section 1.6.1 reviews the theory, which provides an overall structure for the model, and Section 1.6.2 introduces the hypothesised research model. Sections 1.6.3 to 1.6.11 review prior research to justify the selection of each hypothesised relationship in the research model.

1.6.1 Theory Guiding the Development of the Hypothesised Research Model

The research reported in this study was guided by social cognitive theory (Bandura, 1989). Unlike numerous behavioural theories developed during the early and mid-twentieth century that proposed a stimulus–response type situation, Bandura's social cognitive theory recognises that people are both conscious and active participants in determining their own behaviour and actions. This control or agency means that our actions are in fact the result of an individual's cognitive processes, which involve their thoughts, goals, beliefs and values, rather than being the result of subconscious innate, instinctive desires or drives. In another significant departure from the predominant behavioural theories, Bandura argued that learning should not be assessed solely by the observation of behaviour but instead, learning and performance needed to be considered separately. Bandura describes the process of human development by using a triadic model of reciprocal determinism. In this model, there are three factors: environment (e.g. family, school and wider community), personal characteristics (e.g. expectations, cognition, goals and self-perceptions) and behaviour (e.g. self-regulation). Each of these factors influence and is influenced by each other during a lifelong process of development. Bandura acknowledges that these reciprocal relationships might not be of equal strength, simultaneous or constant in nature.

Social cognitive theory firstly proposes that what people think, feel and believe has a direct impact on the actions that they take. Conversely, the effect of a person's actions will drive their thought processes and emotional reactions. Secondly, it proposes that personal factors are developed and modified by the social environment. People are provided with information via modelling, instruction and social persuasion. This starts from a young age and it shapes their expectations, beliefs, emotions and cognition. The information being provided is guided by the values and beliefs of their family and community, which could include the norms of culture and religion. It is also unfortunate, but true, that a person's physical characteristics such as age, size, race, gender or sex will likely influence the reactions that they evoke from participants in their social environment.

Bandura stated that, "People are products and producers of their own environment" (Bandura, 1989, p.4). He was referring to the fact that a person's behaviour will alter the environment in which they live and that in turn, the environmental conditions that they have helped to create could modify their future behaviour; people have some control over their own development. They might operate in a network of interacting influences but still have a level of awareness that allows for personal agency, or control over thoughts, emotions, motivation and self-reflection. This enables them to make considered decisions on what actions they will take to achieve desired results or goals. During a person's formative years, when their preferences and personal standards are still being shaped, they will require considerable social support to enable a smooth transition through this process.

Bandura's model can be used specifically to model the educational process. A student has personal motivational beliefs, which will guide both their interactions with the psychosocial learning environment and their behaviour in terms of their self-regulation of actions intended to improve learning. Their self-regulation will influence both their motivational beliefs and their interactions with the psychosocial learning environment. The psychosocial learning environment will influence both a person's motivational beliefs and their future self-regulation. Bandura's model of social cognitive theory can be used to explain how a student is an active participant in the educational process. The goal of the study reported in this thesis was to determine the existence of the relationships that Bandura described between the person (motivational beliefs), the environment (psychosocial learning environment) and behaviour (self-regulation) in the specific educational context of university-level mathematics classrooms in the UAE and, if they do, whether they differ for male and female participants.

1.6.2 Hypothesised Model

This study used Bandura's model as the foundation for a research model in an educational context by using the following representations: learning environment (environment), motivation and mathematics anxiety (person), and self-regulation (behaviour). In addition to the constructs in Bandura's model, a mathematics achievement construct was also introduced, as shown in Figure 1-1. Due to the cross-sectional nature of the data collected, it was not possible to confirm the existence of reciprocal relationships, so prior literature and researcher experience was used to determine the stronger of each two-way reciprocal relationship for use in the model.

The purpose of the research model was to provide a structure upon which to base gender comparisons for the relationships between these constructs (Research Objective 4). The relationships in the hypothesised model supported by data analysis would be retained in the research model for these comparisons.

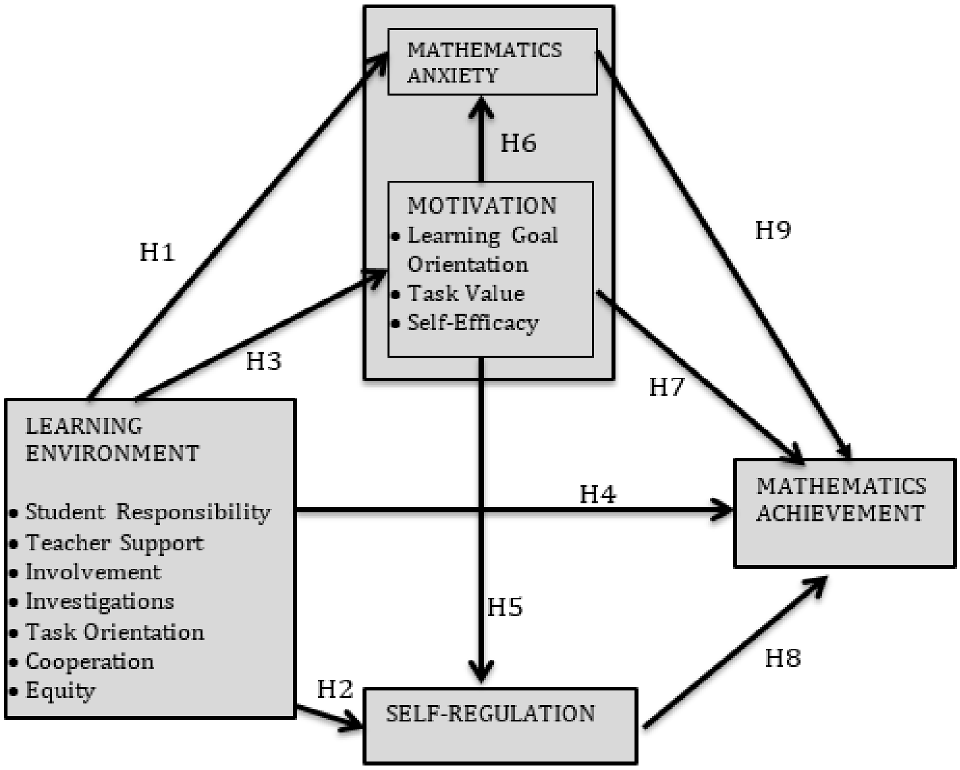

Figure 0-1: Hypothesised Research Model

Prior research supported the existence of the hypothesised relationships between the learning environment, motivation, self-regulation, mathematics anxiety and mathematics achievement constructs in an educational setting. A review of the literature covering the relationships in hypotheses 1 to 9 is described in Sections 1.3.3 to 1.3.11.

1.6.3 Hypothesis 1: Mathematics Learning Environment is Related to Motivation

Hypothesis 1 was that students' perceptions of the mathematics learning environment is related to their level of motivation. For this study, the learning environment construct consisted of the psychosocial relationships within the classroom. It included the degree to which the teacher established a positive relationship with the students by being helpful and friendly, taking a personal interest, providing encouragement and making students feel valued. It also considered the level of student interest, attention and cooperation (Fraser et al., 1996).

Motivation is the most important factor in determining both the quality and quantity of learning that takes place in an educational institution (Middleton & Midgley, 2002). Three components of motivation were included in this study: learning goal orientation, task value and self-efficacy. Students with learning goals intend to improve their ability incrementally over time (Maehr & Zusho, 2009) and treat errors as part of the learning process. To initiate and complete a task, a student must feel that the task is worth doing (Hulleman et al., 2008). Students assign a task value based on their enjoyment of doing the task and the utility of having achieved the task balanced against the cost to take part. Self-efficacy is the perceived capability that a person holds for successfully completing a task (Bandura, 1993), which is based on information received. This information includes past experiences, vicarious experience and social persuasion. The three components of motivation are reviewed in greater depth in Sections 2.3.1–2.3.3, and the relationship between learning environment and motivation is reviewed in Section 2.3.4.

Previous research indicated that students' perceptions of the learning environment influenced their level of motivation (see, e.g., Afari et al., 2013; Fraser & Lee, 2009; Lim & Fraser, 2018). Positive feedback, which is a component of the learning environment, has been shown to increase self-efficacy, whereas negative feedback has been shown to have the opposite effect (Schunk & DiBenedetto, 2015). Other aspects of the learning environment reported to have a positive impact on students' self-reports of task value include teacher inter-personal relationships (Brekelmans et al., 1990; Telli et al., 2010); meaningful and interesting tasks (Hagen & Weinstein, 1995); teacher support and expectations (Gilbert et al., 2013); and perceived quality of teaching (Winheller et al., 2013). Aspects of the learning environment shown to have an impact on the uptake of learning goals include teacher support and expectations (Gilbert et al., 2013) and classroom structures (Greene et al., 2004). In light of the strong and consistent influence of the learning environment on student motivation, it was hypothesised that the learning environment created in tertiary level mathematics classes in the UAE would influence students' motivation.

1.6.4 Hypothesis 2: Mathematics Learning Environment is Related to Self-Regulation

Hypothesis 2 was that students' perceptions of the mathematics learning environment is related to their level of self-regulation. Self-regulation in learning requires the learner to show personal initiative to set goals, use cognitive and meta-cognitive strategies, monitor progress and display perseverance and adaptive skill to make changes in their approach to continue along the mastery pathway (Zimmerman, 2015).

Research has consistently reported a link between the learning environment and the successful use of self-regulatory activities (Opolot-Okurut, 2010; Wentzel, Muenks, McNeish, & Russell, 2017), and the relationship has been described as being reciprocal in nature (Bembenutty, 2011b). Improved academic outcomes have been achieved by students using instructor feedback to initiate self-regulation and improve academic performance (Brown et al., 2016). Students are able to extend their self-regulatory knowledge by integrating self-regulated learning into the mathematics classroom (Perels et al., 2009) and completing a specialised self-regulatory training course (Cleary & Platten, 2013). These studies have shown that manipulating the learning environment to introduce self-regulatory practices can have a positive impact on their uptake and successful use. In light of the strong and consistent influence of learning environment on self-regulation, it was hypothesised that the tertiary level mathematics learning environment would influence students' self-regulation.

Self-regulation is reviewed in greater depth in Section 2.4, including the influence of the learning environment on self-regulation (Section 2.4.2).

1.6.5 Hypotheses 3: Mathematics Learning Environment is Related to Mathematics Anxiety

Hypothesis 3 was that students' perceptions of the mathematics learning environment is related to their level of mathematics anxiety. The mathematics learning environment has consistently been shown to be related to mathematics anxiety (Taylor & Fraser, 2013; McMinn & Aldridge, In Press; Deieso & Fraser, 2018). Students are more susceptible to anxiety in mathematics than most other subjects, as the nature of the subject means that students are frequently subjected to failure (Furner & Gonzalez-DeHass, 2011).

The classroom teacher has a considerable impact on the learning environment and is therefore a major determinant of a student's mathematics anxiety (Jackson & Leffingwell, 1999). Numerous studies report the personal issues that many elementary teachers have with mathematics anxiety and how this impacts their ability to teach the subject and provide students with positive attitudes and self-efficacy (Chang & Beilock, 2016; Lake & Kelly, 2014; Mizala et al., 2015). Teaching style is important because when students perceive the learning environment to be caring, challenging and mastery oriented, they are better prepared to deal with the negative emotions (Ashcraft, 2002; Chang & Beilock, 2016). In light of this prior research, it was hypothesised that the mathematics learning environment would influence students' mathematics anxiety.

Mathematics anxiety is reviewed in greater depth in Section 2.5, including the influence of the learning environment on mathematics anxiety (Section 2.5.1).

1.6.6 Hypothesis 4: Mathematics Learning Environment is Related to Mathematics Achievement.

Hypothesis 4 was that students' perceptions of the mathematics learning environment is related to their level of mathematics achievement. Numerous studies report a positive relationship between the learning environment and achievement (Fraser, Aldridge, & Adolphe, 2010; Fraser & Kahle, 2007; Teh & Fraser, 1995). The influence of the learning environment on mathematics achievement has been reported to be either direct or mediated by motivation (Peters, 2013; Winheller et al., 2013) or self-regulation (Brown et al., 2016; Cleary & Platten, 2013). Studies supporting the influence of learning environment on mathematics achievement have done so using a variety of learning domains and different aspects of the learning environment. Stronge et al. (2015) not only reported quality of instructional delivery to be a critical factor for student learning but also that teachers who were caring, confident, motivated and enthusiastic were also conducive to student success. Given the number of studies that have reported the impact of the learning environment on mathematics achievement, it was hypothesised that the mathematics learning environment would influence mathematics achievement.

Mathematics achievement is reviewed in greater depth in Section 2.6, as is the influence of the learning environment on mathematics achievement (Section 2.6.3).

1.6.7 Hypothesis 5: Motivation is Related to Self-Regulation

Hypothesis 5 was that a student's level of motivation is related to their level of self-regulation. Researchers report that motivation is required for self-regulatory activities to be initiated and maintained (Ryan & Deci, 2000; Pintrich, 2004). Students with a learning goal orientation have been shown to be more successful in using self-regulatory activities (Diseth, 2011). They are also able to maintain high levels of self-efficacy despite experiencing failure, which is an indication of an adaptive process (Zimmerman, 2015; Zusho & Edwards, 2011). Other studies report that students with performance goals have a greater tendency to develop maladaptive strategies (Norem, 2008), which despite being negative, are also self-regulatory. Students who feel the task is important and interesting are more likely to engage in self-regulatory activities (Boekaerts & Corno, 2005; Wolters & Rosenthal, 2000). Given the support for the impact of motivation on self-regulation, it was hypothesised that motivation would influence self-regulation.

Motivation and self-regulation are reviewed in greater detail in Sections 2.3 and 2.4, respectively, as is the influence of motivation on self-regulation (Section 2.4.1).

1.6.8 Hypothesis 6: Motivation is Related to Mathematics Anxiety

Hypothesis 6 was that a student's level of motivation is related to their level of mathematics anxiety. A student's level of motivation has been reported to determine the onset and impact of mathematics anxiety (Chang & Beilock, 2016). High levels of some or all of the components of motivation mean that some students are better able to manage failure outcomes without experiencing mathematics anxiety and its associated negative emotions and maladaptive consequences.

Self-efficacy has been shown to have a negative and reciprocal relationship with mathematics anxiety (Jain & Dowson, 2009). It is easy for students who have low self-efficacy due to the difficulties they encounter, to become discouraged and develop a fear of failing (Ahmed et al., 2012). Students with a learning goal orientation attribute failure to a lack of effort rather than lack of ability, which allows them to face a larger number of failures before suffering mathematics anxiety (Chang & Beilock, 2016). Students with high intrinsic value (Furner, 2011; Ramirez, Shaw, & Maloney, 2018) or utility value (Wang, 2015) for a subject are able to maintain their self-efficacy and effort for longer when faced with challenges. Research does not say that students with high levels of motivation will never suffer from mathematics anxiety, but rather that it would take longer before its onset than for students with low levels of motivation.

Given the reported importance of motivation in delaying the onset of mathematics anxiety, it was hypothesised that motivation was related to mathematics anxiety. Mathematics anxiety is reviewed in greater depth in Section 2.5, including the influence of motivation on mathematics anxiety (Section 2.5).

1.6.9 Hypothesis 7: Motivation is Related to Mathematics Achievement

Hypothesis 7 was that a student's level of motivation is related to their level of mathematics achievement. Self-efficacy has been shown to be strong and positive predictor of mathematics achievement (Anderman & Gray, 2015; Kalaycıoğlu, 2015; Lee, Lee & Bong, 2014). The relationship has also be found to reciprocal in nature, with achievement results affecting the level of self-efficacy (Grigg et al., 2018; Seaton et al., 2014). Task value has been reported to have a positive relationship with mathematics achievement (Kriegbaum et al., 2014; Chiu & Xihua, 2008), with some studies also reporting a reciprocal relationship between mathematics achievement and task value (Wigfield, 1994; Eccles & Wigfield, 2002). A number of studies have reported a positive relationship between a learning goal orientation and mathematics achievement (Azar et al., 2010; Keys et al., 2012; Kriegbaum et al., 2014).

Given the consistent reports of the impact of motivation on mathematics achievement, it was hypothesised that self-reports of motivation would influence mathematics achievement. Mathematics achievement is reviewed in greater depth in Section 2.6, including the influence of motivation on achievement (Section 2.6.1).

1.6.10 Hypothesis 8: Self-regulation is related to mathematics achievement

Hypothesis 8 was that a student's level of self-regulation is related to their level of mathematics achievement. Students with self-regulatory knowledge and skills are able to use cognitive and meta-cognitive strategies to achieve goals. They persevere, self-monitor, adapt strategies and regulate effort to be successful (Zimmerman, 1990). Numerous studies report a positive relationship between self-regulation and achievement. Increases in achievement have been linked to self-regulatory activities such as using feedback (Brown et al., 2016), self-monitoring (Schunk, 1982), organising and transforming (Nota et al., 2004) their time and study environment, and help seeking (Altun & Erden, 2014). On the downside, a decline in achievement was linked to the use of a surface approach (Azar et al., 2010).

Given the consistent reports of the impact of self-regulation on achievement, it was hypothesised that self-regulation was related to mathematics achievement. The influence of self-regulation on achievement is reviewed in greater depth in Section 2.6.2.

1.6.11 Hypothesis 9: Mathematics Anxiety is Related to Mathematics Achievement

Hypothesis 9 was that a student's level of mathematics anxiety is related to their level of mathematics achievement. The relationship between mathematics anxiety and mathematics achievement has been shown to be both negative and reciprocal (Carey et al., 2016), which means that not only can mathematics anxiety impair achievement but also poor achievement can increase mathematics anxiety. An analysis of Programme for International Student Assessment (PISA) results by (Kalaycıoğlu, 2015) revealed that countries with low mathematics achievement had high mathematics anxiety; however, the reverse was not always true for countries with high mathematics achievement. Korea and Japan had high mathematics anxiety despite their high levels of mathematics achievement, which indicates that mathematics anxiety is not the only factor that influences mathematics achievement (Lee, 2009).

The influence of mathematics achievement on mathematics anxiety is reviewed in greater depth in Section 2.6.4.

1.7 Research Objectives

The main aim of the research reported in this study was to determine whether there are gender differences in how university-level mathematics students in the UAE perceive their psychosocial learning environment; their reported levels of motivation, self-regulation and mathematics anxiety; and their level of mathematics achievement as well as to determine whether gender differences exist in the relationships between these factors.

To make these comparisons, it was first necessary to use instruments to measure the students' perceptions of the mathematics learning environment and their reported levels of motivation, self-regulation and mathematics anxiety. The present research used three instruments: What Is Happening In this Classroom? (WIHIC), Students' Adaptive Learning Engagement in Mathematics (SALEM) and Revised Mathematics Anxiety Scale (R-MANX). When using such instruments, it is first necessary to validate the results to ensure that they can reasonably be used to represent the constructs in that particular context. The WIHIC instrument has previously been validated in this context; however, neither the SALEM nor the R-MANX instruments have been translated into Arabic and used at this level in this region.

Research Objective 1:

> To translate and validate the instruments used to measure students' perceptions of the mathematics learning environment and their reported levels of motivation, self-regulation and mathematics anxiety for use in university-level mathematics classes in the UAE.

Given the validation of each of the instruments, an initial gender comparison was made in the students' perceptions of the mathematics learning environment, their reported levels of motivation, self-regulation and mathematics anxiety, and their level of mathematics achievement.

Research Objective 2:

> To evaluate the proposed research model developed for use in the study.

Given the confirmation of the paths in the hypothesised research model, a gender comparison was made to determine whether differences existed in the strength and direction of the relationships.

Research Objective 3:

> To examine whether male and female students in university-level mathematics classes in the UAE differ in terms of their perceptions of the mathematics learning environment, their reported levels of motivation, self-regulation and mathematics anxiety, and their level of mathematics achievement.

Prior to making a gender comparison of the relationships between mathematics learning environment, motivation, self-regulation, mathematics anxiety and mathematics achievement, it was necessary to confirm the existence of these relationships by evaluating a hypothesised research model.

Research Objective 4:

> To determine whether there is a relationship between students' perceptions of the mathematics learning environment, their reported levels of motivation, self-regulation and mathematics anxiety, and their level of mathematics achievement; and to determine whether any relationships that exist differ for male and female students.

1.8 Significance of the Research

The research in this study is significant as it is the only comprehensive study at university level in the UAE. As with other learning environment research, it considers the influence of the psychosocial learning environment on factors such as motivation, self-regulation, mathematics anxiety and mathematics achievement; however, this study also considers the relationships between these factors while examining possible gender differences in these relationships. The research in this study fills a number of gaps. The majority of research in the region has been carried out at either elementary school level (Abu-Hilal & Nasser, 2012; Sartawi et al., 2012) or high school level (Areepattamannil et al., 2015; Alkhateeb, 2001; Dickson et al., 2015; Ghazvini, 2011). Research carried out at university level (Afari et al., 2013; Alzubaidi et al., 2016; MacLeod & Fraser, 2010) did not focus on gender differences. The research in this study fills gaps in the current research by examining the relationships between the classroom learning environment, motivation, self-regulation, mathematics anxiety and mathematics achievement at university level and gender differences in these relationships.

This study is also significant for its methodological contribution in producing dual English/Arabic versions of the SALEM and WIHIC instruments and validating them for use at university level in the UAE.

This study also makes a practical contribution to teaching mathematics at the university level in the UAE by identifying which aspects of the learning environment (student cohesiveness, teacher support, involvement, investigation, task orientation, cooperation, equity) influence motivation (learning goal orientation, task value, self-efficacy), self-regulation, mathematics anxiety and mathematics achievement, as well as how these factors influence each other and what gender differences exist. The results of the research reported in this study could assist educators in catering for the individual learning preferences of both their male and female students.

1.9 Thesis Overview

This thesis is organised into six chapters. Chapter 1 outlined the context of the study by providing a history of the UAE; a summary of the education system and its development; and a description of education at the university involved in this study. It provided a problem statement, which outlined the problems faced by educators in the context studied. It outlined the theory on which the study is grounded. The constructs involved in the study were operationalised and the process followed in the development of the conceptual framework on which to make gender comparison in relationships between constructs was described. The research objectives were listed and the significance of the study was discussed.

Chapter 2 reviews the literature relevant to the study. It provides a history of the development of instruments that measure the psychosocial learning environment and prior research using these instruments directly related to the current study, including the association between the learning environment and student outcomes, and gender differences in perception of the learning environment. Chapter 2 also reviews relevant literature on motivation, self-regulation, mathematics anxiety and mathematics achievement, as well as the relationships between these constructs. Finally, literature that involved gender differences in perception of the learning environment and levels of motivation, self-regulation, mathematics anxiety and mathematics achievement was reviewed.

Chapter 3 describes the research methods used in the study. It outlines the process used to develop a research model to be used to make gender comparisons of relationships between constructs. A description of the sample is provided. The process to prepare dual English/Arabic versions of the instruments used in the study is outlined along with the data collection methods. Details of the data analyses is provided, including the validity and reliability of the instruments; assessing the validity and reliability of the measurement model; evaluation of the research model; testing the hypothesised relationships; and identifying gender differences in the hypothesised relationships that were found to be significant. Finally, ethical issues are examined, including permission, informed consent, confidentiality and consideration.

Chapter 4 provides evidence to the support the reliability and validity of the instruments used to assess the variables (students' perceptions of the mathematics learning environment and their reported levels of motivation, self-regulation and mathematics anxiety) when used at university level in the UAE.

In Chapter 5, the results relating to the remaining three research objectives are reported. First, descriptive statistics are provided to consider the univariate and multivariate normality of the data. The research model is confirmed initially by assessing both the measurement and structural models, which combine the indicator variables (scales) and factors (constructs) from all three instruments. Structural equation modelling (SEM) was used on five simple models comprising three constructs, which included each of the nine hypothesised relationships at least once. The significant relationships from these simple models were combined to form a larger structural model, which included all five constructs. The results of a second round of SEM provided significant relationships that made up the final structural model (research model). Analyses to consider gender differences included independent-sample t-tests to compare students' perceptions of the mathematics learning environment, their reported levels of motivation, self-regulation and mathematics anxiety, and their level of mathematics achievement; and multi-group confirmatory factor analysis (MGCFA) by gender to determine whether the separate male and female data provided satisfactory fit of the final structural model. Finally, results of multi-group structural equation modelling (MGSEM) across gender are reported. These results were used to determine whether the relationships between the five constructs were different for male and female students.

Chapter 6 provides a discussion of the results outlined in the previous chapter. It includes review of possible limitations of the study and efforts made to reduce their impact. Recommendations for future research and practical strategies for use in the classroom are provided. The theoretical, methodological and practical significance of the research is discussed. A concluding remark is provided to complete the research.

Chapter 2

LITERATURE REVIEW

2.1 Introduction

This chapter reviews the literature relevant to the research objectives and to the constructs included in the study. The literature review is organised as follows:

- Field of learning environment research (Section 2.2)
- Student motivation (Section 2.3)
- Student self-regulation (Section 2.4)
- Mathematics anxiety (Section 2.5)
- Mathematics achievement (Section 2.6)
- Gender differences (Section 2.7)
- Summary (Section 2.8).

2.2 Field of Learning Environment Research

A learning environment includes social, psychological and pedagogical contexts where learning occurs (Lim & Fraser, 2018) and is usually, but not exclusively, found in formal settings such as a classrooms. The learning environment, or context of learning, has been the focus of numerous studies that have found it to influence student achievement and attitudes (Brown et al., 2016; Cohn & Fraser, 2016; Schunk & DiBenedetto, 2015). Many studies have made practical efforts to improve these student outcomes through making changes to the learning environment (Fraser, 2015b). The environment is one of the three key factors, or determinants, of Bandura's social cognitive theory (see Section 1.3.1), which describes human development using a triadic model of reciprocal determinism (Bandura, 1986). When using this model, specifically to represent the learning process, it is the learning environment that needs to be examined.

This section reviews the literature related to the field of learning environments. It starts by examining historical learning environment research and how it relates to the present study (Section 2.2.1). Then, In Section 2.2.2 a review of the available learning environment instruments is provided, along with a justification for selecting the instrument used in the current study. The final section (Section 2.2.3) reviews previous research in the field of learning environments relevant to this study, focusing on where the research reported in this thesis fits and how it builds on existing research.

2.2.1 History of Learning Environment Research

The initial recognition of the importance of the environment and its interaction with the inner person as a factor in determining personal behaviour occurred when Lewin (1936) proposed that an individual's behaviour (B) was a function of their personal characteristics (P) and their environment (E), citing the formula $B = f(P, E)$.

Murray (1938) built on the relationship suggested by Lewin. He devised a needs-press model of behaviour, which suggested that each individual has needs based on an inner motivation that directs behaviour towards achieving predetermined goals. He suggested that the social environment a person is working within would influence the achievement of these goals. Murray suggested that this environmental pressure or "press" may enhance or hinder goal achievement. Murray described two types of press: alpha-press, which is the environmental pressure observed by an independent observer; and beta-press, which is the environment pressure experienced by the person as a participant in the environment. This differentiation acknowledges that the two perspectives of environmental pressure may not be the same and that an observer cannot know what a participant is thinking. This ambiguity established a need for participants' views to be sought. Stern et al. (1956) took Murray's model further by dividing beta-press into two distinct aspects: private beta-press, which is an individual's personal view of their environment; and consensual beta-press, which is a shared view of the environment held by group members.

The launching of the Sputnik satellite in the early 1960s created concern that United States (US) science advancement was falling behind that of Russia. To create interest and develop a better understanding of physics, the National Science Foundation instigated a new national high school physics course called Harvard Project Physics. As part of the ongoing evaluation of this course, Walberg and Anderson (1968) developed the Learning Environment Inventory (LEI) to assess students' perceptions of the learning environment. Concurrently, Rudolph Moos developed social climate scales for use in psychiatric hospitals (Moos & Houts, 1968; Moos, 1972; Moos, 1973) and correctional institutions (Moos, 1968). As part of this work, Moos collaborated with Trickett to develop the Classroom Environment Survey (CES) (Trickett & Moos, 1973) for use in the classroom environment. As a result of these developments, Walberg and Moos are credited with developing the first classroom climate scales and the subsequent emergence of learning environment research.

Following the work of Walberg, Moos and their colleagues in the US, classroom climate (also referred to as learning environment) instruments were developed in both the Netherlands and Australia. The focus of the programmatic research carried out in the Netherlands by Wubbels and his colleagues examined the interpersonal relationship in the classroom between teachers and their students (Wubbels & Levy, 1993; Wubbels & Brekelmans, 2005). In this research, Wubbels and his colleagues developed and used the Questionnaire on Teacher Interaction (QTI) extensively.

At the same time as work carried out in the Netherlands, research in Australia carried out by Fraser and his colleagues, resulted in the proliferation of classroom climate instruments suited to students at different education levels and in different learning contexts. This research began with the development of scales to measure the classroom environment in student-centred classrooms rather than the teacher-centred classrooms, for which the LEI and CES were developed.

Since its emergence in the US, learning environment research has spread to many parts of the world. Asia, in particular, has seen a large concentration of such research, beginning in the 1980s and extending through to the present day. Due to their proximity, this research has seen many partnerships between Asian and Australian colleagues, including in Singapore (Chionh & Fraser, 2009; Goh et al., 1995; Lim & Fraser, 2018; Teh & Fraser, 1995; Wong & Fraser, 1996), Indonesia (Fraser et al., 2010), Taiwan (Aldridge et al., 1999; Aldridge et al., 2000), India (Koul & Fisher, 2005), Korea (Lee et al., 2003) and Brunei (Majeed et al., 2002).

Learning environment instruments have several advantages over traditional data collection methods. Besides being economical, learning environment instruments also solicit perceptions from the participants, which were formed over a more extended period than the snapshot provided by the observers. Further, these instruments provide opinions from all the participants rather than just that of a single observer (Walberg & Haertal, 1980). An observer can only provide a record of the behaviour that was observed. Without follow-up interviews, this record is based on opinion. On the other hand, participants' perceptions are highly relevant as they are the determinants of observed behaviour.

During the forty years since the initial work of Walberg and Moos, there has been a proliferation of instruments developed to cater for various situations and meet various needs.

2.2.2 Learning Environment Instruments

This section reviews some of the more widely-used learning environment instruments and focuses on the instruments considered for use in the current study. The review includes the common themes and a timeline of their development, followed by a more detailed review of the instruments, which assesses the contexts of the learning environment included in the current research.

Despite the many different contexts or features that learning environment instruments measure, they share some common characteristics. For example, it is widely accepted that learning environment instruments will display some or all of the dimensions of the human environment scheme developed by Moos (1974). The scheme classifies aspects of human environments into three basic dimensions: (1) the relationship dimension, which assesses interpersonal relationships in the environment and the degree to which people work together and support each other; (2) the personal development dimension, which assesses the structures in place to facilitate personal growth; and (3) the system maintenance and system change dimension, which assesses the degree to which the environment is structured and controlled, has clear expectations and is responsive to change (Moos, 1974). When determining the suitability of the instruments for use in the current research, consideration was given to the coverage of Moos' dimensions of the human environment. The following subsections provide a review of the instruments that had potential for use in the current study, either in their entirety or through selected relevant scales. These instruments include the Learning Environment Inventory (Section 2.2.2.1); Classroom Environment Survey (Section 2.2.2.2); Questionnaire on Teacher Interaction (Section 2.2.2.3); Individualised Classroom Environment Questionnaire (Section 2.2.2.4); College and University Classroom Environment Inventory (Section 2.2.2.5); Constructivist-Orientated Learning Environment Scale (Section 2.2.2.6); Constructivist Learning Environment Survey (Section 2.2.2.7); and What Is Happening In this Class (Section 2.2.2.8). See Table 2-1 for a summary of each instrument, including the education level for which it was developed, the number of items per scale and scale names, and the associated Moos' dimensions.

2.2.2.1 Learning Environment Inventory

Walberg & Anderson (1968) developed the Learning Environment Inventory (LEI) to measure the psychosocial climate of secondary school classrooms. The final version of the instrument consists of fifteen scales of seven items each. The scales and their associated Moos' human environment dimensions are cohesiveness, friction, favouritism, cliqueness, satisfaction and apathy (relationship dimension); speed, difficulty and competitiveness (personal development dimension); and diversity, formality, material environment, goal direction, disorganisation and democracy (system maintenance and system change dimension). Each item is responded to on a 4-point scale (1 = strongly disagree, 2 = disagree, 3 = agree and 4 = strongly agree). The questions are arranged in a cyclical order, and the scoring direction is reversed for some items. This instrument has been used in numerous studies to measure the relationship between the learning environment and student outcomes (Fraser, 1979; Walberg, 1968).

Table 2-1: Summary of the Learning Environment Instruments Considered for this Study

Instrument	Level	Items per scale	Moos' dimensions of the human environment			Reference
			Relationship dimension	**Personal development dimension**	**System maintenance and system change dimension**	
Learning Environment Inventory (LEI)	Secondary	7	Cohesiveness Friction Favouritism Cliqueness Satisfaction Apathy	Speed Difficulty Competitiveness	Diversity Formality Material environment Goal direction Disorganisation Democracy	Walberg & Anderson (1968)
Classroom Environment Survey (CES)	Secondary	10	Involvement Affiliation Teacher support	Task orientation Competition	Order and organisation Rule clarity Teacher control Innovation	Trickett & Moos (1973)
Individualised Classroom Environment Questionnaire (ICEQ)	Secondary	10	Personalisation Participation	Independence Investigation	Differentiation	Fraser (1990)
College and University Classroom Environment Inventory (CUCEI)	Tertiary	7	Personalisation Involvement Student cohesiveness Satisfaction	Task orientation	Innovation Individualism	Fraser & Treagust (1986)
Questionnaire on Teacher Interaction (QTI)	Secondary	8–10	Helpful and friendly Understanding Dissatisfied Admonishing		Leadership Student responsibility and freedom Uncertain Strict	Wubbels & Levy (1993)
What Is Happening In this Classroom (WIHIC)	Secondary	8	Student cohesiveness Teacher support Involvement	Investigation Task orientation Cooperation	Equity	Fraser et al., (1996)
Constructivist Learning Environment Survey (CLES)	Secondary	7	Personal relevance Uncertainty	Critical voice Shared control	Student negotiation	Taylor et al., (1997)
Constructivist-Orientated Learning Environment Scale (COLES)	Secondary	8	Student cohesiveness Teacher support Involvement Young adult ethos Personal relevance	Task orientation Cooperation	Equity Differentiation Formative assessment Assessment criteria	Aldridge et al., (2012)

Adapted from Fraser (2012).

Despite the LEI including scales relevant to this study such as cohesiveness, satisfaction, apathy and goal direction, the instrument was initially developed to assess the learning environment of what is now considered a "traditional" teacher-centred classroom. Further, the factor structure of the LEI has never been established. Given that other instruments offer a better coverage of the scales describing the learning environment, the LEI was not selected for this study.

2.2.2.2 Classroom Environment Survey

Moos and Trickett's Classroom Environment Scale (CES) is a 90-question instrument consisting of nine scales, each with ten items (Moos & Trickett, 1974). The response format is "true" or "false" for all items. The instrument focuses on the teacher behaviour, teacher–student interaction and student–student interaction aspects of the classroom environment and is available in actual and preferred versions for both students and teachers. The scales and their associated Moos' human environment dimensions are involvement, affiliation and teacher support (relationship dimension); task orientation and competition (personal development dimension); and order and organisation, rule clarity, teacher control and innovation (system maintenance and system change dimension). The CES includes scales relevant to the current study such as involvement, teacher support and task orientation; however, as with the LEI, the CES assesses a teacher-centred learning environment (Trickett & Moos, 1973), which makes many scales irrelevant to the current study. Although satisfactory validity and reliability of the CES have been reported (Fisher & Fraser, 1983; Moos, 1978; Trickett & Moos, 1973), the factor structure of the CES has not been established. CES is also a long instrument with a response format, which would enable limited analysis. Given these factors, the CES was not selected for the current study.

2.2.2.3 Questionnaire on Teacher Interaction

The Questionnaire on Teacher Interaction (QTI) was developed by Wubbels and his colleagues (Wubbels & Levy, 1993) for use in secondary schools in the Netherlands. It was based on the interpersonal diagnosis of personality (Leary, 1957). The teacher–student relationship is assessed using a model of interpersonal teacher behaviour.

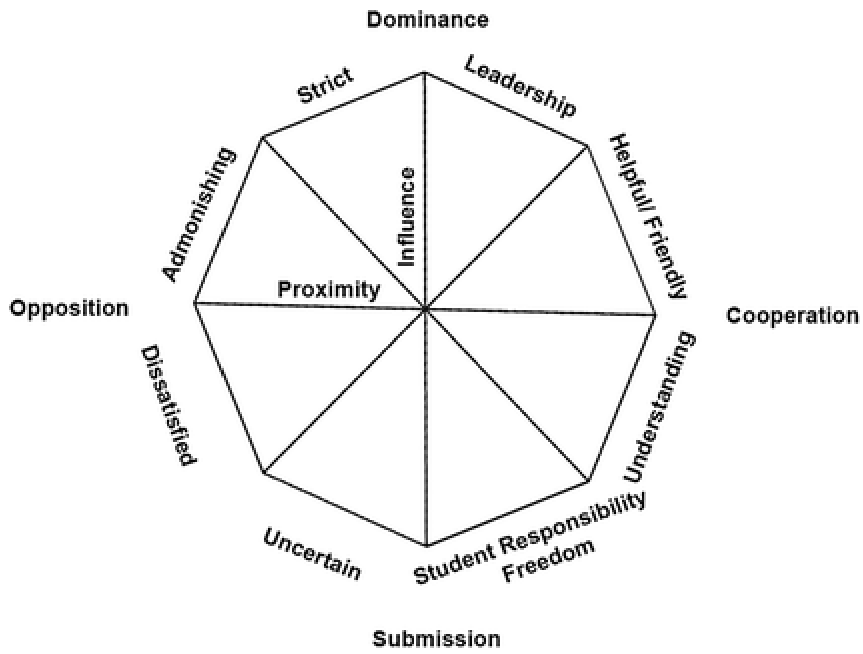

Figure 2-1: The QTI Scales and their Relationships

The model consists of scales for influence and proximity (see Figure 2-1). Influence is measured on a dominance (D) – submission (S) continuum and proximity on an opposition (O) – cooperation (C) continuum. The two scales are placed on perpendicular axes to form four quadrants. Bisecting the right angles in each quadrant forms eight sectors. Each sector is labelled according to its adjacent axes, with the nearer of the two axes recorded first to indicate a higher determination of that characteristic. Each sector represents one of the eight teacher types: strict (DO), admonishing (OD), dissatisfied (OS), uncertain (SO), student responsibility freedom (SC), understanding (SC), helpful/friendly (CD) and leadership (DC). Descriptors are provided for each teacher type. The initial questionnaire consisted of seventy-seven items. Each of the scales had between nine and eleven items, which was later reduced to six items per scale, with the items presented in a cyclical order. Each item is scored on a 5-point Likert scale ranging from "never" to "always" (Wubbels & Brekelmans, 2005). The class mean scores are calculated for each of the eight behaviours to form a teacher's interpersonal profile. The questionnaire produces four different versions. The first version assesses a student's perception of their current learning environment (student actual); the second version assesses a student's preferred learning environment (student ideal); the third version assesses the teacher's perception of their learning environment (teacher self); and the final version assesses a teacher's perception of their ideal learning environment (teacher ideal).

The validity and reliability of the questionnaire has been tested in numerous studies (Brekelmans et al., 1990). The extensive use of the QTI worldwide is attested by the fact that it has been translated into English, French, German, Hebrew, Russian, Slovenian, Swedish, Norwegian, Finnish, Spanish, Mandarin, Korean and Indonesian (Fraser, 2012). Teacher–student interaction is an important factor in determining the level of learning in a classroom. Researchers have established a positive relationship between teacher–student interaction and student achievement and affective outcomes (Goh & Fraser, 2000; Wubbels & Brekelmans, 2005). However, the QTI measures teacher–student interaction, focusing on the relationship dimension of the human environment. Given that the research reported in this study sought to explore a broader definition of the learning environment, the QTI was not considered beneficial.

2.2.2.4 Individualised Classroom Environment Questionnaire

The Individualised Classroom Environment Questionnaire (ICEQ) was developed by Rentoul and Fraser (1979). The questionnaire focused on individualised learning and inquiry-based education. After refinement, involving interviewing teachers and students and seeking expert feedback (Fraser & Butts, 1982; Fraser, 2012), the final version consisted of five scales of ten items each (Fraser, 1990). The scales and their associated Moos' human environment dimensions are personalisation and participation (relationship dimension); independence and investigation (personal development dimension); and differentiation (system maintenance and system change dimension). Students respond to the items using a 5-point frequency scale (1 = almost never, 2 = seldom, 3 = sometimes, 4 = often and 5 = very often). Scoring was reversed on several items. Different instrument versions include actual, preferred, teacher, long and short forms. Satisfactory internal consistency and discriminant validity have been achieved in many studies (see e.g., Burden & Fraser, 1993; Fraser & Butts, 1982).

The scales relevant to the study reported in this thesis were the degree to which students were allowed to make their own decisions about learning and behaviour (independence), and the emphasis on the skills and processes of inquiry (investigation). However, given that the study involved participants enrolled at university level, it was considered unlikely that the learning environment would focus on encouraging students to participate (participation), demonstrating concern for the welfare and growth of individuals (personalisation) or providing individualised programs for students (differentiation) (Rentoul & Fraser, 1979). Therefore, ICEQ was not considered suitable for use in this study.

2.2.2.5 College and University Classroom Environment Inventory

Early instruments developed for use at the tertiary level were developed during the 1960s and 1970s. These early versions were based on business models and measured the institutional climate of universities and technical institutes (Halpin & Croft, 1963; Stern, 1970). Despite this early work, a gap existed in measuring the classroom climate of these tertiary-level classrooms. With this in mind, Fraser and Treagust (1986) developed the College and University Classroom Environment Inventory (CUCEI) to assess the climate of smaller tertiary level classes such as seminars and tutorials. Existing scales, developed for use at the secondary school level, were used, although some items were modified or rewritten to make them suitable for use in seminars and tutorials. CUCEI consists of seven scales, with seven items per scale. These scales and their Moos' human environment dimensions are personalisation, involvement, student cohesiveness and satisfaction (relationship dimension); task orientation (personal development dimension); and innovation and individualism (system maintenance and system change dimension). The items are presented in a cyclical order and responded to using four options (1 = strongly agree, 2 = agree, 3 = disagree and 4 = strongly disagree). Half of the questions were negatively worded to guard against passive responses and were reverse scored. This instrument has been used and validated in a number of studies (Dorman, 2014; Fraser & Treagust, 1986; Joiner et al., 2002; Yarrow et al., 1997). However, it was also reported to show poor statistical performance in a study by Logan et al. (2006)

Despite being developed for use at the university level, CUCEI was developed explicitly for tutorial or seminar-type classrooms, so it did not suit the learning environment investigated in this study, which was exclusively based on small-scale lectures. Furthermore, CUCEI has exhibited significant reliability problems when used in studies at the secondary and university levels (Logan et al., 2006); therefore, CUCEI was not considered suitable for use in this study.

2.2.2.6 Constructivist-Orientated Learning Environment Scale

The Constructivist-Oriented Learning Environment Scale (COLES) was developed by Aldridge et al. (2012). This instrument drew on existing scales but, unlike other instruments available at that time, focused on teacher–student relationships and teaching processes, with COLES an important aspect of the assessment. The instrument included two new scales: formative assessment, which assesses the extent to which assessment feedback contributes positively to the learning process; and assessment criteria, which measures the degree of clarity of assessment tasks in terms of what is required and how it will be assessed. The other nine scales were drawn from existing instruments. The eleven scales and their Moos' human environment dimensions are student cohesiveness, teacher support, involvement and personal relevance (relationship dimension); task orientation, cooperation, formative assessment and young adult ethos (personal development dimension); and equity, differentiation and assessment criteria (system maintenance and system change dimension). Each scale consists of eight items and each item requires a response on a 5-point frequency scale (1 = almost always, 2 = often, 3 = sometimes, 4 = seldom and 5 = almost never). Previous research using COLES has reported strong validity and reliability for both the actual and preferred versions of the instrument (Aldridge et al., 2012; Bell & Aldridge, 2014).

Despite including a number of scales relevant to this study, the length of the instrument was considered too long for use in the current study, which also needed to administer instruments to assess levels of motivation, self-regulation and mathematics anxiety.

2.2.2.7 Constructivist Learning Environment Survey

The Constructivist Learning Environment Survey (CLES) measures the extent to which the constructivist epistemological practices are being implemented in the classroom (Taylor et al., 1997). The teacher's role in a constructivist classroom differs from that in a traditional classroom. In a constructivist classroom, the teacher does not merely relay what is considered "factual" information but facilitates opportunities for students to interpret or re-conceptualise their world. The communicative relationship between teacher and student needs to allow for both open and critical discourse (Taylor et al., 1997). CLES consists of five scales, these scales and their Moos' human environment dimensions are personal relevance and uncertainty (relationship dimension); critical voice and shared control (personal development dimension); and student negotiation (system maintenance and system change dimension). The survey included six items per scale, with each of the 30 items scored on a 5-point frequency scale (1 = almost always, 2 = often, 3 = sometimes, 4 = seldom and 5 = almost never). The results demonstrate that CLES has satisfactory internal consistency reliability and factorial validity. CLES has also been used and validated in a number of other studies (Aldridge et al., 2000; Dorman, 2001; Dorman & Adams, 2004; Kim et al., 1999; Nix et al., 2005; Ogbuehi & Fraser, 2007; Peer & Fraser, 2015; Taylor et al., 1997; Spinner & Fraser, 2005).

The current study involves engineering students studying mathematics at university level. Most of the faculty are mathematics academics and do not have academic or practical qualifications in education; neither do the students exhibit characteristics that indicate they were taught in constructivist learning environments at the secondary school level. Given these factors, CLES was not selected for use in this study.

2.2.2.8 What Is Happening In this Classroom

To create the What Is Happening In this Classroom? (WIHIC) instrument, Fraser et al. (1996) brought together what they considered to be the most salient scales from the existing learning environment instruments and combined them with two new scales that measured the then-contemporary issues in education: investigation and equity. Three WIHIC scales were related to Moos' relationship dimension (student cohesiveness, teacher support and involvement). These scales describe a classroom where students help and support each other; the teacher is approachable and inspiring; and the learners are active and included in the learning process. Three scales were related to Moos' personal development dimension (investigation, task orientation and cooperation). These scales describe a learning environment where the students work together; have goals; and understand the importance of completing tasks. Their learning is constructed, so has depth and connection. One scale was related to Moos' system maintenance and system change dimension: equity. This scale describes a learning environment where the teacher treats students equally and fairly. Overall, WIHIC describes a learning environment that would not be considered "traditional", yet today neither would it be considered contemporary. It describes an environment where relationships are positive, students are motivated, and goals and processes are in place to enhance the depth and lasting nature of the learning experience.

WIHIC was selected for use in this study as it provided good coverage of all of Moos' dimensions of the human environment (Moos, 1974). It was also shown to have satisfactory reliability and validity in many contexts and has been used successfully at university level. Most importantly, the scales included in the WIHIC provided a suitable measure of the learning environment for this study. Further details of the WIHIC instrument are provided below.

The original version of WIHIC, which included 90 items distributed over seven scales, was field-tested with a group of 335 junior high school students in Australia. Following statistical analysis and interviewing of students, 54 items survived (Fraser et al., 1996). Aldridge et al. (1999) tested an expanded version of the instrument, which contained 80 items, during a cross-national comparative study involving 1,081 students in 50 classrooms in Australia and 1,879 students in 50 classrooms in Taiwan. During this process, WIHIC was reduced to its current version, which contains seven scales with eight items in each. According to Aldridge & Fraser (2000), the instrument displayed a strong factorial validity, internal consistency reliability and the ability to differentiate between classes. Dorman (2003) confirmed the results obtained by Aldridge & Fraser (2000) with his cross-national sample of 3,980 students from Australia, the United Kingdom (UK) and Canada. Dorman (2008) reported confirmatory factor analysis results, which supported the seven-scale a priori structure of both the preferred and actual version of the instrument, in a study involving 978 secondary school students in Australia. These studies confirmed the suitability of WIHIC for use as a measure of classroom learning environment with a variety of groups and in different contexts.

Over the last two decades, WIHIC has become the most widely used tool to assess the classroom climate. Researchers have also used WIHIC as part of a process to evaluate an education innovation or to guide changes in approach. Helding and Fraser (2013) evaluated the effectiveness of a teacher development program in Florida by using WIHIC to assess the level of change that occurred in participating teachers' classrooms. Soebari & Aldridge(2015) used this same method with a Bahasa Indonesian version of WIHIC in a pre-post design to determine the success of an Indonesian teacher's professional development program in instigating change in the classroom. Aldridge et al. (2009) used a version of WIHIC modified for use with primary school–aged students to guide improvement in the teaching practice of teachers enrolled in a distance education course in South Africa.

WIHIC has been translated into several languages and used in studies that reported satisfactory validity and reliability, including Spanish (Robinson & Fraser, 2013), Mandarin (Aldridge et al., 1999; Aldridge & Fraser, 2000), Korean (Kim et al., 2000), Bahasa (Fraser, Aldridge, & Adolphe, 2010) and Arabic (Afari et al., 2013; Alzubaidi et al., 2016; MacLeod & Fraser, 2010). Of particular interest to this study were the Arabic versions of WIHIC. The study by MacLeod and Fraser (2010) carried out with 763 college students in the United Arab Emirates (UAE) provided students with an English or Arabic version of a modified three-scale version of the WIHIC. The study by Afari et al. (2013) involved a modified five-scale version of the WIHIC. In another study, Alzubaidi et al. (2016) used a dual English/Arabic version of WIHIC. However, this was published after the data collection was complete in the present study.

2.2.3 Prior Research in the Field of Learning Environment

Since the initial development of learning environment instruments in the 1960s, research involving the measurement of the learning environment has snowballed. Along with this proliferation, different lines of research have evolved. Fraser (2007, 2012, 2015), as part of his regular reviews of learning environment research, considered these lines of research to be the association between the classroom environment and student outcomes; the evaluation of educational innovations; and teachers' attempts to improve classroom and school environments. Within these general themes, several research areas or applications have also developed, including cross-national comparative studies; gender differences; students' transition between levels of education; the relationship between the school-wide environment and the classroom climate; school psychology; and typologies of classroom environments. The study reported in this thesis drew on two lines of research identified by Fraser (2015a): the association between the learning environment and student outcomes; and gender differences (both in the perception of the learning environment and the associations between the learning environment and student outcomes). The following review describes the scope of prior research in these areas, including general themes, types of learning environments, levels of education, countries, languages and different cognitive and affective outcomes. It considers the aspects of the learning environment and the student outcomes covered in earlier studies (see Table 2-2 for a summary of the studies reviewed).

In this section, the review outlines the impact of the learning environment on student outcomes in general. A review of the literature that focuses on the impact of the learning environment on the specific constructs included in this study is presented in subsequent sections, including the impact of the learning environment on motivation (Section 2.3.4), self-regulation (Section 2.4.2), mathematics anxiety (Section 2.5.1), mathematics achievement (Section 2.6.3) and gender differences (Section 2.7.1).

Research examining the relationship between the learning environment and student outcomes has been the most prolific learning environment research over the decades. However, it has also laid the foundation for the research on educational innovations. Establishing a link between student perceptions of the learning environment and student outcomes has provided educationalists with an avenue for improving student outcomes, both affective and cognitive (Fraser, 2015).

The association between learning environment and student outcomes has been reported in numerous research. Positive and significant correlations have been found in many different countries, cultures, levels, languages and subject areas. The consistency of results, despite the variation in contexts, was apparent in the meta-analysis carried out by Haertel et al. (1981). The analysis included a combination of 734 correlations from twelve different studies involving 17,805 students, in 823 classes, across four countries and eight subjects. Results supported 31 out of 36 hypothesised associations between learning environments and student outcomes. More favourable student outcomes were positively associated with the constructs cohesiveness, satisfaction, task differentiation, formality, goal direction, democracy and material environment, and negatively associated with friction, cliqueness, apathy, disorganisation and favouritism. Aspects of the learning environment were consistent in direction to cognitive, affective and behavioural learning outcomes, although the strength of the correlations was frequently significantly different between studies.

Table 2-2: Studies Investigating the Influence of Learning Environment on Student Outcomes

Study	**Country**	**Subject**	**Level**	**Outcome variables**
Wolf & Fraser (2008)	US	Science	Middle school	Attitudes, Achievement
Peters (2013)	US	Algebra	University	Affective outcomes
Fast et al. (2010)	US	Mathematics	Upper elementary	Self-efficacy
Tosto et al. (2016)	UK	Mathematics	Secondary	Subject interest Academic self-concept Self-efficacy Achievement
Winheller et al. (2013)	New Zealand	Reading, writing, mathematics, languages	Elementary/ high school	Confidence in mathematics Liking for mathematics
Gilbert et al. (2013)	US	Mathematics	Middle school	Motivation
Afari et al. (2013)	UAE	Mathematics	College	Academic efficacy

Many of the studies cited above evaluated the links between the learning environment and affective and cognitive outcomes. In these studies, the association between learning environment and affective outcomes was stronger than the association between learning environment and cognitive outcomes. Wolf and Fraser (2008) reported a strong and consistent relationship between learning environment and attitudes but a weaker association between learning environment and achievement. Numerous studies have reported a direct link between the learning environment and affective outcomes while also reporting that the link between learning environment and achievement is indirect. For example, Peters (2013) and Fast et al. (2010) reported a positive association between learning environment and mathematics self-efficacy. Mathematics self-efficacy provided a mediating effect of the learning environment on achievement. Tosto et al. (2016) found that the learning environment was positively associated with subject interest and academic self-concept, but not mathematics achievement. However, subject interest and academic self-concept were positively associated with mathematics achievement, which allowed the learning environment to indirectly influence mathematics achievement. Winheller et al. (2013) stated that quality of learning was related to “confidence in” and “liking for” mathematics, which in turn predicts student achievement.

While the research investigating the impact of the learning environment on student affective and cognitive outcomes has been comprehensive, its scope has tended to be narrow by only considering the relationship between learning environment and one or two other constructs. The study reported in this thesis built on and extended these previous studies by considering the impact of the learning environment as a single component of a complex research model. This extends previous work by establishing direct and indirect links between learning environment and affective (motivation, mathematics anxiety) and cognitive (mathematics achievement) outcomes. Further, the research is carried out in the unique context of university-level mathematics classrooms in the UAE. Given the limited research carried out on this subject in the Middle East and the current transition from single-sex to co-educational education in the region, the study reported in this thesis is timely and relevant.

2.3 Student Motivation

According to Pintrich and Schunk (2002, p.405), motivation is “the process whereby goal-oriented activity is instigated and sustained”. It is commonly accepted that this process includes a combination of expectancies, beliefs, goals and values (Eccles & Wigfield, 2002). Others such as Kulh (1987) and Corno (1993), consider motivation to involve only the initiation of action, with volition driving the process following this initiation stage through to completion. This extended definition of motivation, suggested by Pintrich and Schunk (2002), was used in this study.

A person’s motivational beliefs are continuously in a state of flux. In the context of learning, a person’s motivational beliefs represent one of the three aspects of Bandura's (1986) triadic, reciprocal, deterministic model of social cognitive theory. Motivational beliefs determine the contribution that a person makes to the psychosocial learning environment, and in turn, the motivational beliefs are influenced by feedback about that contribution (Brown et al., 2016). These beliefs will also guide the self-regulated actions that a person will take to improve their prospect of successful learning. Feedback resulting from these actions will influence future motivational beliefs (Brown et al., 2016). Given that one of the key research objectives for the research reported in this thesis was to test a model based on Bandura’s (1986) social cognitive theory, it was necessary to establish the meaning of motivation (for this study) and to operationalise the constructs that would be used to measure motivation.

Those involved in education agree that motivation is essential for the success of the learning process. According to Gilman and Anderman (2006, p. 326), “a thorough understanding of student motivation and contextual effects that influence motivation is essential towards transforming schools from perceived intellectual prisons, devoid of relevance and personal meaning, into environments that support exploration learning and creativity among all students”. Motivation is a critical factor in determining the amount and quality of learning in an educational institution and, therefore, the institution’s overall success (Midgley, 2002). Despite its importance, many schools face a crisis when motivating students. Research has been directed towards understanding the construct of motivation. Classroom practices or structures can be designed and implemented to enhance motivation and hence the level of achievement and school success (Ames, 1992).

Three constructs of motivation have been frequently researched: learning goal orientation (Bong, 2009; Eccles & Wigfield, 2002; Linnenbrink, 2005); task value (Eccles & Wigfield, 2002; Federici & Skaalvik, 2014; Meece et al., 2006); and self-efficacy (Murphy & Alexander, 2000; Popa, 2015). Achieving high motivation levels requires positive contributions in all three component areas (Velayutham et al., 2011). The following sections define the three constructs of motivation selected for use in this study and justify their inclusion. These constructs were learning goal orientation (Section 2.3.1), task value (Sections 2.3.2) and self-efficacy (Section 2.3.3). Section 2.3.4 reviews the relationship between motivation and the learning environment. The relationships between motivation and the other constructs that make up the research model are reviewed in later sections: self-regulation (Section 2.4.1), mathematics anxiety (Section 2.5.2) and mathematics achievement (Section 2.7.1).

2.3.1 Learning Goal Orientation

The primary focus of this section is to review the learning goal orientation construct and justify its inclusion in this study as a component of the motivation construct. A description of learning goal orientation is provided, and comparisons are made with other types of goal orientation.

Learning goal orientation is important as it is an overriding approach that students employ during the learning process or to evaluate their ability (Elliott & Dweck, 1988). Previous research has indicated that a student's learning goal orientation influences their motivation, engagement and subsequent success or failure (Covington, 2000; Steinmayr et al., 2011). Elliott & Dweck (1988) state that each goal creates and organises its own world by evoking different thoughts and emotions and calling forth different behaviours. Elliott & Dweck (1988) also state that goals generate a framework for processing. Learning goal orientation is essential because it contributes to the overall motivational level and, according to Anderman & Gray (2015), it is why students strive to achieve.

Early research proposed a dichotomous two-goal model of achievement goals, which included mastery and performance goals (Ames & Archer, 1988; Harackiewicz et al., 1998; Maehr & Midgley, 1996; Meece & Holt, 1993; Nicholls, 1984). Due to a large amount of parallel research, many other labels are also used for goal orientations with similar descriptions. It is necessary to clarify these terms before comparing findings of the various types of goal orientation. Mastery goals have also been referred to as learning goal orientation (Dweck & Leggett, 1988; Elliott & Dweck, 1988) or task goals (Greene et al., 2004; Middleton & Midgley, 1997; Urdan & Maehr, 1995). Performance goals are also known as performance goal orientation (Waege, 2009) or ego goals (Boekaerts, Smit, et al., 2012; Kaplan & Maehr, 1999). Learning goal orientation focuses on the learning process and mastering new tasks or skills. Students with learning goal orientation try to improve their ability incrementally over time and view errors as part of the learning process (Maehr & Zusho, 2009). Students with learning goal orientation are prepared to choose challenging tasks (Spieker & Verlin, 2004) and show persistence (Barron & Hulleman, 2015; Skaalvik et al., 2015). These students tend to attribute failures to a lack of effort rather than ability (Else-Quest et al., 2010; Seegers et al., 2002), meaning they are not easily discouraged and as part of an adaptive process (Cerasoli et al., 2014; Luo et al., 2011; Pantziara & Philippou, 2015; Pulkka & Niemivirta, 2015; Wang et al., 2011; Wolters & Benzon, 2013; Zimmerman, 2008) they look for ways to improve (Dupeyrat & Mariné, 2005; Spinath, 2005). Students with learning goal orientation are more likely to employ higher-level learning strategies and self-regulation (Ames & Archer, 1988; Diseth, 2011; Keys et al., 2012;Wolters, 2003). Elliot (1999) and Pintrich (2000) proposed that mastery goals (learning goal orientation) should be divided into mastery-approach goals, as described above, and mastery-avoidance goals, where the goals differ from mastery goals in that the student concentrates on avoiding a lack of mastery. Although they remain engaged, their goal is to avoid not knowing (Bong, 2009; Elliot & McGregor, 2001; Huang, 2016).

Prior to using learning goal orientation in this study, it was also necessary to consider the performance goal alternative, as any disadvantages of performance goals add weight to their non-selection and justify the selection of learning goal orientation. Students with performance goal orientation see results as a measure of their competence. They are concerned with how others perceive their competence and how they judge themselves. They tend to attribute their failures to a lack of ability, which frequently leads to a reduction in self-efficacy (Elliot & Harackiewicz, 1996; Peterson, Brown & Jun, 2015) and, in turn, effort (Covington, 2000). Performance goals can lead to a mixed pattern of adaptive and maladaptive outcomes (Sommet & Elliot, 2017), which encouraged researchers to separate performance goals into performance-approach goals and performance-avoidance goals (Elliot, 1999; Elliot & Harackiewicz, 1996; Midgley et al., 1998; Skaalvik, 1997). Performance-approach goals focus on students displaying competence, whereas performance-avoidance goals focus on not looking incompetent or stupid. Performance-avoidance goals may result in a student achieving a state of learned helplessness or apathy (Else-Quest et al., 2010; Hoffman, 2010; Zimmerman, 2015) because they believe they will fail no matter what (Chipangura, 2014; Duckworth et al., 2016; Eccles & Wigfield, 2015). This maladaptive, self-protective process can take on several forms. For example, self-handicapping involves the withdrawal of effort so that future failure is not attributed to a lack of ability (Anderman & Gray, 2015; Covington, 1992; Elliot & Church, 2003; Norem, 2008). Future successes under these self-imposed limiting conditions may even boost self-efficacy. By contrast, defensive pessimism involves the student remaining engaged but driven by the fear of failure (Elliot & Church, 2003; Norem, 2008). Students may also display false effort, where they merely appear to carry out the required task but are not really engaged, or even academic cheating (Covington, 1992; Meece et al., 2006). Since these approaches involve cognitive disengagement and focus on the avoidance of appearing incompetent, they also include a reduction in help-seeking (Bong, 2009; Linnenbrink, 2005; Urdan & Schoenfelder, 2006).

In contrast to performance goal orientation, researchers agree that learning goal orientation is beneficial for students of all ability levels, as it enables them to maintain motivation and engagement. It allows students to raise their level of self-efficacy through successful goal attainment, but most importantly, it allows them to be resilient and maintain their level of self-efficacy in the face of failure outcomes (Martin & Marsh, 2006; Skaalvik et al., 2015; Zimmerman, 2000). Learning goal orientation has also been associated with a range of positive traits including persistence; positive coping (Friedel et al., 2007); choosing challenging tasks; deep learning (Sommet & Elliot, 2017; interest (Tosto et al., 2016); intrinsic value (Wolters et al., 1996); use of higher-level self-regulative strategies (Wolters & Hussain, 2015); positive social attitudes (Kaplan & Maehr, 2007); low anxiety (Martin & Marsh, 2006); and high self-efficacy (Vrugt et al., 2009). In contrast, performance goal orientation can be associated with anxiety (Furner & Gonzalez-DeHass, 2011); low retention of knowledge; disruptive behaviour (Kaplan & Maehr, 1999); low self-efficacy (Huang, 2016); low grades; avoidance of help-seeking; and self-handicapping (Liem et al., 2008).

Given the general acceptance that learning goal orientation will produce positive outcomes and the continued debate about the possible advantages and disadvantages of performance goal orientation, the research reported in this study focused on the conditions under which learning goal orientation is acquired. Large numbers of students in the UAE are ill-equipped to study mathematics. However, little research has been carried out on student learning goal orientation when entering university to study mathematics, and none compares gender differences in learning goal orientation. Further, Maehr and Zusho (2015) recommend that future research consider goals as part of a more extensive and situated process. This study fills this research gap by considering goals as part of a motivation construct and by considering the relationships between motivation and learning environment, self-regulation, mathematics anxiety and mathematics achievement.

2.3.2 Task Value

Even when a student has learning goal orientation and a high level of self-efficacy (see Section 2.4.3), this may not be sufficient to initiate action or persist to complete a task or learn a new skill (Hulleman et al., 2008; Wigfield & Eccles, 1992). As a mathematics educator of more than 30 years, I have found that it is not uncommon to hear a student ask, “Why do we need to know this?” or “When are we going to use this?” These students are trying to determine the value of the task.

Task value is a reason for doing a task. Eccles & Wigfield (2002) suggested that these reasons fall into four categories: attainment value, intrinsic value, utility and cost. Attainment value is based on individual identity or self-schema. A task may allow an individual to demonstrate that they are who they think they are or who they would like to be (Eccles & Wigfield, 2002). Intrinsic value is the enjoyment that is gained from doing a task and is similar to the concept of interest, as described by Schiefele (1991) and Ryan and Deci (2000). When a person enjoys doing a task, they persist at that task for longer and with less effort than they would at a task they disliked doing. Utility value is what can be gained from doing the task. The utility of a task is related to extrinsic motivation in that value is not placed on working on the task itself but instead on the instant benefits gained or doors opened when the task is completed. Cost refers to both resources expended and opportunities lost. Expended resources include the more direct costs such as time, effort and finances. If it was necessary to choose between tasks, then by their very non-selection, the opportunities provided by these tasks are lost, either in the interim or permanently.

The value placed on a task is subjective and will vary from individual to individual (Wigfield & Cambria, 2010). The attainment component of the value placed on a task will be dependent on a particular individual's self-schema, which is determined by a complex combination of factors such as gender, social, economic status, culture and interests. The perception of the difficulty of a task may also prove to be necessary. Wigfield & Cambria (2010) reported that individuals valued tasks more highly when considered difficult. Wigfield (1994) stated that individuals attached more value to a task that they could do well. A high value will be associated with tasks that they can do well despite the perceived high level of difficulty. The value assigned to a task may vary over time. Eccles & Wigfield (2002) reported that individuals might attempt to maintain self-efficacy by lowering the value assigned to a task they cannot do well. Individuals will have different affective memories for similar evaluations or related events. Even when individuals have previous achievement outcomes at the same level, their perceptions of these results may be considerably different. The value an individual places on a task may be influenced by their perception of how others, such as parents and teachers, perceive them. Parents' views of their children may in turn be shaped by their judgement of their children's ability as well as their cultural and religious norms, whereas a teacher's view may be formed by an evaluation of previous achievement outcomes.

The task value construct is an important enabler of the learning process. When individuals place a high value on a task, they are more likely to initiate action, show greater persistence and exert more effort (Cole et al., 2008; Wigfield & Cambria, 2010). They are more likely to use effective learning strategies such as processing, self-monitoring and deep information processing (Ames & Archer, 1988; Meece et al., 1988). Task value has been associated with academic success (Pintrich & Schunk, 2002; Wigfield & Eccles, 2002), and Cole et al. (2008) confirmed that utility value could predict performance. Wigfield and Eccles (2002) found that children tended to develop intrinsic value first, then attainment and utility value. They also found a decline in the value assigned to mathematics during the years at school. Wigfield &

Eccles (2002) attributed this decline to increased emphasis on evaluation and associated pressures, which decreased any intrinsic value developed earlier. In their view, this decline coincided with a transition from learning orientation goals to performance orientation goals as students moved from primary to secondary school.

Whether it is due to a continual, incremental decline, as described above, or for a more extreme reason, some students fail to perceive value in the tasks assigned. Students who do not find tasks interesting or worthwhile become disengaged and, as a consequence, tend to achieve poor academic results (Vallerand et al., 1993). Wigfield & Cambria (2010) refer to this type of disengagement as student apathy and state that it is the most severe motivational problem teachers have to deal with. Several reasons have been suggested for this severe form of amotivation; for example, children from a minority ethnic or racial group may not receive the same opportunities as other groups and may begin to question the value of continued participation (Ogbu, 1992; Ogbu, 2003). Students who do poorly at school eventually reduce their assigned value to a task as a self-protective mechanism, and continued poor academic results lead to further devaluation of tasks. A state of apathy may be achieved by continuing this downward spiral (Covington, 1992; Benders, 2011).

Given these findings, task value can be viewed as an essential component of motivation. If increasing task value (intrinsic and utility value) is to be used to improve motivation, then tasks will need to be both meaningful and interesting (Hidi & Renninger, 2006; Hulleman et al., 2008). Students need at least some authority to make choices regarding tasks they attempt. There will also need to be an emphasis placed on the personal relevance of each task (Cole, Bergin, & Whittaker, 2008; Hidi & Renninger, 2006). Each task should provide each student with a personal challenge, and evaluation should recognise effort and improvement rather than having the sole focus on normative comparisons (Denissen, Zarrett, & Eccles, 2007).

Task value was of particular interest to this study, as no prior study had reported this aspect of motivation in the UAE. Firstly, it is an integral part of motivation, so optimal engagement and learning will only occur when a student sees intrinsic and utility value in completing a task. Secondly, the UAE is unique; with its oil-based economy and high demand for engineers, students have received a sizeable stipend and other benefits while studying mathematics as part of their engineering program. Reports of task value could indicate whether students are enrolling in the course primarily due to the incentives, leading to a motivation problem.

2.3.3 Self-Efficacy

Bandura (1997) states that self-efficacy is the "perceived capabilities for learning or performing actions at designated levels". It is a person's belief about whether they can master a skill or task. This belief is an important factor during learning, as it will affect the chance of a skill or task being successfully acquired or completed. Self-efficacy is specific to a particular task or skill. Several factors influence a person's self-efficacy to perform a specific skill or task. Each individual receives information from several sources about their ability to be successful. After receiving the information, it is first interpreted and appraised before deciding how it will impact a person's ability to complete the task. The sources of this information include mastery experience, vicarious experience, social persuasion and physiological indices (Bandura, 1986). Research related to each of these sources of information and how they affect learning is reviewed below.

Mastery experience is based on completing similar tasks in the past. Prior success in a similar task is a powerful source of self-efficacy (Usher & Pajares, 2006; Van Dinther, Dochy, & Segers, 2011). Determining the relevance of a particular mastery experience concerning a current task or skill requires several factors about the mastery experience to be considered, including task difficulty, the effort required to complete the task, the amount of external assistance received, task outcomes, and patterns of success and failure.

Vicarious experience is gained by observing others complete a task or attain a skill. The premise is that if they can do it, why can't I? Given this line of thinking, it is unsurprising that the influence will be more decisive when there is greater similarity between the observer and the model, such as in peer modelling (Bandura & Adams, 1977; Schunk, 1989). Vicarious experience is a less direct indicator of a person's ability to complete a task than mastery experience. As a result, vicarious experience will be given less weight when mastery experience is available but greater importance when mastery experience is absent.

The third factor influencing self-efficacy is social persuasion. We are influenced by what people tell us, especially if we view them as knowledgeable and reliable, and we feel that the information they are supplying is realistic (Bong & Skaalvik, 2003; Schunk, 1989). Receiving positive feedback is likely to enhance self-efficacy, but negative feedback is likely to lower self-efficacy (Schunk & DiBenedetto, 2015). Self-efficacy generated solely through social persuasion is unlikely to be sustained unless it is followed by positive results (Schunk, 1989).

The fourth factor influencing self-efficacy is a person's emotional and physiological state. Pajares (1996) stated that a high level of self-efficacy may create a feeling of serenity when attempting complex tasks. However, on the other hand, a feeling of anxiety or stress may undermine self-efficacy and cause poor performance.

An individual may receive information from one or more of the above-mentioned sources (Schunk & DiBenedetto, 2015). The information received will not provide the same level of evidence, so it will not be treated equally (Usher & Pajares, 2009). Mastery experience evidence may be more compelling than vicarious experience and social persuasion (Maehr & Zusho, 2009; Schunk, 1991; Usher & Pajares, 2009). It is also possible that different factors, or even a single factor, may provide contradictory evidence of a person's capability of completing a task (Stevens et al., 2004). An individual will need to process the information cognitively. This process will involve evaluating each piece of information to see how it relates to the task at hand and comparing different pieces of information to determine which is more important or relevant. Finally, after considering all information, the individual's confidence level would be ascertained. Even if a person has had a relevant mastery experience, they still need to consider the length of time since it occurred and the number of failures that have occurred during this time. A person's current level of self-efficacy for a task will also affect how they perceive new information (Usher & Urdan, 2016). If they have high self-efficacy based on prior feedback and then receive some negative feedback it is less likely that the level of self-efficacy will change, or the degree of change will be less, than if they started with a lower level of self-efficacy and received the same negative feedback (Schunk & DiBenedetto, 2015).

Self-efficacy is a strong predictor of levels of accomplishment (Pajares, 1996; Stevens et al., 2004). Students with high self-efficacy are more likely to succeed, so it is an important factor in learning. For these reasons, self-efficacy was included as a component of motivation. However, high self-efficacy alone is not sufficient to complete a task successfully. The task also needs to be valued and fit into a person's learning goal orientation. These three components of motivation (learning goal orientation, task value and self-efficacy) are not stand-alone constructs; they interact and need to be considered together. The present study examines all three components and examines their relationships with other constructs that influence the learning process.

2.3.4 Learning Environment and Motivation

Prior research has indicated that students' perceptions of the learning environment positively impact their motivation (Aldridge & Rowntree, 2021; Gilbert et al., 2013). This section reviews the research that has looked at the influence of learning environment factors on the three components of motivation (learning goal orientation, task value and self-efficacy). It also reviews studies carried out at university level.

Few studies have examined the relationships between students' perception of the learning environment and students' learning goal orientation. However, of those that have, the findings indicate a positive relationship between students' perceptions of the learning environment and self-reports of learning goal orientation, such as mastery goals. For example, it was reported that classroom structures determined the saliences of different goal orientations, which then influenced both self-efficacy and task value (Ames, 1992; Aldridge & Rowntree, 2021; Velayutham & Aldridge, 2013)

Most research on the association between learning environment and task value concentrated on either aspect of the learning environment or aspects of task value. For example, some studies report positive associations between learning environment and the following aspects of task value: subject interest ((Koul et al., 2018; Riconscente, 2014; Tosto et al., 2016); enjoyment (Afari et al., 2013; den Brok et al., 2005; Magen-Nagar & Steinberger, 2017; Telli et al., 2010); a liking for the subject (Winheller et al., 2013); intrinsic interest (van der Veen & Peetsma, 2009); and utility (Gilbert et al., 2013). Learning environment factors found to influence task value included interpersonal teacher behaviours (Telli et al., 2010, Tosto et al., 2016); teacher expectations and support (Gilbert et al., 2013); quality of teaching (Winheller et al., 2013); teacher caring and subject matter explanations (Riconscente, 2014); and the introduction of engineering and technology activities (Koul et al., 2018). The relationships between learning environment and task value were positive, whether they used the broader learning environment construct or concentrated on a single learning environment construct.

Positive relationships have been reported between students' perceptions of the learning environment and both academic efficacy (Afari et al., 2013; Dorman, 2001; Dorman & Adams, 2004) and self-efficacy (Alzubaidi et al., 2016; Fast et al., 2010; Lim & Fraser, 2018; Peters, 2013; Tosto et al., 2016). These associations have been found in various contexts, including at university level (Alzubaidi et al., 2016; Peters, 2013) and in the UAE (Afari et al., 2013). McMinn (2018) carried out one study at tertiary level in the UAE; however, this study involved pre-service teachers and their self-efficacy in teaching primary level mathematics. The research reported in this study differs from McMinn's because it involves a different group of students and investigates their motivation to learn mathematics rather than teach mathematics. To date, no research has investigated the level of motivation of university-level mathematics students in the UAE. The current study also considers the relationship between motivation and mathematics achievement. It is a new avenue of research in the UAE. However, it extends motivation research in other contexts by examining student motivation in this unique context.

2.3.5 Instruments Developed to Measure Motivation

This section reviews the instruments developed to measure student motivation levels. A comparison of the merits of each instrument was required to determine which instrument was the most suitable for use in the current study. There have been several instruments designed to measure student motivation for learning, including the

Academic Motivation Scale (Vallerand et al., 1992); Multi-dimensional Motivation Instrument (Uguroglu et al., 1981); Patterns of Adaptive Learning Survey (Midgley et al., 1996); Motivated Strategies for Learning Questionnaire (Pintrich et al. (1993); and the Students' Adaptive Learning Engagement in Mathematics (Chipangura, 2014). This section describes these instruments and justifies their selection or non-selection for use in this study.

Firstly, the Academic Motivation Scale (AMS; Vallerand et al., 1992) consists of 23 items, grouped into seven scales: amotivation, external regulation, introjected regulation, identified regulation, intrinsic motivation – to know, intrinsic motivation – to accomplish, and intrinsic motivation – stimulation. Each scale includes four items, responded to using a rating scale ranging from 1 = not at all to 7 = exactly, which indicates a level of agreement with a statement providing a reason for going to college. Although the instrument provides comprehensive coverage of task value, the other motivation components included in the current study, learning goal orientation and self-efficacy, are not included. For this reason, this instrument was not deemed to be a good fit for the current study.

The Multi-dimensional Motivation Instrument (MMI; Uguroglu et al., 1981) consists of 23 questions on six scales: academic self-concept, academic motivation, social self-concept, locus of control, emotional self-concept and physical self-concept. Each scale has between one and seven items assigned randomly and responded to on a 5-point Likert scale. The rating scale includes 15 different sets of descriptors, which are specific to the question; for example, 1 = seldom to 5 = always; 1 = easy to 5 = hard; 1 = not my fault to 5 = my fault; and 1 = was lucky to 5 = worked hard. With such a variety of descriptors in a single instrument, this instrument would be more difficult to translate into Arabic. Also, the instrument assesses self-concept with four scales but does not include either learning goal orientation or task value scales. The instrument was not selected for use in the study as it does not provide adequate coverage of the components of motivation selected for use in the current study.

The Patterns of Adaptive Learning Survey (PALS; Midgley et al., 1996) includes 94 items, with four to five items per scale that are responded to on a 5-point Likert scale ranging from 1 = not at all true to 5 = very true. The instrument includes scales that measure learning goal orientation and academic efficacy, which could have been included in a hybrid instrument. However, this option was not chosen, as the items were not written specifically for the mathematics classroom.

The Motivated Strategies for Learning Questionnaire (MSLQ; Pintrich et al., 1993) instrument consists of 81 items. The motivation section consists of 31 items divided into six scales: intrinsic goal orientation, extrinsic goal orientation, task value, control of learning beliefs, self-efficacy for learning, and performance and test anxiety. Each item is responded to on a 7-point scale ranging from 1 = not at all true of me to 7 = very true of me. The remaining 50 items of MSLQ are used to assess learning strategies, which are also relevant to the current study. This instrument includes task value and self-efficacy scales but does not include learning goal orientation. Although the instrument also assesses learning strategies (self-regulation), the 50-question format is too long for this study.

The Students' Adaptive Learning Engagement in Science (SALES) instrument (Velayutham et al., 2011) was developed specifically to assess the motivation of high school science students, which means the required reading age is lower than instruments designed for use at university level. The Student's Adaptive Learning Engagement for Mathematics (SALEM) instrument (Chipangura & Aldridge, 2019) was developed by modifying the SALES instrument specifically for high school mathematics students. SALEM not only includes motivation scales for learning goal orientation, task value and self-efficacy, it also includes a self-regulation scale. SALEM benefits from mathematics specificity, and the motivation measures align with those used in this study. Each scale is assessed using eight items, which are responded to using a 5-point Likert scale ranging from 1 = almost never to 5 = almost always. Both the SALEM instrument (Chipangura & Aldridge, 2017) and its parent instrument, SALES (Velayutham et al., 2011), displayed satisfactory reliability and validity when used in earlier studies. SALEM also provides the information required while maintaining the need for brevity. Although some instruments had scales that could have been used successfully, SALEM was selected as the best overall fit for this study. Additional information related to the SALEM instrument is provided in Section 3.5.1.2.

2.4 Student Self-Regulation

Various research suggests that self-regulation is an integral part of the learning process. This section reviews the literature that defines self-regulation and investigates its impact on learning and the success of possible interventions. It will also consider the relationships between self-regulation and motivation (Section 2.4.1) and the learning environment (Section 2.4.3). Finally, a review of the instruments developed to measure self-regulation is provided (Section 2.4.3).

Self-regulation is a multi-faceted, iterative, self-steering process that targets a person's cognition, feelings and actions as well as features of the environment for modulation in the service of one's own goals (Boekaerts et al., 2005; Cleary, Callan, & Zimmerman, 2012). Self-regulation in learning requires the learner to show personal initiative to set goals, utilise cognitive and metacognitive strategies, monitor progress, and display perseverance and adaptive skill to make changes in their approach to continue along the mastery pathway (Zimmerman, 2015). Self-regulation is not limited to asocial events. Social forms of learning, such as modelling, guidance, feedback, coaches and teachers, can be included in the process provided that they are there as a result of the personal initiative of the learner and not imposed by a third party (Pressley, 1995; Zimmerman, 2008). Self-regulation and learning do not necessarily go hand in hand. Some students may have set goals that do not correspond to the learning goals of the class. However, despite a lack of progress towards the class goals and any obvious employment of self-regulatory strategies, they successfully use self-regulation to achieve personal goals.

The focus of the review is on self-regulatory practices that facilitate academic learning. Self-regulated learning consists of three distinct stages: before, during and after action (Boekaerts & Cascallar, 2006; Zimmerman, 2015); otherwise referred to as forethought, performance and self-reflection (Zimmerman, 2015). Self-regulation is not a skill that a person either has or does not have – it has degrees or levels. Zimmerman also describes a novice as typically having distal goals, non-strategic methods, inaccurate self-monitoring, unfavourable attributions and defensive reactions. By comparison, an expert typically has an increased awareness of the effort required to learn, high self-efficacy, positive outcome expectations, intrinsic interest and proximal goals; they would also optimise effort, have good time management, be self-observant, accurately self-evaluate and have positive attributes. These descriptors are at opposite ends of a self-regulatory spectrum, with most people placed somewhere in-between. A person's position on this spectrum is not inherent, as self-regulation is a skill that can be learned and developed (Boekaerts & Corno, 2005; Pekrun et al., 2002; Pintrich, 1995; Zimmerman, 2015).

Both cognitive and metacognitive strategies are part of the self-regulation process. Cognitive strategies include acquiring new knowledge or skills (e.g., deep processing, rehearsal, elaboration, reviewing material, organisation and critical thinking). In contrast, metacognitive strategies involve maximising the effective use of cognitive strategies (e.g., orientation, planning, goal setting, time management, collection of required resources, monitoring, assessing progress and modifying) (Winne, 2015; Zusho & Edwards, 2011). Self-regulation is an iterative or cyclical process. Individual tasks may be completed, but the process is ongoing (Boekaerts & Cascallar, 2006; Zimmerman, 2002). It is also an adaptive process. The self-reflection stage involves self-evaluation or self-judgement. This stage provides the learner with information about the effectiveness of the strategies used. Following this assessment, they may deem it necessary to modify or adapt previous strategies as a part of a continual search for improvement (Boekaerts, 1999; Pintrich, 2004).

Self-regulation is a crucial component of the learning process as considerable research has been carried out which reports that self-regulation is positively associated with achievement (Boekaerts et al., 2005; Nett et al., 2012; Tee et al., 2021; Wang & Sperling, 2020; Zimmerman & Kitsantas, 2014). These studies suggest that self-regulation practices facilitate the learning process; therefore, it is a central part of the process itself. Researchers and educators, encouraged by these results, have sought methods or interventions that could increase the use (Zimmerman & Kitsantas, 2014) of effective self-regulatory strategies and thereby increase levels of academic achievement. The effectiveness of these interventions will be discussed in Section 2.4.2.

2.4.1 Self-Regulation and Motivation

During early research, self-regulation was viewed as an independent process. However, motivation researchers were quick to point out that even when a student possessed high self-regulatory awareness and skill levels, it did not guarantee that learning would occur. They asserted that motivation is an essential ingredient in the learning process, as it is required for the self-regulatory process to be initiated and maintained over time (Boekaerts, 1993; Pintrich, 2000; Pintrich & de Groot, 1990; Ryan & Deci, 2000).

Learning goal orientation is an important component of motivation. If goals are going to drive the learning process, of which self-regulation is a part, they must be based on personal preferences, values and interests rather than simply meeting task and social demands (Zimmerman, 2015). Research has revealed a positive association between a learning goal orientation and self-regulative strategy use; however, there is either no relationship or even a negative relationship between performance goals and cognitive strategy use. Students with learning goal orientation are more likely to employ self-regulative strategies successfully (Diseth, 2011). These students typically display more persistence and have positive attributes, which enables them to sustain a high level of self-efficacy even when experiencing failure (Zusho & Edwards, 2011).

Students who feel a task they are engaged in is important and interesting are more likely to display greater effort and persistence towards task completion and task quality. Research consistently reports a positive relationship between task value and cognitive and self-regulatory strategies (Boekaerts & Corno, 2005; Pintrich & de Groot, 1990; Wolters & Rosenthal, 2000). In Section 2.3.2, the components of task value were reviewed. Research results show that interest is positively associated with self-regulation practices. O'Keefe and Linnenbrink-Garcia (2014) reported that high value-related interest optimised task performance and supported efficient and effective engagement without depleting self-regulatory resources. Lee et al. (2014) investigated the relationships between academic self-efficacy, interest, goals, self-regulation and achievement over four different subject areas. They reported that individual interest was a direct predictor of self-regulation.

Self-efficacy, reviewed in Section 2.3.3, was a strong predictor of achievement, both directly and indirectly (Lee et al., 2014; Pajares, 1996). Whether or not a person believes that they are capable of completing a task will determine the amount of effort and the level of persistence that they are likely to display (Pajares, 2002; Pintrich & de Groot, 1990). Research supports a link between self-efficacy and achievement and between self-efficacy and self-regulation. Lee et al. (2014) reported that self-efficacy predicted self-regulation, but only when mediated by learning goal orientation. Investigating the influence of motivation and self-regulation on mediating the impact of self-efficacy on achievement with undergraduate psychology students, Komarraju and Nadler (2013) reported that high self-efficacy facilitated the use of metacognitive strategies and resources. They also found that effort regulation and self-control enabled the students to show persistence and overcome difficulties.

The majority of the initial research concentrated on how motivation influenced self-regulation; there has since been considerable research on the process of self-regulation of motivation (Rozendaal et al., 2005; Wolters, 2003; Wolters & Benzon, 2013). This process is based on students knowing motivation, monitoring their level of motivation, and using strategies to control that level. Students must still have some motivation to have the will to self-regulate their motivation. For example, an apathetic student is not motivated to self-regulate their level of motivation. Wolters and Benzon (2013) report that learning goal orientation, course value and self-efficacy are all positive predictors of strategy use to regulate motivation.

Research has shown that all three constructs of motivation, as defined in this study (learning goal orientation, task value and self-efficacy), influence the implementation and successful use of self-regulation. Given that the research reported in this study is grounded in social cognitive theory (Bandura, 1986), the relationship between motivation and self-regulation is reciprocal, although not necessarily to the same degree in each direction. Supported by a large quantity of research, this study included the influence of motivation on self-regulation as a hypothesised relationship.

No previous research has specifically examined the impact of motivational constructs, such as learning goal orientation, task value and self-efficacy, on self-regulatory strategies in university-level mathematics classes. This study is at least a start towards filling this gap while at the same time considering the impact of gender on these relationships.

2.4.2 Self-Regulation and Learning Environment

Initial research in self-regulated learning was largely decontextualized. The move towards domain-specific and context-sensitive measures acknowledged the importance of the environment in determining whether self-regulation would be employed and the likelihood of its success. Cleary et al. (2012) stated that the understanding of self-regulated learning remained incomplete if regulatory activities were separated from context.

Research consistently supports the influence of the learning environment on the uptake of self-regulatory strategies, both directly and indirectly, through its influence on motivation (Opolot-Okurut, 2010; Wentzel et al., 2017). The impact of the environment begins with the students' perceptions of the classroom environment, which then initiates either self-regulatory behaviour or negative actions (Bembenutty, 2011b). A student's perception will be based on an individual's unique characteristics, which differ from student to student.

The influence of the learning environment on student self-regulation and motivation is dependent on the characteristics of the individuals involved. This finding was supported by Wentzel et al. (2017), who reported that peer expectations for pro-social behaviour, effort and mastery orientation influenced the behaviour of individuals, which, in turn, influenced the learning environment, as all students were active participants in their learning environment. Järvenoja et al. (2015) reported that the learning context shaped the regulation process of both individuals and groups, and found that students who used instructor feedback to guide their learning practices increased their self-regulation and academic performance.

The study reported in this thesis is grounded in social cognitive theory, which advocates reciprocal determinism between the environment and behaviour. It accepts that perception of the learning environment would influence self-regulation, which, in turn, influences the learning environment. However, it was only possible for the study to focus on a relationship in a single direction. It was decided that the relationship between learning environment and self-regulation was more robust and was included as one of the hypothesised relationships in the research model.

The association between the classroom-learning environment and self-regulation is important because it offers educators the opportunity to control or manipulate the learning environment to improve students' knowledge and skills in self-regulatory practices and thereby improve educational outcomes. Instructors need to provide students with strategies to use (Dignath-van Ewijk & van der Werf, 2012). Some of these interventions have reported considerable success. Perels et al. (2009) described an intervention where self-regulated learning was integrated into a mathematics class unit for an experimental class. In contrast, a control class did not receive the same training. After controlling for initial differences, the results demonstrated that the experimental class displayed higher levels of self-regulation and achievement. Cleary and Platten (2013) reported on the implementation of the Self-Regulation Empowerment Programme (SREP), which involved four students over eleven weeks. Although all four students showed an improvement in both self-regulation and motivation, their responsiveness varied. Cleary and Platten noted that students with low motivation levels prior to the intervention had poor attendance and displayed only a slight improvement during the program.

Many researchers have found that students can extend their knowledge of self-regulatory strategies (Boekaerts & Corno, 2005; Boekaerts et al., 2013; Cleary et al., 2012; Pintrich, 1995), but they also note that a knowledge of self-regulatory strategies was enough to improve educational outcomes. Many researchers have also emphasised the importance of motivation (Pintrich, 1995; Pintrich & de Groot, 1990; Zimmerman, 2015; Zimmerman & Kitsantas, 2014). Hattie et al. (1996) felt that students needed teacher assistance and support until the strategies became automatic. In contrast, Boekaerts and Cascallar (2006) went a step further by suggesting that awareness of strategies degraded performance until they became automatic.

Research suggests that few teachers provide a learning environment conducive to fostering self-regulatory practices. In an overview of studies, Moos & Ringdal (2012) noted that explicit instruction on self-regulatory practice was rare despite its importance to effective learning. According to Moos and Ringdal, student-teachers could cater to self-regulatory strategies in their classrooms with training. The effectiveness of this training for experienced teachers depended on their willingness to try new methods. Moos and Ringdal suggested that before teachers could effectively teach and support self-regulatory practices in their classrooms, they needed to reflect on their teaching practices and their effect on student performance. They felt that if teachers cannot self-regulate their practices, they are less likely to believe that their students are capable of doing so.

Most of the literature reviewed in this section involved primary or secondary school students. There has been little research carried out to determine how the learning environment is related to self-regulatory practices at the tertiary level, and there is none involved in mathematics classes in the UAE. Without first establishing this relationship, there is little point in attempting to use the learning environment to foster the uptake of self-regulatory practices. The researchers' experience suggests that university-level mathematics students in the UAE could benefit from greater self-regulatory knowledge and improved skills. This study should provide a clearer picture of the situation and determine whether future interventions are necessary.

2.4.3 Instruments that Measure Self-Regulation

Two instruments have frequently been used to measure students' self-regulatory practices: the Learning And Study Strategies Inventory (LASSI) and the Motivated Strategies for Learning Questionnaire (MSLQ). LASSI was developed by Weinstein et al. (1987) and consists of ten scales with eight items per scale. The ten scales are 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. MSLQ was developed by Pintrich et al. (1993) and consists of two parts: the first part measures motivation, as discussed in section 2.4.3; and the second part measures self-regulation. The self-regulation part includes nine scales with four to twelve items per scale. The nine scales are rehearsal, elaboration, organisation, critical thinking, metacognitive, time and study, effort regulation, peer learning and help-seeking. Both instruments were developed for use at university level and require a high level of English to understand the questions.

LASSI consists of 80 questions and MSLQ 81 when the motivation and self-regulation parts are combined, which means they will require a considerable amount of time for participants to complete. Given that the participants taking part in this study were English as a Second Language (ESL), the instrument needed to require a more moderate language level. Due to this constraint, neither of these instruments was selected for use in this study.

The Students' Adaptive Learning Engagement in Science (SALES) instrument was developed by Velayutham et al. (2011) for use in science classes at secondary school level. Chipangura (2014) later modified SALES to be more specific to mathematics classrooms. As with SALES, the Students' Adaptive Learning Engagement in Mathematics (SALEM) questionnaire consists of four scales, with eight items per scale. The scales are learning goal orientation, task value, self-efficacy and self-regulation. SALEM was chosen for use in the current study as the language was less complex, the scales covered the constructs to be measured, and the questionnaire required less time to complete than the alternatives (for more information, see Section 3.6.1.2).

2.5 Mathematics Anxiety

This section reviews the literature related to mathematics anxiety, a key variable in the research reported in this study. The section begins by introducing the concept of mathematics anxiety, and then examining the scope of the problem and its impact on mathematics performance. The section goes on to review prior research on the relationships between mathematics anxiety and the learning environment (Section 2.5.1), motivation (Section 2.5.2) and self-regulation (Section 2.5.3). Finally, it reviews instruments that have been developed in previous research to measure mathematics anxiety (Section 2.5.4).

Mathematics anxiety is a feeling of tension that interferes with manipulating numbers and solving mathematical problems (Richardson & Suinn, 1972). Mathematics anxiety brings a feeling of helplessness, tension or panic when performing mathematics operations (Gresham, 2007). It is an adverse emotional reaction towards mathematics, which can be debilitating (Hill et al., 2016). Mathematics anxiety consists of both cognitive and affective components. The cognitive component includes concern about performance and the consequences of failure. In contrast, the affective or emotional component includes nervousness in testing situations and the associated physiological reactions (Dowker et al., 2016), such as sweating, increased heart rate (Pletzer et al., 2015), increased cortisol secretion (Hellhammer et al., 2009) and increased neural activity (Bishop, 2009; Chang & Beilock, 2016; Núñez-Peña, Bono, & Suárez-Pellicioni, 2015). Of concern is the consistent negative relationship reported between mathematics anxiety and mathematics achievement (Devine et al., 2012; Dowker et al., 2016; Pletzer et al., 2015; Pekrun & Stephens, 2015; Ramirez et al., 2018). Numerous studies have established that mathematics anxiety disrupts the working memory required for many mathematics calculations (Ashcraft, 2002; Pletzer et al., 2015). The impact of mathematics anxiety on mathematics performance is discussed in Section 2.8.4.

There is a wide range of opinions about the number of people that potentially suffer from mathematics anxiety. Chang and Beilock (2016) stated that mathematics anxiety was a global problem and reviewed the Programme for International Student Assessment (PISA) data for 2012, with 65 participating countries. The results indicated that 33% of 15-year-olds reported that they experience a feeling of helplessness when attempting mathematics problems. Chang and Beilock (2016) also reported that 25% of four-year degree students and 80% of college students suffered from moderate to high levels of mathematics anxiety in the US. They stated that in all Organisation for Economic Co-operation and Development (OECD) countries, 14% of the variation in mathematics achievement could be attributed to mathematics anxiety. Chinn (2008) reported that between 2% and 6% of mainstream secondary school students in the UK suffer from mathematics anxiety. There have also been inconsistent results from studies reporting the age at which students become susceptible to mathematics anxiety.

Previous research has reported conflicting results about whether mathematics anxiety is present in early elementary school. Numerous studies have reported this to be the case (see, e.g., Beilock et al., 2010; Chang & Beilock, 2016; Jansen et al., 2013; Mizala et al., 2015; Ramirez et al., 2018; Wu et al., 2012) while others do not (see, e.g., Dowker et al., 2012; Haase et al., 2012; Wood et al., 2012). These differences can be explained, at least in part, by the definition of mathematics anxiety used in each study and the various components of mathematics anxiety (e.g., cognitive or affective) that were being measured. Despite these differences, mathematics is a significant issue that causes students to avoid mathematics-related educational tracks and career choices (Ashcraft, 2002; Mizala et al., 2015; Scarpello, 2007) when there is an increasing demand for these types of graduates. Further, according to Chinn (2008), mathematics anxiety has also been attributed to poor levels of numeracy, which is concerning given that 50% of people in the UK cannot do mathematics above an 11-year-old level.

The following sections review the impact of the learning environment on the level of student mathematics anxiety (Section 2.5.1), the influence that mathematics anxiety has on the level of student motivation (Section 2.5.2), and the relationship between the use of self-regulatory strategies and mathematics anxiety (Section 2.5.3). Finally, the instruments used to measure mathematics anxiety will be reviewed (Section 2.5.4). The impact of mathematics anxiety on mathematics achievement will be reviewed in Section 2.6.4.

2.5.1 Mathematics Anxiety and the Learning Environment

Numerous studies have been carried out which report that learning is an important determinant of mathematics anxiety (Deieso & Fraser, 2018; McMinn & Aldridge, 2020). The general consensus with these studies is that this relationship is negative, meaning that the more positive the learning environment, the lower the level of mathematics anxiety.

Given the nature of the subject, mathematics students were frequently subjected to "failure". Teaching style has proven important in dealing with this failure (Ashcraft, 2002). Students who perceive the learning environment as caring, challenging and mastery-oriented are better prepared to deal with possible negative emotional reactions without transitioning into maladaptive coping strategies (Chang & Beilock, 2016). Furner and Gonzalez-De Hass (2011) supported this view by finding that a focus on mastery goals reduced mathematics anxiety. The influence of the learning environment on mathematics anxiety is highlighted in a study by Deieso and Fraser (2018), which found that students reported less involvement, less positive attitudes to mathematics inquiry, and less enjoyment of mathematics after transitioning from primary to secondary school. Of relevance to this study is the reported increase in mathematics anxiety.

Jackson and Leffingwell (1999) stated that due to teachers' impact on the classroom-learning environment, teacher behaviour is a prime determinant of mathematics anxiety. Several studies reported that a large number of primary teachers struggle with mathematics anxiety, which affects their confidence in teaching mathematics (Bursal & Paznokas, 2006; McMinn & Aldridge, 2020), and their ability to instil students with positive attitudes and self-efficacy in the subject (Chang & Beilock, 2016; Lake & Kelly, 2014; Maloney & Beilock, 2012; Mizala et al., 2015). Hembree (1990) completed a meta-analysis of 151 studies and found that elementary education students had higher mathematics anxiety than students doing any other course, even "remedial algebra" and "developmental mathematics". This outcome has also been repeated in more recent studies (Gresham, 2007; Mizala et al., 2015). Beilock, Gunderson, Ramirez, and Levine (2010) reported that even one year with a teacher suffering from mathematics anxiety led to a decline in mathematics achievement, notably for female students. Chang and Beilock (2016) suggested that female teachers with mathematics anxiety inadvertently transmit their anxiety to the female students by endorsing stereotypes. Given the predominance of female teachers at elementary level this is not a small problem. The study carried out by Mizala et al.. (2015) reported that pre-service elementary teachers with mathematics anxiety had lower expectations for mathematics achievement and they extrapolated under-achievement in mathematics to general area achievement, but only for the female students. They felt that this affected a teacher's capacity to develop an inclusive learning environment. A more detailed comparison of gender differences in mathematics anxiety will be provided in Section 2.7.4.

The relationship between mathematics anxiety and the mathematics classroom-learning environment, despite generally being negative, provides an avenue for the reduction of mathematics anxiety (Chinn, 2008) via manipulation of the classroom-learning environment. Some studies have attempted to do just this. To reduce students' failure experiences, Jansen et al. (2013) used a computer adaptive program with elementary students. The program maintained the student success rate by adjusting the level of problems to match student ability. The study included a control group, in which children practiced mathematics as normal, and three experimental groups that experienced pre-set success rates. Results of the six-week trial included a decrease in mathematics anxiety for all groups, no change in perceived competence for any group, and an improvement in mathematics performance, but only for the experimental groups. A comparison of the results of the three experimental groups revealed that the higher the pre-set success rate, the more problems the students attempted and the greater their improvement in mathematics performance.

2.5.2 Mathematics Anxiety and Motivation

Mathematics anxiety is at its worst a debilitating affliction, but even at a low level it will influence a student's level of motivation to participate in the subject. As defined in this study, the motivation construct consists of three components: learning goal orientation, task value and self-efficacy. As discussed in Section 2.3, these components are intertwined when determining a student's level of motivation to be successful at mathematics. This section reviews past studies that have examined the impact of these components of mathematics anxiety on motivation.

Numerous studies have reported a negative relationship between mathematics anxiety and self-efficacy. For some studies, the relationships were negative and reciprocal but not necessarily equal (Akin, 2012; Goetz et al., 2010; Hembree, 1990; Hoffman, 2010; Jain & Dowson, 2009; Lee, 2009). For example, the path from self-concept to mathematics anxiety was found to be twice as strong as the path from mathematics anxiety to self-concept (see Ramirez et al., (2018). In other words, a decrease in self-concept would result in a more significant increase in mathematics anxiety than the other way round (Dowker et al., 2012). Findings also suggest that relationships between mathematics anxiety and self-efficacy behave cyclically, unless there is an intervention (Dowker et al., 2012). For example, a reduction in self-efficacy leads to an increase in mathematics anxiety, which, in turn, either directly or indirectly, by a drop in performance, contributes to a fall in self-efficacy and a subsequent increase in mathematics anxiety. Feedback from learning mathematics can be judgemental, as most problems tend to be either right or wrong. If students experience difficulty, they can easily become discouraged and fear failure (Ahmed et al., 2012), which exacerbates mathematics anxiety. Given that self-efficacy is a strong predictor of mathematics achievement, a reduction of self-efficacy caused by mathematics anxiety will negatively impact performance (Chinn, 2008; Hoffman, 2010). The degree of impact of negative outcomes on mathematics anxiety will depend on an individual's existing level of self-efficacy and performance (Chang & Beilock, 2016).

This literature review identified only a handful of studies that examined the relationships between mathematics anxiety, student learning goal orientation and task value. For learning goal orientation, only one study was located (see Chang & Beilock, 2016). The findings suggested that students with a learning goal orientation tend to attribute failure to a lack of effort rather than ability. Therefore, students with a learning goal orientation can deal with more failures before they risk developing mathematics anxiety or maladaptive strategies. Students with a high intrinsic value for mathematics tended to maintain their self-efficacy and effort (Furner & |Gonzalez-DeHass, 2011). Wang reported that intrinsic mathematics motivation moderates the relationship between mathematics anxiety and mathematics performance. For example, one study involving pre-service teachers found that teachers advocating the utility of mathematics might assist in circumventing the onset of mathematics anxiety (Wang, 2015) and prevent the depreciation of motivation levels.

2.5.3 Mathematics Anxiety and Self-Regulation

The problem of mathematics anxiety would appear to affect all aspects of learning mathematics. As Ramirez et al. (2018) suggested, both educators and researchers need to find ways to assist students in controlling the problem so they can reach their potential in mathematics. One way to overcome this could be the development of self-regulatory strategies. Findings suggest that students who have knowledge and skill in using adaptive self-regulatory strategies are better equipped to deal with negative results when learning mathematics than those without these tools (Jain & Dowson, 2009). Students who self-regulate are not as quick to view poor results as a reflection of their mathematics ability but tend to attribute them to a failure of the strategies they have employed (Zusho & Edwards, 2011). Following a negative outcome, these students can better analyse their tactics and effort and plan an alternative strategy (Ader & Erktin, 2010). The success of new cognitive or metacognitive strategies will determine whether the risk of mathematics anxiety has been avoided or merely delayed.

Past studies have examined the success of strategies to reduce the impact of mathematics anxiety. Such studies include reappraising pre-performance anxiety (Jamieson et al., 2010); focused breathing (Sullivan & McDonough, 2007); stimulating neural circuits involved in cognitive control (Brunyé et al., 2013); cognitive behaviour group therapy, relaxation training, acceptance and commitment therapy (Sarkar et al., 2014); and listening to sedative music and expressive writing (Zettle, 2003).

Self-regulatory strategies are not all focused on overcoming the problem in a positive manner. Avoidance is a natural reaction for students suffering from mathematics anxiety, who either have low self-efficacy, performance goals, or little knowledge or skill in adaptive self-regulation (Chang & Beilock, 2016). Avoidance may take the form of self-handicapping (Winne, 2015; Wolters & Benzon, 2013), in which the student makes little effort so that poor results are not attributed to a lack of ability. Any success achieved under these conditions will inflate the achievement. A student may even achieve a state of learned helplessness (Boekaerts, 1997; Rosenzweig & Wigfield, 2016), where they feel that no matter what they do, they will fail, so they stop participating. Some students adopt a pessimistic defensive strategy, which enables them to positively use their fear of failure. They may have low self-efficacy and expectations, but they use this as motivation to make an effort necessary to ensure that their fears are not realised (Garcia, 1995; Lee et al., 2014; Norem, 2008). Defensive pessimists remain pessimistic about future outcomes even when they have achieved the same level as more optimistic students. Elliot and Church (2003) reported that attempts to make defensive pessimists more optimistic resulted in poorer results. These maladaptive strategies inevitably add to the students' poor mathematics performance.

Many studies included in this review were carried out using pre-service teachers to either determine mathematics anxiety levels in future educators or determine the effectiveness of mathematics methods courses in increasing pre-service teachers' confidence to deliver a mathematics program without perpetuating their own anxieties. However, Ramirez et al. (2018) recommended that future mathematics anxiety research needs to include diverse populations. The current study takes up this challenge by examining the relationships between mathematics anxiety, mathematics learning environment, motivation, self-regulation and mathematics achievement for undergraduate students who are engineering students rather than pre-service teachers and determining whether these relationships differ according to gender (Section 2.7.4). Therefore, this study adds to the existing body of research on mathematics anxiety, as the population is unique, with its own set of circumstances and has not been investigated previously.

2.5.4 Instruments Developed to Measure Mathematics Anxiety

This section reviews the instruments designed to measure mathematics anxiety and justifies the selection of an instrument for use in this study. These instruments include the Mathematics Anxiety Rating Scale (MARS), Revised Mathematics Anxiety Rating Scale (RMARS), Mathematics Attitude Scale (MAS), Mathematics Anxiety Scale (MANX) and Revised Mathematics Anxiety Scale (R-MANX).

Richardson and Suinn (1972) developed the Mathematics Anxiety Rating Scale (MARS) comprising 98 items. Each item provides a brief description of everyday behavioural situations, suitable for students and non-students. Respondents' level of anxiety is measured using a 5-point rating scale ranging from 1 = not at all to 5 = very much. A Cronbach alpha coefficient of .97 indicated the instrument was reliable as there was a high level of inter-correlation between items. Later, Alexander and Martray (1989) developed the Revised Mathematics Anxiety Rating Scale (RMARS), an abbreviated version of MARS comprising 25 items. This instrument included three sub-scales: Numerical Task Anxiety, Mathematics Course Anxiety and Mathematics Test Anxiety. A study by Baloğlu and Koçak (2006) reported Cronbach alpha coefficients of 0.95, 0.87, and 0.88, respectively, for each sub-scale, indicating that RMARS maintained the reliability of the original instrument.

Fennema and Sherman (1976) developed the Mathematics Attitude Scale (MAS) for use with high school students. This comprehensive instrument includes nine scales, of which one assesses mathematics anxiety. The scale includes 12 items designed to measure feelings of anxiety related to mathematics, including dread and nervousness.

Items are responded to on a 5-point rating scale ranging from 1 = strongly disagree to 5 = strongly agree. Betz (1978) focused on mathematics anxiety using 10 of the 12 items from the mathematics anxiety scale of the MAS. Several items were rewritten to make them suitable for use at college level. Half of the items were positively worded, and the other half negatively worded. The negatively worded items were reverse scored. Betz reported an internal consistency coefficient of .92, indicating that the scale was sufficiently reliable to be studied in relation to other variables.

Erol (1989) developed the Mathematics Anxiety Survey (MANX), a 45-item survey. The items, which are responded to using a 4-point rating scale ranging from 1 = never to 4 = always, describe everyday life and academic situations that require mathematical thoughts or tasks. A study carried out by Erktin and Oner (1990) reported that MANX was highly reliable, with an internal consistency reliability coefficient of 0.91. Bursal and Paznokas (2006) later produced the Revised Mathematics Anxiety Scale (R-MANX) by reducing the MANX to 30 items and changing the response format to a 5-point rating scale ranging from 1 = almost never to 5 = almost always. They also negatively worded and reverse-scored seven of the 30 items. The internal consistency reliability coefficient for the R-MANX was reportedly 0.90, which was also highly reliable.

Students taking part in the study reported in this thesis were required to respond to instruments on perceptions of learning environment, motivation and self-regulation and mathematics anxiety. To reduce the likelihood of respondent fatigue, it was essential to limit the number of items. Therefore, the study used one of the abbreviated mathematics anxiety questionnaires, R-MANX, which contained only 30 items. More information about the survey and the reasons for its selection are provided in Chapter 3.

2.6 Mathematics Achievement

In education, student achievement is an assessment of progress against pre-determined standards or learning outcomes, which are part of the curriculum for a course (National Research Council, 1993). Mathematics achievement can be assessed in many ways, but the most predominant assessment tool is still a test or examination, despite the move towards more modern pedagogical practices. A student's level of achievement is important, as they will be judged by it. It may determine whether they are deemed capable of moving onto the next level of study or have the requisite skills to undertake a particular degree or do a particular job.

An instructor's ability to teach and motivate their students can be judged by the students' achievement in their classes (Schrader & Helmke, 2015). Achievement may determine whether an instructor is offered tenure or can successfully apply for other teaching positions. Administrators will use achievement to determine whether there has been a satisfactory return for the investment made. The stakes are high for all involved. Mathematics achievement results, such as PISA and Trends in International Mathematics and Science Study (TIMSS) have a strong impact on educational policy and research (Schrader & Helmke, 2015). A large body of research attempts to understand the impact of various factors on achievement (Schrader & Helmke, 2015).

This section reviews the literature that has examined the relationships between mathematics achievement and motivation, self-regulation, learning environment and mathematics anxiety. The order in which these variables are considered allows for the variables that have a more direct relationship to be considered first, as these direct relationships combine to form the more complex indirect relationships. Therefore, Section 2.6.1 reviews the literature that examines the relationships between motivation and achievement, Section 2.6.2 self-regulation and achievement, Section 2.6.3 learning environment and achievement, and Section 2.6.4 mathematics anxiety and achievement.

2.6.1 Motivation and Achievement

As outlined in Section 2.4, motivation in this study consists of learning goal orientation, task value and self-efficacy. These components of motivation not only interact with other variables but also influence each other. Although research has reported the relationship between motivation and achievement to be reciprocal (Grigg et al., 2018), this study has focused on the influence of motivation on achievement. The relationship in this direction supports the prospect of a motivational intervention to improve achievement. Section 2.6.1.1 reviews the influence of self-efficacy on achievement, Section 2.6.1.2 the influence of task value on achievement and Section 2.6.1.3 the influence of the learning goal orientation on achievement.

2.6.1.1 Self-Efficacy and Achievement

Self-efficacy is the belief a person has that they can complete a task. Several studies have reported self-efficacy as the strongest predictor of mathematics achievement (Arens et al., 2020; Holenstein et al., 2022; Grigg et al., 2018; Kalaycıoğlu, 2015; Lee et al., 2014; Yusuf, 2011) when compared with other factors. These factors include social-economic status and mathematics anxiety (Kalaycıoğlu, 2015; Zhang & Wang, 2020); achievement motivation (Yusuf, 2011); and self-regulated learning strategies (Lee et al., 2014; Yusuf, 2011). High levels of self-efficacy correlate to high levels of effort and persistence (Skaalvik et al., 2015). Self-efficacy is not a constant. It is in a continual state of flux with the assessment of new information provided to the learner (Bandura, 1989).

These studies found self-efficacy to predict achievement directly, but some also found indirect relationships via self-regulated learning strategies (Lee et al., 2014; Yusuf, 2011) and achievement motivation (Yusuf, 2011). The study by Kalaycıoğlu (2015) involved the PISA results of 8,806 students from England, Greece, Hong Kong, Netherlands, Turkey and the US. The study compared the relationships between self-efficacy, socio-economic status, mathematics anxiety and mathematics achievement. Self-efficacy was the most significant predictor of mathematics achievement in all six countries.

2.6.1.2 Task Value and Achievement

The second component of motivation examined in this study was task value. Task value includes the internal enjoyment a learner experiences simply by doing a task. It also includes utility value, which is the perceived usefulness of the task. Task value is an essential component of learning as this is what stirs a learner into action. A high level of self-efficacy may not necessarily translate into action unless the task is deemed worthwhile (Eccles & Wigfield, 2002).

Previous studies that have reported positive relationships between task value and achievement (Briley et al., 2009; Chiu & Xihua, 2008; Lee et al., 2014). For example, a study of 107,975 fifteen-year-olds, which compared their PISA test scores and questionnaire responses, reported that students scored higher when they had a greater interest in mathematics (Chiu & Xihua, 2008). Another study by Kriegbaum et al. (2014), involving 6,020 German students, reported that all motivation components contributed to the prediction of mathematics competence. However, the interest component only did so when self-regulation mediated the relationship. Other studies have supported the mediating effect of self-regulation on the relationship between task value and mathematics achievement (see Briley et al., 2009; Lee et al., 2014). This result is not unexpected given that task value is, by definition, what stirs an individual into action, whereas self-regulation provides the cognitive and metacognitive strategies required to act effectively.

Students do not judge all assessments as having the same value or importance. If an assessment is viewed to be of low importance, this can influence motivation and the subsequent level of achievement. Cole et al. (2008) compared task value (interest, usefulness and importance) with both effort and mathematics achievement in low stakes tests at university level in the US. The use of low stakes tests was significant in this study as it meant that there would be a greater range in students' perceptions of the usefulness and importance of the test. The results revealed that both usefulness and importance significantly predicted effort and achievement, meaning that students who perceive a test as useful and important work harder and achieve higher scores. In contrast, the effort of those students who do not attribute the same worth to the test suffers, as do their results.

Previous studies have indicated a positive relationship between task value and achievement. Students tend to place greater value on a task that they can do well (Wigfield, 1994). For tasks that they have low competence in, students may employ a coping strategy that involves devaluing the importance of the task, so that any failure will have less impact on their self-efficacy (Eccles & Wigfield, 2002).

2.6.1.3 Learning Goal Orientation and Achievement

Learning goal orientation was the third component of motivation to be assessed in this study. As discussed in Section 2.3.1, it is an overriding approach employed by a student during the learning process (Anderman & Gray, 2015). It provides purpose and direction. It is important because it contributes to the overall motivation level of the student and plays a role in whether that motivation level is likely to be maintained.

Research results concerning the impact of learning goal orientation on achievement have been varied. In some studies, learning goal orientation contributed to predicting mathematics competence, even after controlling for prior achievement and intelligence (see, e.g., Chen & Wong, 2015; Kriegbaum et al., 2014; Putwain et al., 2018; Ruishi et al., 2021). By contrast, other studies found that performance-approach and performance-avoidance goals did not predict mathematics performance directly (see Keys et al., 2012; Steinmayr & Spinath, 2009). Instead, learning goal orientation positively predicted self-regulation (deep processing), which, in turn, positively predicted mathematics achievement (Hutagalung et al., 2020). They also reported that performance-approach and performance-avoidance goals positively predicted self-regulation (surface processing) and that surface processing negatively predicted mathematics achievement. Studies by Keys et al. (2012) and Steinmayr and Spinath (2009) supported the positive relationship between learning goal orientation and mathematics achievement. Mixed results such as these are not surprising given the nature of performance goals. For some students, performance goals may not undermine their learning and may survive some failures. However, other students may have become victims of their failures and transitioned into maladaptive strategies to cope (Covington, 2000; Sommet & Elliot, 2017).

2.6.2 Self-Regulation and Achievement

Self-regulation (Section 2.4) is an adaptive process where the learner takes personal initiative to manage their learning process. They employ cognitive and metacognitive strategies to achieve predetermined goals. Students with self-regulation demonstrate perseverance, self-monitor their progress, adapt strategies and regulate their efforts to succeed (Zimmerman, 1990). Few learners will be expert self-regulators; however, most will self-regulate to some extent.

Self-regulatory skill and knowledge alone is not enough to guarantee academic success. The importance of self-regulation has already been highlighted above, as numerous studies have found that self-regulation mediated the relationship between self-efficacy and mathematics achievement and between task value and mathematics achievement. This section reviews the studies focused on the direct relationship between self-regulation and mathematics achievement.

Numerous studies report a positive correlation between self-regulation and achievement (see, e.g., Alotaibi, 2017; Brown et al., 2016; Hutagalung et al., 2020; Popa, 2015; Sahranavard et al., 2018; Sayedi et al., 2017; Schunk, 2017; Zimmerman & Kitsantas, 2014). These studies have covered all levels of education from elementary school (Sayedi et al., 2017; Schunk, 2017), to high school (Hutagalung et al., 2020; Popa, 2015; Tee et al., 2021; Zimmerman & Kitsantas, 2014) and university levels (Alotaibi, 2017; Altun & Erden, 2014; Brown et al., 2016; Nota et al., 2004; Sahranavard et al., 2018). The studies found different aspects of self-regulation to positively predict achievement, including organising and transforming (Nota et al., 2004); time and study environment, and help seeking (Alotaibi, 2017;Altun & Erden, 2014); self-monitoring (Nett et al., 2012; Schunk, 2017); and deep processing (Azar et al., 2010). Although the focus has tended to be on improving achievement, not all self-regulatory strategies do so. For example, Azar et al. (2010) found that the surface approach negatively predicts achievement.

The overwhelming evidence in studies such as those described above has provided a general acceptance that effective use of self-regulatory strategies can improve achievement outcomes. The degree of improvement that is possible is dependent on many factors, not least the motivation to use the strategies available. However, it may be substantial, as shown by Nota et al. (2004), who reported that 80% of the variation in first- and second-year university grades could be attributed to organising and transforming. These results have provided a mandate for other researchers to devise and test self-regulatory interventions geared explicitly towards increasing achievement. Examples of these interventions can be found at elementary (Perels et al., 2009), high school (Cleary & Platten, 2013) and university (Brown et al., 2016) levels. The interventions included general self-regulatory strategies (Perels et al., 2009); detailed feedback (Brown et al., 2016); and a Self-Regulation Empowerment Programme (Cleary & Platten, 2013). All of these studies reported that their interventions had been successful in improving achievement; however, the need for sufficient motivation to be present to use the strategies was also cautioned (Brown et al., 2016; Cleary & Platten, 2013).

By its very definition, self-regulation has a reciprocal relationship with achievement. The self-monitoring aspect of the self-regulatory process involves using available feedback, including assessments results, to provide direction for future strategy implementation. Pintrich and de Groot (1990) confirmed this in their study, which reported that achievement was positively associated with self-efficacy and self-monitoring when mediated by self-efficacy; however, adverse achievement outcomes reduced self-efficacy and subsequent self-monitoring.

2.6.3 Learning Environment and Achievement

The relationship between students' perception of the learning environment and achievement was reviewed in Section 2.3. This section summarises this research and considers the reciprocal nature of the relationship.

Fraser & Kahle (2007) stressed the importance of the learning environment, finding that the classroom, peer and home environments were all positively associated with attitude. However, only the classroom environment was positively associated with achievement. Studies that have reported a relationship between learning environment and achievement have done so differently. In some studies, it was reported that students' perception of the learning environment was a positive predictor of achievement (see, e.g., Chionh & Fraser, 2009; Cohn & Fraser, 2016; Fisher, Henderson, & Fraser, 1997; Fraser, Aldridge, & Adolphe, 2010; Fraser & Kahle, 2007; Goh & Fraser, 1998; Robinson & Fraser, 2013; Stronge, Grant, & Xu, 2015; Teh & Fraser, 1995). In other studies, the relationship between learning environment and achievement was mediated by motivation (see, e.g., Fast et al., 2010; Peters, 2013;

Winheller et al., 2013), or by self-regulation (see, e.g., Bembenutty, 2011b; Brown et al., 2016; Cleary & Platten, 2013; Perels et al., 2009).

As learning environment research has expanded, researchers have investigated the influence of learning environment on achievement. Establishing this relationship was important as it provided educators with the evidence needed to improve achievement through interventions that manipulated the learning environment to provide students with a learning environment that they perceived more favourably. These studies differed in terms of the type of learning environment and the aspects or scales of the learning environment.

Not all studies reported a direct relationship between learning environment and achievement. Some studies reported the relationship to be mediated by motivation and self-regulation. Those studies which reported that the influence of the learning environment on achievement is mediated by motivation found this relationship to be mediated by self-efficacy (see, e.g., Fast et al., 2010; Tosto et al., 2016; Winheller et al., 2013) and task value (see, e.g., Tosto et al., 2016; Winheller et al., 2013). Aspects of the learning environment positively associated with self-efficacy were caring, challenging and mastery orientated (Fast et al., 2010). Other aspects of the learning environment were positively associated with both self-efficacy and task value. For example, quality of teaching (Winheller et al., 2013) and favourable inter-personal relationships (Tosto et al., 2016) were found to be connected to confidence in and a liking for mathematics (Winheller et al., 2013) and mathematics self-efficacy, academic self-concept and mathematics interest. Studies reporting the mediating effect of self-regulation on the relationship between learning environment and mathematics achievement did so for feedback (Brown et al., 2016) and delayed gratification (Bembenutty, 2011a).

All of these studies reported an indirect relationship between learning environment and achievement. They reported aspects of the learning environment that were positively associated with either motivation (self-efficacy or task value) or self-regulation, followed by motivation or self-regulation having a positive association with mathematics achievement. The current study extends on the research reported above as it considers learning environment and mathematics achievement as part of a larger model. This larger model includes motivation, self-regulation, mathematics anxiety and mathematics achievement. The benefit of a larger model is that it can analyse the relationships between constructs simultaneously rather than in isolation, as is the case with many studies.

2.6.4 Mathematics Anxiety and Mathematics Achievement

Mathematics anxiety has been described in detail in Section 2.6. Although the relationship between mathematics achievement and mathematics anxiety is reciprocal, this section focuses on the hypothesised relationship, which is the influence of mathematics anxiety on mathematics achievement. Gender differences in mathematics anxiety are reviewed in Section 2.8.4.

The extent to which mathematics anxiety affects mathematics students has been widely debated but it is generally accepted that the problem is significant. The negative impact of mathematics anxiety on mathematics achievement has been reported in numerous studies (see, e.g., Ader & Erktin, 2010; Al Mutawah, 2015; Kalaycıoğlu, 2015; Núñez-Peña et al., 2013; Pletzer et al., 2015; Pourmoslemi et al., 2013; Wu et al., 2012). These studies consistently report a negative relationship between mathematics anxiety and mathematics achievement, despite the diverse populations studied. In one large-scale study extending across different countries (England, Greece, Hong Kong, the Netherlands, Turkey and the US), the 2012 PISA results were analysed using structural equations modelling for each country (Kalaycıoğlu, 2015). The results revealed statistically significant relationships between mathematics anxiety and mathematics achievement in countries with low mathematics achievement (such as Greece, Turkey and the US). In another study, which involved university students in Iran, strong relationships between high mathematics anxiety and low mathematics achievement were found (Pourmoslemi et al., 2013). Interestingly, this study also found that the highest levels of mathematics anxiety were reported by students with scores near the pass grade.

Other studies have reported that a high level of mathematics anxiety does not automatically equate to low mathematics achievement (Chang & Beilock, 2016; Lee, 2009). Lee (2009) found that many factors influence mathematics achievement and mathematics anxiety was only one of them. The study found that students from Asian countries such as Korea and Japan had high levels of mathematics anxiety despite a high level of achievement. In contrast, students from Western countries such as Finland, the Netherlands, Liechtenstein and Switzerland followed a more predictable pattern, with high levels of achievement being more closely related to low levels of mathematics anxiety.

Previous research has found that mathematics anxiety and mathematics achievement have a reciprocal relationship (see Carey et al., 2016; Chang & Beilock, 2016). That is, not only does mathematics anxiety impair mathematics performance, but poor mathematics achievement can also increase mathematics anxiety in future mathematical activities. Under certain conditions, this cycle may continue unabated in a downward spiral unless interrupted by an appropriate intervention (Carey et al., 2016).

This section has reviewed variables that impact mathematics achievement. The impact of motivation, self-regulation, learning environment and mathematics anxiety have all been discussed. Each of these variables has been shown to influence mathematics achievement. These variables influence achievement directly, but they also interact with each other to produce an indirect influence. The relationships are domain-specific and, therefore, complex. Ramirez et al. (2018) acknowledged the need to increase the body of research by studying diverse populations to gain a greater understanding of how the variables impact achievement. In the future, the results of these studies may be used to maximise achievement. This study involves a population with a unique combination of cultural, historical and economic characteristics that has received very little attention.

2.7 **Gender Differences**

Society has long been concerned with providing equal opportunities for various groups based on gender, ethnicity and socio-economic status. To do this, first it has to be established whether a group is disadvantaged and then affirmative action taken to narrow the gap with other groups (Abdulla & Ridge, 2011; Ridge, 2010). Education in the UAE is predominantly single-sex, although this is beginning to change in the early primary and tertiary levels of education. Culture also dictates the different levels of freedom and expectations experienced on male and female students outside the formal learning environment. In the UAE, the experiences that define each gender occur a lot more independently than they would in most other countries (Profanter, 2011).

This section reviews previous studies related to gender differences for the variables pertinent to this study: learning environment (Section 2.7.1), motivation (Section 2.7.2), self-regulation (Section 2.7.3), mathematics anxiety (Section 2.7.4) and mathematics achievement (Section 2.7.5). Research in this area has been described as complex, multi-dimensional and having conflicting results (Hogrebe, 1987; Lang, 2009); however, what is indisputable is that overall fewer women are choosing to pursue STEM-based careers than men (Stoet et al., 2016), despite efforts to reduce the imbalance.

2.7.1 Learning Environment and Gender Differences

In Section 2.2, numerous studies were cited which supported the idea that students' perception of the learning environment was positively associated with both the students' attitudes and achievement (Fraser & Kahle, 2007; Koul et al., 2018; Lim & Fraser, 2018; Majeed et al., 2002; Robinson & Fraser, 2013; Winheller et al., 2013). This section reviews the differences between male and female students' perceptions of the learning environment, which is an important issue for those concerned with gender differences in educational outcomes and the provision of equal opportunities for both male and female students. Given numerous studies support the positive relationship between learning environment and student outcomes, it becomes especially important that the type of learning provided does not favour one gender over the other, but rather optimises the opportunities provided to both genders.

Some research has been carried out specifically to determine whether gender differences in students' perception of the learning environment exist, whereas others have considered this question as part of a larger study. Although the results have varied considerably, the vast majority of studies have found that female students perceive the learning environment more positively than male students. Female students have been found to view the student–teacher interaction more positively (Goh et al., 1995; Levy et al., 2003; Quek et al., 2005); perceive the teacher to be more understanding, helpful and friendly and less uncertain, dissatisfied, and admonishing (Goh et al., 1995; Levy et al., 2003); and report higher levels of task orientation and teacher support (Telli, Sibel, den Brok Perry, 2009; Waxman & Huang, 1998), involvement, affiliation, rule clarity (Huang, 2003; Waxman & Huang, 1998), expectation, investigation and cooperation, order and organisation, satisfaction, student aspirations (Waxman & Huang, 1998), equity (Telli et al., 2010), integration and rules cohesion (De Juan et al., 2016).

Contrary to the studies above, a smaller number of studies have found that male students perceived the learning environment more favourably. In these studies, male students perceived higher levels of cohesion and competitiveness (Majeed et al., 2002), teacher support, involvement, investigation, task orientation, and equity (Kim et al., 2000), and higher levels of group work and greater involvement (Samuelsson & Samuelsson, 2016). Male students also perceived more positive teacher behaviour, such as leadership, helpful and friendly, understanding, and student responsibility, and lower levels of more negative teacher behaviour, such as dissatisfied and admonishing, and strict (Kim et al., 2000). Given that participants were drawn from single-sex schools and data collection was administered by the local teachers, it is possible that student views may not have been provided without influence. It should also be noted that a number of studies have found gender differences in perception of the learning environment to be either insignificant or minimal (Chipangura & Aldridge, 2017; Dhindsa & Fraser, 2004; Henderson & Fisher, 2008; Khine et al., 2018).

The studies investigating gender differences in students' perception of the learning environment, which have been cited above, have reported a variety of results. This variation is unsurprising as each study is reporting perceptions of a unique learning environment, by a unique group of students. Two important points gained from reviewing these studies are that the majority of studies reported that female students had a more positive perception of their learning environment and that male and female students may not perceive the same learning environment in the same manner, as students' perception of the learning environment was gender-dependent and domain-specific and reflected social roles, values and beliefs (Koul et al., 2012).

The difficulty in generalising these results indicates the dangers of attempting to do so for the current study, in which Emirati students were attending single-sex, university-level mathematics classes. There was no expectation that the male and female learning environments would be the same. The interest was in whether one gender would perceive their learning environment more positively than the other perceived theirs. This information is important at this time in the UAE as the structure of its educational institutions is changing. Primary and secondary school education has traditionally been single-sex, but there is now a move towards co-education. Following an amalgamation, the university involved in this study is gradually reducing the number of classes at its single-sex campuses

2.7.2 Gender Differences in Motivation

The review in Section 2.3 examined how the three motivation constructs used in this study (learning goal orientation, task value and self-efficacy) interact with each other and their impact on affective and cognitive student outcomes. This section builds on the earlier review by considering the impact of gender on how these constructs interact and how they influence student outcomes.

2.7.2.1 Learning Goal Orientation

Few studies have been carried out to determine whether gender differences exist in the uptake of the various types of goal orientation. Of those that have, most have reported that female students are more likely to use a learning goal orientation and male students a performance-approach goal orientation (D'Lima et al., 2014; Middleton & Midgley, 1997; Pajares & Valiante, 2001), or even a performance-avoidance goal orientation (Koul et al., 2012). Not all studies revealed gender differences in goal orientation. For example, Brown and Kanyongo (2010) found no gender difference when comparing the goal orientations of 545 elementary school students from Trinidad and Tobago; however, the study involved very young students and low level goals.

2.7.2.2 Task Value

A number of studies have focused on establishing whether gender is a mediator of the level and type of task value that students assign to various tasks, how these values may change over time, and the impact any differences may have on future participation in mathematics. Studies carried out in a variety of contexts have consistently found that male students are more intrinsically motivated and female students more extrinsically motivated (Chipangura & Aldridge, 2017; D'Lima et al., 2014). Meece et al. (2006) surmised that causal attributions relating to competency, value and self-efficacy were domain specific. In this case, male students had more positive beliefs in mathematics, science and sport, whereas female students had more positive beliefs in language, arts and reading. Watt (2004) also reported that intrinsic and utility values favoured male students for mathematics and female students for English. In contrast, Guo et al. (2015) found that male and female students had similar values under certain conditions.

The value assigned to a task is not a constant, as it can change over time. A number of studies have focused on this aspect of task value assignment These studies consistently showed that students' subject-related values declined after students reached adolescence (Eccles et al., 1993; Frenzel et al., 2010; Ganley & Lubienski, 2016; Jacobs et al., 2002; Watt, 2006, 2008), or in some cases during the entire period of primary and secondary school (Jacobs et al., 2002). Despite the decline in intrinsic value assigned to tasks (Frenzel et al., 2010; Watt, 2008) by both male and female students, the trajectory for male students remained higher than that of female students for mathematics and higher for female students for English (Watt, 2008). These results are consistent with the view that individuals place a higher value on a task they believe they can do well (Wigfield, 1994) and that they may lower the value of a task they cannot do well (Eccles et al., 1993).

Gender differences in task value may be a factor in the imbalance between the numbers of male and female students enrolling in mathematics courses at senior secondary school level and having mathematics-related career aspirations (Watt, 2006). As a result of stereotype threat (Franceschini et al., 2014), female students may perceive mathematics to be more difficult than male students do and as a result, female students have lower mathematics self-competency beliefs and intrinsic value for mathematics, higher school participation rates, lower utility value, and lower mathematics-related career aspirations (Watt, 2006). Watt also found that female students with high utility values for mathematics tended to have high mathematics-related career aspirations. However, male students with moderate to high utility value for mathematics also reported high mathematics-related career aspirations.

Given the gender imbalance in high school participation rates in mathematics and mathematics-related career aspirations, it has been recommended that action is taken to reduce the decline in utility value experienced by female students (Gaspard et al., 2015; Watt, 2006).

2.7.2.3 Self-Efficacy

Numerous studies have found that male students report higher self-efficacy for mathematics and science than female students (Diseth et al., 2014; Ganley & Lubienski, 2016; Goetz et al., 2013; Huang, 2013; Peters, 2013; Sullivan & McDonough, 2007; Yerdelen-Damar & Peşman, 2013). As with task value, the difference in self-efficacy was found to exist even when male students did not achieve at a higher level than female students (Diseth et al., 2014; Else-Quest et al., 2010; Peters, 2013; Yerdelen-Damar & Peşman, 2013). By contrast, female students were found to report higher levels of self-efficacy than male students for language and arts (Bandura et al., 2001; Watt, 2004), and other studies have reported no gender difference in levels of self-efficacy (Guo et al., 2015; Lundeberg et al., 2000; Schnell et al., 2015).

It has been suggested that stereotype threat may explain why female students frequently have lower mathematics self-efficacy than male students (Felson & Trudeau, 1991; Franceschini et al., 2014). Findings suggest that as part of the socialisation process, female students hear from numerous sources that they are less capable at mathematics than male students (Bandura, 2001). Further, female students are also subject to lower expectations and goals in mathematics and receive less support than male students (Agger & Meece, 2015). Combined with the over-confidence shown by male students, stereotyping encourages female students to ignore comparative results and believe that they are not as good at mathematics as male students. For example, in a study of female university-level students enrolled in an introductory statistics course, students completed measures to assess implicit mathematics stereotyping, mathematics self-efficacy and mathematics achievement (Franceschini et al., 2014). The study examined differences between two groups, one that experienced a stereotype threat (that is, they were informed that the test had been used to show that female students were less able than male students); and the other experienced a stereotype lift (that is, they were informed that the test had previously been used to show that female students were more able than male students). The results revealed that only female students with implicit mathematics gender stereotyping were sensitive to the threat–lift manipulations, whereas those with weak stereotypes were not. Aronson et al. (1999) showed that stereotype threat is not restricted to female students. The study involved telling one group of white male students, for whom no stereotype of low ability exists, that the mathematics test they were about to take had been used to show that Asian male students excelled in mathematics compared with white male students. The results demonstrated that the white male students who experienced the stereotype threat performed worse than the white male control group, who experience no stereotype threat.

Thiessen (2007) suggested that a second contributor to low female mathematics self-efficacy could be the different way in which female students assess their ability in the subject. A study of more than 23,000 Canadian adolescents revealed that the female students judged their ability in a subject relative to their results in other subjects. Since they generally achieve at a higher level in languages, they consider themselves less able in mathematics and sciences. On the other hand, the male students tended to overestimate their ability in a subject by using only their highest marks as an indicator of their ability.

The constructs that make up motivational beliefs have a definite impact on students' participation and mathematics achievement and their intentions to pursue mathematics-related careers. Even though any historical gender imbalance in mathematics achievement has disappeared over the past three decades, there remains an imbalance in the numbers of female students compared with male students electing to study mathematics at higher levels and seek employment in associated careers. Agger and Meece (2015) suggested that it is essential to continue studying domain-specific motivational processes over a wide range of groups to understand and address these continued disparities. The current study is adding to this pool by contributing information about the motivational beliefs of university-level mathematics students, a group of students that has received little attention to date.

2.7.3 Gender Differences in Self-Regulation

As described in section 2.4, self-regulation is a multi-component, iterative, self-steering process. Individuals set goals, use cognitive and metacognitive strategies, monitor progress and make necessary adjustments. This section focuses on how male and female students use self-regulation as part of their learning process.

Gender differences in the self-regulatory process have been reported in several studies. Generally, findings suggest that, when compared with male students, female students gain more benefits from the process (Bandura, 2001; Bembenutty, 2007; Duckworth & Seligman, 2006) by applying higher level planning, study management, learning focus and persistence (Martin et al., 2013), and effort regulation; and more frequent use of rehearsal and organisation strategies (Bembenutty, 2007), goal setting, use of planning strategies, record keeping, self-monitoring and structuring the environment to optimise learning (Zimmerman et al., 1992), attentional and emotional regulation (Williams et al., 2016), internal locus of control, time management, self-testing, concentration, information processing and selecting main ideas (Ghazvini & Khajehpour, 2011). Some studies did report male students' use of positive self-regulatory strategies, external locus of control, and use of study aids and test strategies (Ghazvini & Khajehpour, 2011). However, male students frequently applied negative maladaptive strategies such as self-sabotage and self-handicapping (Martin, 2004). Bonneville-Roussy et al. (2017) found that these disengagement coping strategies were detrimental to male students and explained a significant amount of variation in outcomes.

Unfortunately, greater use of self-monitoring and self-judgement strategies does not always prove to be beneficial to female students. Female students tend to set themselves higher academic standards, which if not attained dissuade them from continued participation in a subject. Concannon and Lloyd (2010) revealed that male students had a higher intention to persist because they based their decision on their ability to complete the coursework, whereas female students' intentions to persist were guided by their beliefs of their ability to achieve good grades.

The positive association between self-regulation and achievement supports the importance of self-regulation to the learning process (Altun & Erden, 2014; Duckworth & Seligman, 2006). Weis et al. (2013) add support to this argument by reporting that female students displayed a higher level of behaviour regulation and that behaviour regulation had a positive association with achievement.

2.7.4 Gender Differences in Mathematics Anxiety

Mathematics anxiety is a feeling of tension when dealing with numerical problems. As described in Section 2.6, mathematics anxiety includes cognitive and affective components. The cognitive component is concerned with performance and consequences of failure, whereas the affective component is concerned with nervousness in testing situations. There are degrees of mathematics anxiety, but at the upper end, it can be debilitating (Hill et al., 2016). The literature reviewed in Section 2.7.4 supported a negative impact of students' mathematics anxiety on their mathematics achievement and the desire for them to continue studying mathematics in the future. This section considers how mathematics anxiety may affect male and female students differently and if it does, what the consequences of these differences might be.

There is considerable research to support the view that females suffer more from mathematics anxiety than males (Else-Quest et al., 2010; Hill et al., 2016; McLean et al., 2011; Moore, 2010; Park & French, 2013; Stoet et al., 2016), with McLean et al. (2011) reporting that women consistently have a higher prevalence of all types of anxiety disorders than men. A number of studies, analysing large sets of data, revealed how widespread the problem was by confirming that female students have higher mathematics anxiety than male students in many countries and at a variety of different levels of education. Stoet et al. (2016) meta-analysis of 2003 and 2012 PISA data for 761,655 15-year-old students from 68 countries found that female students generally experience higher mathematics anxiety. Interestingly, this study found that even in countries with high gender equality, the level of mathematics anxiety is lower overall but the difference between the genders is greater because mathematics anxiety in males decreases more than for females. Else-Quest et al. (2010) used 2003 TIMSS data for 493,495 middle and high school students from 69 different countries to produce similar findings.

A smaller number of studies reported mixed results. Keshavarzi and Ahmadi (2013) reported no overall gender difference in mathematics anxiety; however, female students exhibited more anxiety in both problem solving and evaluation, whereas male students experienced more anxiety through the teacher. It should be noted that in this study, the participants were grade 2 and 3 students from single-sex schools. The study used a broad definition of anxiety, which included anxiety through the teacher. Given the lower level of behaviour regulation exhibited by male students (see Section 2.7.3), this type of anxiety was more likely to be experienced by male students. Female students still experienced higher levels of anxiety in the more commonly examined aspects of anxiety.

The age at which the onset of mathematics anxiety begins depends on the aspects of the construct that are assessed. A study by Van Mier, Schleepen and Van den Berg (2019) with grade 2–4 students found that mathematics anxiety exists in young children and that the level of anxiety was the same for male and female students. Mathematics anxiety negatively moderated mathematics performance, but only for female students, and was greatest at grade 2. A wealth of research indicates that female students suffer more from mathematics anxiety; it can start at a young age; and for female students, especially once they have mathematics anxiety, it is difficult to overcome. A longitudinal study with grade 7–12 students by Ma and Xu (2004) revealed that the stability effect, which enabled mathematics anxiety to be passed from year to year, was significantly higher for female students and that it occurred regardless of their performance. Jameson and Fusco (2014) found that adults have lower mathematics self-efficacy and even higher mathematics anxiety levels. Park and French (2013) reported that female students even had higher anxiety in subjects they had a history of performing well in, such as foreign languages.

As noted in Section 2.6, students with lower mathematics self-efficacy or self-concept were more susceptible to mathematics anxiety. Earlier in this section, evidence supported female students having lower self-efficacy; therefore, they have higher mathematics anxiety than male students (Devine et al., 2012). The reasons for female students having lower self-efficacy, which were discussed earlier, include stereotype threat (Ding et al., 2006; Dowker et al., 2016; Beilock et al., 2007) and the fact that female students assess their ability in a subject relative to their ability in other subjects (Thiessen, 2007).

2.7.5 Gender Differences in Mathematics Achievement

Historically mathematics achievement may have favoured male students, but this trend has changed over the last 30 years. Today, some studies show that female students are achieving at a higher level in mathematics than male students (Ding et al., 2006; Guo et al., 2015; Voyer & Voyer, 2014), and some show that male students are achieving at a higher level than female students (Geist & King, 2005; Irwing & Lynn, 2005; Goh & Fraser, 1998). In some cases, findings show a parity between male and female students' mathematics achievement (Hyde & Mertz, 2009;(Lindberg et al., 2010) Lindberg et al., 2010). A large scale study using TIMSS data (e.g., Guo et al., 2015) found that female students had higher mathematics achievement and educational aspirations. This study was supported by Voyer and Voyer (2014), whose meta-analysis of 369 studies involving school students found that the reported female advantage extended to most subjects, including mathematics. On the other hand, Geist & King (2005) analysed the National Assessment of Educational Progress data for 2005 to reveal that on average, male students were achieving about two points higher than female students.

A number of studies have reported no gender difference in mathematics achievement. Lindberg et al (2010) carried out a meta-analysis of 242 studies on mathematics achievement from 1990 to 2007, which covered 1,286,350 students, and reported no gender difference in either mean or variation.

Detailed analysis of assessment questions revealed that gender differences in mathematics achievement may depend on the types of questions (Liu & Wilson, 2009;

Louis & Mistele, 2012). Liu and Wilson (2009) analysed gender differences in the various types of questions in the 2000 and 2003 PISA data to report that male students scored higher on the complex multiple-choice and space and time items, but there was no gender difference in the standard multiple-choice items. Louis and Mistele (2012) did the same type of analysis for the 2007 TIMSS assessment and they found that female students performed better in algebra and male students performed better in the remaining mathematics topics.

To understand the gender differences in mathematics achievement in the region in which the current study was carried out required a review of the 2019 TIMSS data. The report detailed the gender differences in both grade 4 and grade 8 students' mathematics achievement in the UAE. At grade 4 level, 50% of the respondents were male and 50% were female. The difference between the average male and female mathematics scores was not statistically significant. At grade 8 level, 52% of the respondents were male and 48% were female. The difference between the average male and female mathematics scores was not statistically significant.

In summary, the results of the studies reporting gender differences in students' perception of the learning environment, motivation, self-regulation, mathematics anxiety and mathematics achievement are mixed. However, there is strong support for several generalisations. Female students report a preference for a learning goal orientation, extrinsic value for mathematics and lower self-efficacy in the subject. They are more successful in the use of self-regulatory strategies. Due to their low level of self-efficacy, female students are more likely to suffer from mathematics anxiety. On the other hand, male students reported a higher preference for performance goals, intrinsic value for mathematics and higher levels of mathematics self-efficacy, but lower uptake on self-regulatory strategies, or even a tendency towards maladaptive strategies. Due to their higher level of self-efficacy, male students are less likely to report mathematics anxiety.

In Section 2.2, numerous studies reported the positive association between the perception of the learning environment and mathematics attitudes and mathematics achievement. This section also reported gender differences in students' perception of the learning environment, with just as many studies reporting the male perception to be more positive as those reporting the female perception as more positive. Although these results appear inconsistent, they highlight the need to consider male and female students separately when attempting to optimise the learning environment and subsequent levels of achievement. The studies that compared gender differences in mathematics achievement also provided mixed results, which indicated that no one gender is naturally "better" at mathematics, but rather it is dependent on other mitigating factors.

The literature referenced above indicates the differences between genders, but there is still a need to gather data that considers a broader context. As mentioned in the introduction to this section, this study provides information about a context that has received little attention. This study contributes to this area.

2.8 **Summary**

Social cognitive theory was drawn upon for the development of the research model used in this study. Social cognitive theory contends that reciprocal relationships exist between the environment (classroom learning environment), personal influences (motivation and mathematics anxiety) and behaviour (self-regulation). Social cognitive theory has provided the framework for considerable research in an educational setting. The research in this study considered all of the hypothesised relationships between learning environment, motivation, mathematics anxiety and self-regulation as well as the relationships between these factors and mathematics achievement. Understanding these interactions is important as it offers the opportunity to manipulate the factors, particularly the learning environment, to increase the effectiveness of mathematics education.

Learning environment research has consistently established a link between learning environment and affective and cognitive student outcomes. Students who report a more favourable perception of the learning environment also report higher self-efficacy, self-concept and achievement levels. This relationship has been confirmed in different contexts and within various learning environments, levels, subjects and countries. Studies have consistently reported direct relationships between learning environment and affective outcomes such as self-efficacy and subject interest, and an indirect relationship between learning environment and achievement, which has been mediated by these affective outcomes. Bandura's (1986) social cognitive theory states that students are active participants in their environment. The current study considers gender differences in the relationships between mathematics learning environment and motivation, self-regulation, mathematics anxiety and mathematics achievement. Since education in the UAE is single-sex, the learning environments reported by male and female students will not be different perceptions of the same environment, but rather reports of specific male and female learning environments. Having been an educator in the UAE for more than a decade, it is apparent that these learning environments are not the same at either high school or university levels. This study will compare male and female student perceptions of their learning environments and the differences in the relationships with the other factors. This information is important as consideration is given to a move towards co-educational education.

Motivation instigates and sustains engagement in an activity. In an educational setting, high levels of motivation have been associated with three components: learning goal orientation, self-efficacy and task value. Learning goal orientation provides the structure and direction for the learner. They aim to master an activity by demonstrating incremental improvement. Students with learning goal orientation choose challenging tasks and continuously look for ways to improve, including using higher-level self-regulatory strategies. Most importantly, they view failure as the result of lack of effort rather than lack of ability, which enables them to maintain self-efficacy and continue their learning process for longer, even in negative achievement feedback. Self-efficacy is a student's belief that they can be successful and is specific to a particular task. The most important contributor to self-efficacy is mastery experience, which occurs when a student has previously been successful in a particular or similar task. Vicarious experience gained by viewing others complete tasks is also important, especially when the observations involve participants considered to be equals. Positive information provided by social groups, such as class, family or community, act as a form of social persuasion to add to self-efficacy beliefs. The third component of motivation is task value. Even with a learning goal orientation and a high level of self-efficacy, task value is required for action to occur. Task value includes attainment, intrinsic, utility and cost components. Motivation is an integral part of any learning process. However, little research has been carried out on mathematics education at the university level and none in the UAE. This study looked to understand the role motivation played in this unique context and how motivation differed for male and female students.

Self-regulation is a multi-component, iterative, self-steering process that targets cognition, feelings and actions. Positive self-regulatory actions involve setting goals, employment of cognitive and metacognitive strategies, self-monitoring of progress, perseverance and adaptive skills. Research has pointed out that knowledge of self-regulatory strategies is not enough and that students also require a high level of motivation, as mentioned above. Research has reported that the learning environment can influence the uptake of self-regulation, either directly or indirectly through motivation. It also reports that the use of self-regulatory activities directly impacts achievement. These relationships provide an avenue for improving mathematics achievement by teaching self-regulatory skills. It is necessary to understand the level of self-regulation present to do this. No research has been carried out on self-regulation in the context covered in this study. This study looked to fill this gap.

Mathematics anxiety is the feeling of tension or helplessness when faced with numerical calculations. The nature of the subject means that students are frequently subjected to failure. Research has consistently reported the negative affect of mathematics anxiety on mathematics achievement. Research reporting the size of the problem has been inconsistent due to the variety of contexts and definitions used. However, there is a consensus that the problem is significant. The impact can be seen as large numbers of students opt out of mathematics courses when the demand for such skills is increasing. The learning environment is a prime determinant of mathematics anxiety. When the learning environment is caring, challenging, goal-oriented and self-regulatory aware, students are better equipped to deal with the negative emotions associated with mathematics anxiety. Given that mathematics anxiety has relationships with learning environment, motivation, self-regulation and mathematics achievement, a more complete picture can be achieved with its inclusion in the research model used by the research reported in this study.

Mathematics achievement is important as it is used to assess students, instructors and programs. Results can have an impact on educational policy and research. Research has reported that mathematics achievement influences and is influenced by motivation, self-regulation and mathematics anxiety. Motivation has consistently been shown to be positively associated with achievement levels, including self-efficacy, both directly and indirectly through self-regulation; utility directly and interest indirectly through self-regulation; and learning goal orientation indirectly through self-efficacy. The association between learning environment and mathematics achievement has been reported to be direct or mediated by motivation and self-regulation. As mentioned above, mathematics anxiety has been reported to have a negative effect on mathematics achievement. A number of these relationships are reciprocal. Given the wide-ranging influence of mathematics achievement on the educational process, it was included in the research model used in the current study.

Gender differences in mathematics education have been the focus of numerous studies, with many generalisations being consistently supported. Female students are more likely to have a learning goal orientation and male students a performance goal orientation. Male students report a higher intrinsic value for mathematics, which is reflected in the numbers of male students enrolling in higher-level mathematics courses. Male students tend to possess more positive beliefs in their mathematics ability even though their achievement levels are frequently lower than for female students, whereas female students tend to be more confident in arts and languages. The most common explanation for this difference is stereotype threat, which is a form of social persuasion. Female students hear from many different sources, from an early age, that male students are better at mathematics. Another explanation is that the female students make a relative comparison with their other subjects, which they are achieving even better in. Female students are more likely to employ positive self-regulatory practices, such as effort regulation, rehearsal and engagement. In contrast, male students are more likely to use maladaptive strategies, such as self-handicapping and disengagement coping strategies. The research reported in this study focuses on gender differences in a unique context. Education in the UAE has historically been single-sex, even at university level. Unlike other countries, the educational system in the UAE produces university graduates of whom 70% are female, including over 58% of all STEM graduates. Gathering information that can assist in explaining this anomaly is important as the country looks to transition into co-educational education.

Chapter 3

RESEARCH METHODS

3.1 Introduction

The literature review, presented in Chapter 2, detailed the theoretical framework that guides this study. This chapter describes the practical issues involved in the planning and carrying out of the research described in this thesis using the following headings.

- Research design (Section 3.2)
- Research model (Section 3.3)
- Research objectives (Section 3.4)
- Sample (Section 3.5)
- Data collection (Section 3.6)
- Data analysis (Section 3.7)
- Ethical considerations (Section 3.8).

3.2 Research Design

The research reported in this study used both explanatory correlational and causal-comparative designs (Cresswell, 2012; Mertler, 2016) The first stage of the research involved an explanatory correlational design in developing the research model, which required hypothesising and evaluating links between the constructs included in the study. If analyses established correlations, they were described in terms of strength and direction.

The second stage of the analysis involved a causal-comparative design in determining whether there were gender differences in the students' perceptions of the mathematics learning environment, their reported levels of motivation, self-regulation and mathematics anxiety, and their level of mathematics achievement. This method was also used to determine whether relationships between these constructs differed for male and female students.

3.3 Research Model

One of the goals of this study was to examine whether gender differences exist in the relationships between the mathematics learning environment, motivation, self-regulation, mathematics anxiety and mathematics achievement constructs. First, it was necessary to establish the relationships between these constructs before examining possible gender differences. The development and evaluation of the research model was intended to establish a structure upon which gender comparisons could be made. The basis of the research model, as introduced in Chapter 1, was Bandura's social cognitive theory and its associated model of triadic reciprocal determinism (Bandura, 1989). Due to the importance of student achievement in the educational process, this variable was included as a fifth construct in the model. The hypothesised research model (Figure 3-1) consisted of the hypothesised relationships between the five constructs. The study sought to test these relationships to determine whether the data supports them. Only relationships that were supported were retained as the structure for the gender comparisons. The interactions shown in the model were not expected to be equal nor exhaustive. Further, it was acknowledged that a relationship might exist for one or more of the factors that represent a construct.

Based on the literature review (see Chapter 2), the following hypotheses were delineated to represent the relationships displayed in the model. As defined by this study, the five constructs were introduced in Chapter 1 (Section 1.3) and the hypothesised relationships between them were operationalised and justified by past research (Sections 1.3.3 to 1.3.11). A summary of the relationships is provided below:

- Hypothesis 1: Mathematics learning environment is related to motivation.
- Hypothesis 2: Mathematics learning environment is related to self-regulation.
- Hypothesis 3: Mathematics learning environment is related to mathematics anxiety.
- Hypothesis 4: Mathematics learning environment is related to mathematics achievement.
- Hypothesis 5: Motivation is related to self-regulation.
- Hypothesis 6: Mathematics anxiety is related to motivation.
- Hypothesis 7: Motivation is related to mathematics achievement.

- Hypothesis 8: Self-regulation is related to mathematics achievement.
- Hypothesis 9: Mathematics anxiety is related to mathematics achievement

Each of the hypothesised relationships was evaluated to determine the relevance of the model for use in this study.

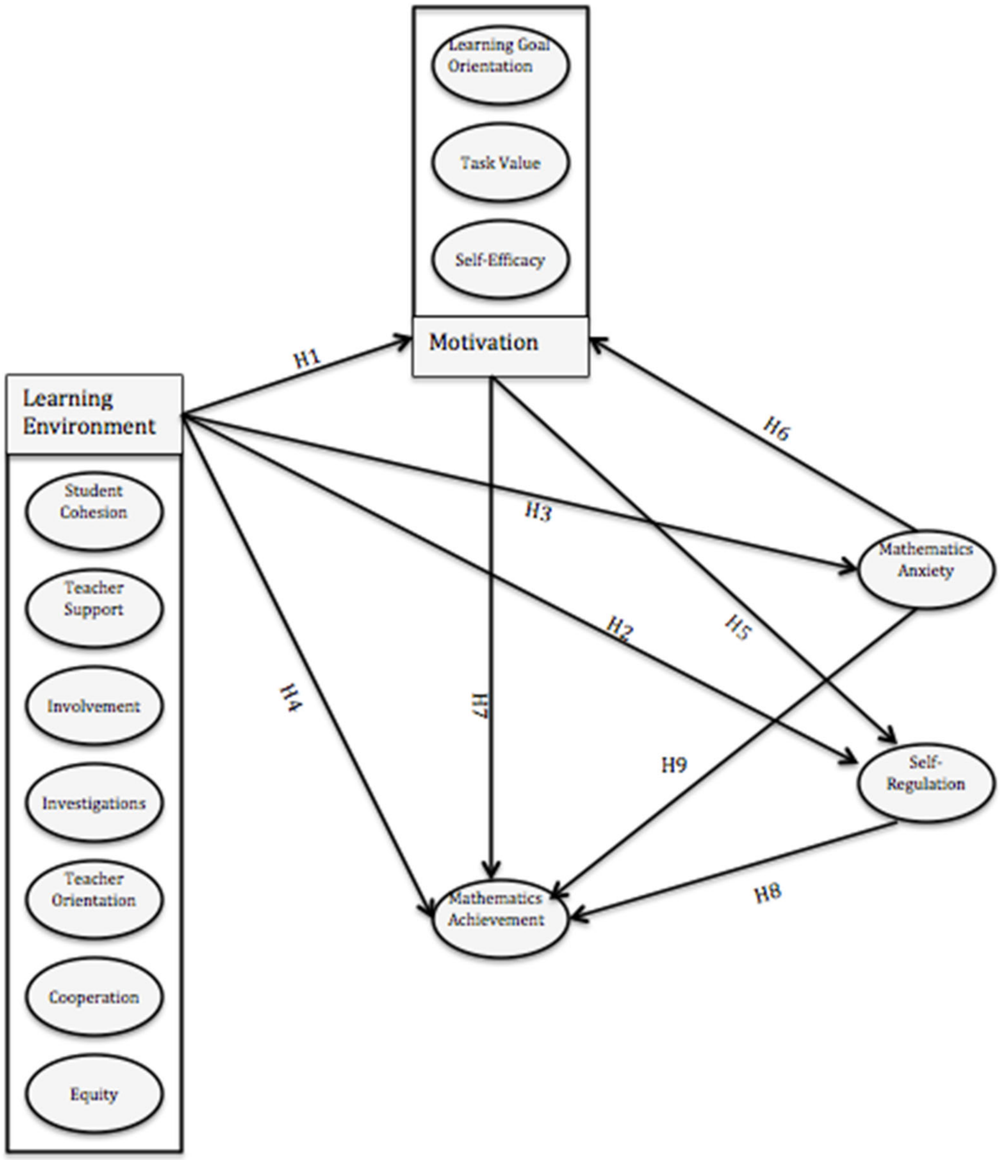

Figure 3-1: Path Diagram of the Hypothesised Research Model.

3.4 Research Objectives

The research objectives that guided this study, introduced in Chapter 1, are reiterated here.

Research Objective 1:

> To translate and validate the instruments used to measure students' perceptions of the mathematics learning environment and their reported levels of motivation, self-regulation and mathematics anxiety for use in university-level mathematics classes in the UAE.

Research Objective 2:

> To evaluate the proposed research model developed for use in the study.

Research Objective 3:

> To examine whether male and female students in university-level mathematics classes in the UAE differ in terms of their perception of the mathematics learning environment, their reported levels of motivation, self-regulation and mathematics anxiety, and their level of mathematics achievement.

Research Objective 4:

> To determine whether there is a relationship between students' perceptions of the mathematics learning environment, their reported levels of motivation, self-regulation and mathematics anxiety, and their level of mathematics achievement; and to determine whether any relationships that exist differ for male and female students.

3.5 Sample

The selection of participants for the current study involved cluster sampling from a single university to represent first-year mathematics students at university level in the

United Arab Emirates (UAE). The university involved in the study specialised in engineering degrees and included a small number of science graduates. The majority of the students at the university were from one of the seven emirates comprising the UAE, with a small number from other Gulf countries.

The cluster selection was based on the practicalities of access and the availability of achievement data. Although they were taught separately on two adjacent campuses, the university had both male and female students. There was no restriction on the gender of the lecturers teaching on the two campuses, whereas in UAE government high schools, only male lecturers can teach male students. Therefore, most lecturers taught the same course at both the male and female campuses, which reduced the possibility of teacher influence as a confounding variable. The university provides students with a significant stipend, accommodation and transportation each weekend for those who did not reside in Abu Dhabi. As the university therefore enrols students from all seven emirates, the study results are potentially generalisable across the whole of the UAE.

All students enrolled at the university were required to study mathematics, including a minimum of Calculus 1, Calculus 2, Calculus 3, Linear Algebra and Differential Equations. Enrolling students had to pass a placement test to enter directly into first-year mathematics (Calculus 1) otherwise they would first need to complete a zero credit Pre-calculus foundation course. There were only a few students who could, or wanted to, enter directly into Calculus 1. Students who did not meet the minimum English language requirements were also required to complete an intensive English language course before admission into the degree program. Therefore, it can be assumed that all students involved in the study had a reasonable understanding of the English language.

The sample consisted of all consenting students studying mathematics at or below the first-year university level (see Table 3-1 for a breakdown of the sample). The sample consisted of 426 students (73%) out of a total of 580 students enrolled in 19 Pre-calculus classes (12 female and seven male) and eight Calculus 1 classes (five female and three male). This participation rate reflected the attendance on the day, as all students present opted to participate. Overall, there were 17 classes with female students (n = 287) and 10 classes with male students (n = 139). The difference between the number of female and male student participants reflected the proportion of each sex enrolled at the university and represented the proportion of each sex enrolled in STEM degrees nationally and in the region (Ainane et al., 2019). The majority of students were between 18 and 22 years of age.

Table 3-1: Sample Summary

Course	Females	Males	Total
Pre-Calculus	208	92	300
Calculus 1	79	47	126
Total	287	139	426

3.6 **Data Collection**

This section provides details of the instruments administered to collect the data (Section 3.6.1), including the preparation and modification required before use; the translation of the surveys into Arabic (Section 3.6.2); and the procedures used during the data collection process (Section 3.6.3). Finally, this section details the collection of mathematics achievement data (Section 3.6.4).

3.6.1 Instruments

Three surveys were administered to assess the constructs in the research model (excluding achievement). The three surveys were What is Happening In this Class? (Section 3.6.1.1), Students' Adaptive Learning Engagement in Mathematics (Section 3.6.1.2) and Revised Mathematics Anxiety Scale (Section 3.6.1.3). This section details the development, necessary changes and reasons for the selection of each survey.

3.6.1.1 What Is Happening In this Class?

The What Is Happening In this Class? (WIHIC) survey was used to assess students' perceptions of the psychosocial learning environment in the mathematics classrooms.

Although WIHIC was developed initially by Fraser et al. (1996), Aldridge et al. (1999) developed a more economical version. This refined version comprises eight items in each of seven scales: student cohesiveness, teacher support, involvement, investigation, task orientation, cooperation and equity. A brief description of each scale and sample item is provided in Table 3-2.

Table 3-2: WIHIC Instrument Scales, Scale Descriptions and Sample Items

Scale name	**Scale description**	**Sample item**
Student cohesiveness	The extent to which students know, help and support one another.	I work well with other members of the class.
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.
Involvement	The extent to which students have attentive involvement interest, participate in discussions, do additional work and enjoy the class.	I give my opinion during class discussions.
Investigation	The extent to which skills and processes of inquiry, and their use in problem solving and investigations, are emphasised.	I carry out investigations to test my ideas.
Task orientation	The extent to which it is important to complete planned activities and to stay on the subject matter.	I know the goals for this class.
Collaboration	The extent to which students collaborate rather than compete with one another on learning tasks.	I collaborate with other students in class activities.
Equity	The extent to which their teacher treats students equally.	I am treated the same as other students in this class.

Source: Used with permission of Aldridge et al. (1999)

WIHIC was selected for use because it has been used and validated in numerous countries and languages, at many levels of education and across a range of subjects (see Chapter 2 for more information). Although two prior studies have used both Arabic and dual English/Arabic versions of WIHIC at the tertiary level (Afari et al., 2013; MacLeod & Fraser, 2010), neither of these studies included all seven scales. However, the strong validity and reliability of WIHIC when used in prior studies made it a suitable choice.

Participants responded to the 56 items of the WIHIC survey using a 5-point frequency response scale: almost never, seldom, sometimes, often and almost always. Each of the seven scales was assessed using a block of eight consecutive items to reduce participant confusion (Aldridge & Fraser, 2008). All items were positively worded to maximise response accuracy and consistency, as recommended by Schriesheim et al. (1991). Each item was presented in English and Arabic (see Afari et al., 2013). This dual-language format, which has been used successfully in prior studies, allowed the participants, who were all bilingual, to use the language of their choice and use the second language to aid clarification if necessary (a full copy of the WIHIC survey is available in Appendix 1).

3.6.1.2 Students' Adaptive Learning Engagement in Mathematics

The Students' Adaptive Learning Engagement in Mathematics (SALEM) survey was used to assess student motivation and self-regulation. SALEM was adapted by Chipangura and Aldridge (2017) from the Students' Adaptive Learning Engagement in Science (SALES) survey (Velayutham et al., 2011) to make it suitable for use in mathematics classes. Although it had not previously been used at tertiary level, SALEM was selected because of its specificity for use in mathematics classrooms, the small size of the university classes involved in the study, the instruments economy and the evidence of reliability reported in previous research (see Chipangura & Aldridge, 2017). Further, SALES had also shown to be reliable in terms of factor structure and internal consistency reliability (Chipangura & Aldridge, 2017; Velayutham et al., 2012).

SALEM comprises eight items in each of four scales: learning goal orientation, task value, self-efficacy and self-regulation. A brief description of each scale and sample item is provided in Table 3-3.

Participants responded to the items using a 5-point Likert scale: strongly disagree, disagree, not sure, agree and strongly agree. As with WIHIC, each scale was measured using a block of eight consecutive positively worded items with each block below a scale heading and each item was presented in English and Arabic, as described in Section 3.6.2. (A full copy of the SALEM questionnaire is available in Appendix 2.)

Table 3-3: SALEM Instrument Scales, Scale Descriptions snd Sample Items

Scale name	Scale description	Sample item
Learning goal orientation	The extent to which students' drive/desire to develop skills and competencies by mastering tasks.	One of my goals is to learn new mathematics content.
Task value	The extent to which students value the task given to them.	What I learn is relevant to me.
Self-efficacy	Students' level of beliefs/judgements about their capabilities to perform a task.	I can complete difficult work if I try.
Self-regulation	The extent to which students are both cognitively and meta-cognitively able to participate in their learning.	I don't give up even when the work is difficult.

3.6.1.3 Revised Mathematics Anxiety Scale

The Revised Mathematics Anxiety Scale (R-MANX), developed by Bursal & Paznokas (2006), was selected to assess the student's mathematics anxiety. R-MANX was translated into Arabic using the methods outlined in Section 3.6.2. The translated items were combined with the original English version to produce a dual-language format (see Appendix 3 for the English/Arabic version of R-MANX). R-MANX consisted of 30 statements describing everyday life and academic situations requiring mathematics or mathematical processes. The construct did not have any pre-determined scales. Twenty-three of the items described anxious situations. The remaining seven items were polar opposite statements that described non-anxious situations (requiring the statements to be reverse scored). Given the nature of mathematics anxiety and its impact on the ability of participants to carry out certain activities, seven items included "negated regular" language (Schriesheim et al., 1991). Respondents rated each statement on a 5-point frequency response scale: almost never, seldom, sometimes, often and almost always. R-MANX provides respondents with a score ranging from 30 to 150, which indicates their overall level of mathematics anxiety: a score of 30 represents the lowest level of anxiety, whereas a score of 150 represents the highest level of anxiety. Bursal & Paznokas (2006) developed the items for the survey from items in the Mathematical Anxiety Scale (MANX) survey (Erktin & Oner, 1990). In the study carried out by Bursal and Paznokas (2006), the Cronbach's alpha reliability coefficient for the R-MANX questionnaire was 0.9.

Given that the instrument was designed to assess the level of mathematics anxiety experienced by pre-service elementary teachers (Bursal & Paznokas, 2006), minor modifications were required to ensure that the statements applied to students studying mathematics. For example, the item "I can reject helping a child with his homework, because I am afraid of facing a question I cannot solve" was changed to "I would refuse to help a younger student with solving his mathematics homework since I am afraid of facing a question which I cannot solve". (A full copy of the modified R-MANX is available in Appendix 3.)

3.6.2 Translating the Instruments into Arabic

Given that the students involved in this study were all native Arabic speakers, the instruments were made available in Arabic and English to maximise face validity. Although prior studies have used only a translated version of an instrument (MacLeod & Fraser, 2010), given that all the students in the survey enter the university with a proficient standard of English, a dual English/Arabic version of the instrument was deemed more helpful in this study. Although the students are considered bilingual, they have varying strengths in each of the two languages; therefore, a dual layout with the Arabic translation directly below the English wording was used. This layout has been used successfully in previous learning environment studies (see Afari et al., 2013; Aldridge et al., 2006)). Including both languages helped increase the students' understanding of the items and optimise the accuracy of the students' responses.

It was necessary to translate the WIHIC, SALEM and R-MANX instruments into Arabic to create dual-language layouts for these instruments. To accomplish this, a rigorous method of translation, back translation, verification and modification was used, as described by Ercikan (1998). This process required an initial translation of English into Arabic by a professional translator who was familiar with the educational context. The initial translation was followed by back translation from Arabic back into English by a second translator who was not familiar with the instruments. The researcher then compared the original English version with the back translation to ensure that the original meaning had been maintained. (The dual English/Arabic versions of each of the WIHIC, SALEM and R-MANX instruments are available in Appendices 1, 2 and 3, respectively).

3.6.3 Collection of Data

Data collection was carried out over three days towards the end of semester 1 (August to December), which was the first semester the students were enrolled in the course. Administering the survey at this time allowed students sufficient experience in their classes to provide informed opinions. Spreading the administration over the three days enabled the researcher to maximise consistency by personally administering the surveys for 24 of the 27 participating classes. For the remaining three classes the procedures were standardised by ensuring that the lecturer assisting with data collection was sufficiently briefed beforehand and provided with a step-by-step guide to follow.

Participants responded to all three instruments in a single lesson to reduce the number of disruptions to lessons. Administering the survey within class time meant that students knew the class that the surveys related to. For each class, the researcher provided a brief, verbal explanation of how to respond to the instruments. This information was printed at the start of each survey package. On average, the participants took approximately 20 minutes to respond to the instruments.

3.6.4 Achievement Data

In addition to the instruments described above, achievement data was also collected. The achievement data consisted of each student's final grade for their respective mathematics course. These grades were collected at the end of the semester and consisted of three tests (50% weighting), quizzes, homework (20%) and the final exam (30%). The coordinator of each respective course supplied the students' final grades which included student identification numbers to allow matching with instrument data.

The collection of achievement data enabled analysis to determine whether there were relationships between mathematics achievement and students' perceptions of mathematics learning environment, motivation, self-regulation and mathematics anxiety.

3.7 Data Analysis

This section details the analyses used to address each of the research objectives. It describes the preparation of the data (Section 3.7.1), the procedures used to provide evidence to support the validation of the three instruments (Section 3.7.2), the evaluation of the research model (Section 3.7.3), testing of the hypothesised relationships (Section 3.7.4) and consideration of gender differences in construct perception and the relationships between constructs (Section 3.7.5).

3.7.1 Data Preparation

The three instruments (WIHIC, SALEM and R-MANX) were collected together as a booklet. Each class set was indexed with the course code and section number. Each booklet included the students' identification number to allow matching with the students' achievement data. Data entry services entered the data into an excel spreadsheet. Once complete, the researcher checked 10% of the participants' data to ensure the accuracy of the data entry. This check revealed an acceptable error rate of less than 0.1%.

The 426 participants responded to 118 items each (a total of 50,268 items). The responses to 85 (0.2%) of the items were missing. There was no pattern to these omissions and no participant had more than three responses missing. The missing responses were replaced with a value of 3 (Cresswell, 2012), the middle score on the 5-point scale employed in all instruments. The researcher entered each student's achievement data by matching it to instrument responses using the student identification numbers. Following the entry of the achievement data, the student identification numbers were deleted from the excel spreadsheet. There was no missing achievement data.

Initial data screening was carried out at the data entry level to identify disengaged participants. A participant's data was highlighted if any patterns such as repetition were identified in their responses. Further inspection identified a small number of participants with some duplication of responses; however, these responses were still in line with other students' responses in the same classes.

3.7.2 Validity and Reliability of the Instruments

Research Objective 1 sought to provide evidence to support the validity and reliability of the WIHIC, SALEM and R-MANX instruments when used at university level in the UAE. All of the instruments had been used in prior studies. Given that these studies all reported strong evidence to support the validity and reliability of the instruments, it was determined that the constructs were well defined and that the items were a good measure of each construct, thereby satisfying the requirements of both content and face validity. Since the Arabic versions of these instruments had not been used previously with first-year university-level mathematics students, it was necessary to provide support for the validity and reliability of the instruments when used in this context. Analysis included exploratory factor analysis (Section 3.7.1.1), internal consistency reliability (Section 3.7.1.2), discriminant validity (Section 3.7.1.3) and the ability to differentiate between classes (Section 3.7.1.4).

3.7.2.1 Factor Analysis

Exploratory factor analysis involving principal axis factoring, as recommended by Gorsuch (1990) and Costello and Osborne (2005), was used to examine the factor structure. Factor analysis was considered appropriate because it calculates the structure using only the shared variance. Further, oblique rotation was selected as it permits the factors to be correlated, making it suitable for use in social sciences. Therefore, the data was subjected to principal axis factoring with oblique rotation separately for each instrument using SPSS version 26.

Prior to this process, it was necessary to determine the suitability of the data for exploratory factor analysis. There is no predetermined minimum sample size for factor analysis, as the size of the sample required is dependent on how well the factors correlate (Fabrigar et al., 1999). Therefore the Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy was used to determine whether the sample size was sufficient for factor detection. A satisfactory KMO value is required to be greater than .5 (Kaiser, 1970; 1974). A KMO value of less than .5 indicates the need to collect more data and according to Hutcheson and Sofroniou (1999), a KMO value of .5 to .7 is mediocre, .7 to .8 is good, .8 to .9 is great and above .9 is superb. Bartlett's Test of Sphericity (Bartlett, 1954) was also used to compare the component correlation matrix with the identity matrix. If the components were measuring the same construct, then one would expect the components to be correlated but not too highly correlated, otherwise they may be measuring the same aspect of that construct. For Bartlett's Test of Sphericity, when the approximate chi-square is greater than the degrees of freedom, there is a significant difference between the component correlation matrix and the identity matrix, which indicates components are correlated and the data is suitable for factor reduction.

Providing satisfactory KMO and Bartlett's Test of Sphericity results were achieved, it was deemed that the data was suitable for factor analysis and additional analysis would take place. The exploratory factor analysis process groups the items that correlate highly with each other into factors. The number of factors and the number of items contained within each factor were then compared with the instrument items in each scale to determine whether they matched. If an item did not load with the other items on the same scale against the same factor, then a decision was made as to whether the item should be retained for further analysis. To be retain an item it was required to load at least .4 on the a priori factor and less than .4 on any other factor (as recommended by Matsunaga (2011)).

3.7.2.2 Internal Consistency Reliability

Internal consistency reliability measures how well the items loaded onto the same factor are related to each other. Cronbach's alpha was used to provide an estimate of internal consistency. This method involves splitting the data into two halves and finding the associated correlation coefficients. Calculating Cronbach's alpha is the mathematical equivalent to finding the mean correlation coefficient after repeating this process with all possible split-half groupings (Trochim et al., 2016). Very high alpha values may indicate that some scales were redundant and could have been omitted from the instrument. Cronbach's alpha values between .7 and .9 indicate good internal reliability consistency, although it is noted that the value increases when there are a large number of items loading on a factor (Field, 2005).

3.7.2.3 Discriminant Validity

Discriminant validity determines whether factors that measure different aspects of a construct are sufficiently related, but not so related that they measure the same aspect of the construct (Field, 2005). Correlation coefficients greater than .8 would indicate unnecessary duplication of scales (Cronbach, 1951; Field, 2005).

In this study, the component correlation matrix, which was generated during oblique rotation, was used to provide the correlations between all pairs of scales in an instrument so that discriminant validity can be determined.

3.7.2.4 Ability to Differentiate Between Classes

Analysis of variance (ANOVA) was used to determine the ability of individual scales in each instrument to distinguish between the 27 class groups. The eta-squared statistics, which is the ratio of the sum of squares between class groups divided by the total sum of squares, were calculated for each scale to determine the proportion of variance that can be accounted for by the difference between class groups. Students in the same class would be expected to have similar perceptions to each other while varying from the perceptions of students in other classes. The variance within class groups is the error due to random sampling. In contrast, the variance between class groups is attributed to the ability of the instrument to distinguish between these class groups. The ability to differentiate between classes requires statistically significant ANOVA results for each scale of a construct.

3.7.3 Confirmation of the Research Model

First, it was necessary to confirm the research model (Research Objective 2). It was necessary to evaluate both the measurement and the structural models to do this. Structural equation modelling (SEM) was used to assess both models. SEM is a single, systematic and comprehensive analysis method (Gefen et al., 2000). The main benefit of this second-generation analysis is that it simultaneously analyses both models. It allows the analysis of the measurement model by using confirmatory factor analysis to load the observed (indicator) variables onto the latent variables or scales. SEM also analyses the structural model by computing the correlation between latent variables and the regression weights between independent and dependent latent variables.

The Analysis of Moment Structures (AMOS) version 26 (Arbuckle, 2019) combined with the maximum likelihood estimation (MLE) function was used to analyse the data. Under ideal sampling conditions, all parameter estimation methods, including those that rely on partial least squares (PLS), would provide reasonable parameter estimates. MLE was chosen as it provides the most precise parameter estimates (Gefen et al., 2000). Suggested criteria vary but generally include the normality of the univariate and multivariate variables, a sample size of approximately 400 and at least three manifest variables for each latent variable (Hox & Bechger, 1998). The sample size must not be too large, as this would increase the likelihood of a valid model being rejected (Anderson & Gerbing, 1988; Bagozzi & Yi, 1988).

The measurement model is evaluated in Section 3.7.2.1 and the structural model is evaluated in Section 3.7.2.2.

3.7.3.1 Evaluation of the Measurement Model

The measurement model was evaluated to determine whether the indicator variables adequately represented the latent constructs. AMOS provides analysis of both the univariate and multivariate normality of the data, which needs to be established before using SEM for further analysis. Statistically, data can be assessed for univariate normality by determining skewness and kurtosis (Hair et al., 2014; Tabachnick & Fidell, 2013). The skewness and kurtosis for each variable were calculated using SPSS 26. Skewness and kurtosis indices for each item were required to be within the accepted levels of $|3|$ and $|10|$, respectively (Kline, 2016). Multivariate normality was determined using Mardia's normalised multivariate kurtosis value (Mardia's coefficient), which needs to be less than $p(p+2)$, where p is the number of observed variables in the model (Raykov & Marcoulides, 2008). Only when these tests reveal satisfactory univariate and multivariate normality in the data, is it statistically sound to continue with a covariance-based method such as MLE.

It was recommended by Hair et al. (2014) that to confirm the validity of the proposed measurement model, its construct validity should be examined. Construct validity was examined by investigating convergent validity (Section 3.7.2.1) and discriminant validity (Section 3.7.2.2). Convergent validity was measured using composite reliability (CR) and average variance extracted (AVE) (Fornell & Larcker, 1981).

CR and AVE were calculated using the following formulae:

$$CR = \frac{(\sum_{i=1}^{n} \lambda_i)^2}{\left(\sum_{i=1}^{n} \lambda_i\right)^2 + \left(\sum_{i=1}^{n} \delta_i\right)}$$

$$AVE = \frac{\left(\sum_{i=1}^{n} {\lambda_i}^2\right)}{\left(\sum_{i=1}^{n} {\lambda_i}^2\right) + \left(\sum_{i=1}^{n} \delta_i\right)}$$

Where:

λ_i = factor loading for the indicators on the observed variable

δ_i = measurement error of each indicator

To achieve satisfactory construct validity, all factor loadings should be greater than .5 (Fornell & Larcker, 1981) and CR and AVE should be at least .7 and .5, respectively (Nunnally & Bernstein, 1994).

Discriminant validity, which assesses the degree to which the constructs are empirically different, was evaluated by examining the correlations between scales. As suggested by Fornell & Larcker (1981), for the discriminant validity to be satisfactory, the square root of the AVE for a scale should be higher than the correlations shared between the scale and the other scales in the model.

Finally, the model fit was evaluated using the following fit statistics calculated using AMOS: chi-square (χ^2), Tucker-Lewis index (TLI), comparative fit index (CFI), incremental index of fit (IFI), root-mean-square error of approximation (RMSEA) and standardised root-mean-square residual (SRMR). No single fit index comes without limitations, so it is necessary to utilise a selection of indices and consider the overall results. Hair et al. (2014) caution against simply highlighting the indices for which the model meets the criteria and stress that it is equally important to seek an explanation when an index does not satisfy a criterion.

Chi-square and SRMR are absolute fit indices that determine whether the predicted variance-covariance matrix is equal to the sample variance-covariance matrix. The chi-square test is a stringent test in that it determines whether the model fits the population exactly. It is a “badness of fit” test, with significant results indicating a poor-fitting model. Chi-square is inflated by sample size (Brown, 2006) and for sample sizes over 400, the model is almost always a poor fit (Harrington, 2009).

The second absolute fit index used is SRMR, which considers the average difference between the correlations in the input matrix and those predicted in the model. RMSEA is a parsimony correction index. Unlike the absolute fit indices, it only seeks to assess the extent that the model fits “reasonably well” in the population (Brown, 2006). RMSEA includes a built-in penalty for complexity. Unlike the absolute fit indices, RMSEA is not sensitive to large sample sizes and although it may falsely reject models with a small sample, this was not an issue for this study.

The third group of indices used to assess the model fit was the comparative fit indices, which evaluate the model relative to a baseline model. For both CFI and TLI, the baseline model is the independence model, which fixes the covariance between all indicator inputs to zero. These indices are not significantly affected by sample size and TLI, as with RMSEA, includes a feature that compensates for model complexity (Brown, 2006). Comparing against a solution with no relationship between variables can make CFI and TLI appear more favourable.

Although there is considerable debate about suitable cut-off values for model fit indices, Hair et al. (2010) suggested that TLI and CFI values of less than .9 indicate lack of fit, values between .9 and .95 indicate a reasonable fit, and values between .95 and 1 indicate a good fit. RMSEA values of .05 or lower indicate a good fit and values between .05 and .08 indicate a reasonable fit. An SRMR value less than .08 would indicate a good fitting model (Hair et al., 2010).

3.7.3.2 Evaluation of the Structural Model

This section describes the analyses used to develop the final structural model, which was required to investigate the relationships between the constructs and evaluate possible gender differences in these relationships.

SEM using MLE was used to determine the significance of relationships. This method required uploading the data collected and the structural model, which showed the proposed relationship between the variables. The MLE function used probability to find the parameter values that were most likely given the data collected. These parameter estimates were used to compute an implied covariance matrix for the specified structure model and then compared with the covariance matrix computed from the actual data collected (Crisci, 2012). The results of the chi-square test were used to determine whether there was a significant difference between the distributions described by the two covariance matrices. These results were used to determine whether there were significant relationships between the factors. An exploratory SEM approach was used to develop an empirical model on which gender differences in relationships could be meaningfully evaluated.

Initially, the relationships in five simple models were investigated. The models are each composed of three of the following five constructs: LE (mathematics learning environment), MOT (motivation), SR (self-regulation), MANX (mathematics anxiety) and ACHT (mathematics achievement). The five models are:

Model 1: LE → MOT → ACHT, incorporating three component models:

- Model 1(a): LE → ACHT
- Model 1(b): LE → MOT
- Model 1(c): MOT → ACHT

Model 2: LE → SR → ACHT, incorporating three component models:

- Model 1(a): LE → ACHT

- Model 2(a): LE → SR
- Model 2(b): SR → ACHT

Model 3: LE → MANX → ACHT, incorporating three component models:

- Model 1(a): LE → ACHT
- Model 3(a): LE → MANX
- Model 3(b): MANX → ACHT

Model 4: MOT → SR → ACHT, incorporating three component models:

- Model 1(c): MOT → ACHT
- Model 4(a): MOT → SR
- Model 2(b): SR → ACHT

Model 5: MANX → MOT → ACHT, incorporating three component models:

- Model 3(b): MANX → ACHT
- Model 5(a): MANX → MOT
- Model 1(c): MOT → ACHT

The five simple models included a total of nine distinct component models, as detailed in Table 3-4. Each of these models represent one of the nine hypothesised relationships. Since mathematics learning environment consisted of seven factors, motivation three factors, and self-regulation, mathematics anxiety and mathematics achievement were all single factor constructs, there were 53 direct relationships to be assessed.

SEM was used to assess the direct relationships between factors in each component model. SEM provided model fit indices and path coefficients with their level of significance. The criteria for the model fit indices are the same as they were for the measurement model. SEM also provided coefficients of determination (R^2) for each dependent variable, which measured the total variance in each dependent variable explained by the independent variables in the model. A minimum requirement of .10

was used, as recommended by Santosa et al., (2005). Provided the model had satisfactory model fit indices, all direct relationships with significant path coefficients were combined to form a more complex structural model. The second round of SEM was used on this model to determine whether it had satisfactory model fit indices and whether the relationships had significant path coefficients. All non-significant relationships were trimmed from the model to leave the final structural model that was used for further investigation.

Table 3-4: Summary of Hypotheses, Simple Models and Relationships

Hypothesis	**Model**	**Relationships**
1: Mathematics learning environment is related to motivation.	Model 1(b): LE → MOT	Factors (LE = 7: MOT = 3) (total relationships 7 x 3 = 21)
2: Mathematics learning environment is related to self-regulation.	Model 2(a): LE → SR	Factors (LE = 7: SR = 1) (total relationships 7 x 1 = 7)
3: Mathematics learning environment is related to mathematics anxiety.	Model 3(a): LE → MANX	Factors (LE = 7: MANX = 1) (total relationships 7 x 1 = 7)
4: Mathematics learning environment is related to mathematics achievement.	Model 1(a): LE → ACHT	Factors (LE = 7: ACHT = 1) (total relationships 7 x 1 = 7)
5: Motivation is related to self-regulation.	Model 4(a): MOT→ SR	Factors (MOT = 3: SR = 1) (total relationships 3 x 1 = 3)
6: Mathematics anxiety is related to motivation.	Model 5(a): MANX → MOT	Factors (MANX =1: MOT = 3) (total relationships 1 x 3 = 3)
7: Motivation is related to mathematics achievement.	Model 1(c): MOT→ ACHT	Factors (MOT = 3: ACHT = 1) (total relationships 3 x 1 = 3)
8: Self-regulation is related to mathematics achievement.	Model 2(b): SR→ ACHT	Factors (SR = 1: ACHT = 1) (total relationships 1 x 1 = 1)
9: Mathematics anxiety is related to mathematics achievement	Model 3(b): MANX → ACHT	Factors (MANX = 1: ACHT = 1) (total relationships 1 x 1 = 1)
Total		53 relationships

The possible mediating effects of mathematics learning environment factors on mathematics achievement through motivation, self-regulation and mathematics anxiety were identified during the SEM analysis of the direct relationships in the five simple models. If the direct components of the possible mediated relationship were both significant, the relationship was further investigated using Mplus version 8.3 (Muthen & Muthen, 2019). Bootstrapping was used to create 95% confidence intervals of the standardised specific direct and indirect effects. If neither confidence interval included zero, it was concluded that there was a statistically significant mediated effect (Hayes, 2009). As recommended by Collier (2020), the results reported included confidence intervals for both indirect and direct effects and levels of significance for each relationship.

Provided the measurement model has satisfactory construct validity and model fit and the structural model has satisfactory model fit and coefficients of determination, the research model (final structural model) can be used for further analysis.

3.7.4 Testing the Hypotheses

A literature review provided the basis for selecting nine hypothesised relationships between the mathematics learning environment, motivation, self-regulation, mathematics anxiety and mathematics achievement constructs. These hypotheses provided the initial structure for developing the final structural model upon which gender differences were assessed. Initially, SEM was used to find significant relationships in five simple models based on the hypothesised relationships. The significant relationships were then combined to form a larger model to undergo a second round of SEM. The relationships that remained significant formed the final structural model, which was used to compare the strength and direction of male and female relationships. The selection of the hypothesised relationships could be supported by corresponding relationships in the final structural model. Regardless of the results, it could not be assumed that these relationships, nor the directions of relationships, were the only ones that may have existed; however, it does provide some structure to investigate possible gender differences.

3.7.5 Gender Differences

To address Research Objectives 3, analysis was undertaken to determine whether male and female students differed in terms of their perception of the mathematics learning environment, their reported levels of motivation, self-regulation and mathematics anxiety, and their level of mathematics achievement. The analysis also considered whether gender differences in these perceptions were different in Pre-calculus classes to those in Calculus classes. Differences between scale means for Pre-calculus and Calculus classes were compared for male and female students.

Research Objective 4 was to determine whether male and female students differed in terms of the strength and direction of their relationships between mathematics learning environment, motivation, self-regulation, mathematics anxiety and mathematics achievement. Before making these comparisons, it was first necessary to confirm measurement invariance, which assesses a construct's psychometric equivalence across the two groups. When measurement invariance is demonstrated, the participants across the groups interpret individual scale items and the latent factor that they represent in the same way (van de Schoot et al., 2012). This was done using multi-group confirmatory factor analysis across gender, as described in Section 3.7.5.1.

3.7.5.1 Multi-Group Confirmatory Factor Analysis Across Gender

Multi-group confirmatory factor analysis (MGCFA) is a procedure that allows researchers to specify and estimate a set of models for which the parameters in the MGCFA model can be constrained to equality across groups (Scherer, 2020). According to van de Schoot et al. (2012), three MGCFA models need to be specified to test for measurement invariance based on continuously treated item indicators of a latent variable. These three models are:

1. The *configural invariance* model, which assumes the same factor structure (i.e. number of factors and the pattern of the links between the latent variable and the manifest indicators) across groups.
2. The *metric invariance* model, which constrains the factor loadings to equality across groups based on the configural model.

3. The *scalar invariance* model, which constrains the item intercepts to equality across groups.

Evaluating the model fit indices of each of the models was performed using Mplus version 8.3 (Muthen & Muthen, 2019). Provided satisfactory fit was achieved for the individual models, the difference in fit indices between models was assessed to determine the degree of deterioration. Changes in CFI (ΔCFI) and RMSEA ($\Delta RMSEA$) of < 0.01 are deemed acceptable (Cheung & Rensvold, 2002). For relatively large sample sizes, a ΔCFI value of 0.02 and $\Delta RMSEA$ value of 0.03 were used to evaluate metric invariance (Rutkowski & Svetina, 2014). This analysis was carried out using data from the WIHIC, SALEM and R-MANX instruments.

3.7.5.2 Gender Differences in Scale Means

To address Research Objective 3, comparisons of male and female scale means were carried out, for the whole sample and both the Pre-calculus and Calculus sub-samples. A comparison of differences between Pre-calculus and Calculus for the male and female samples was also made. To determine whether differences were statistically significant independent sample t-tests, along with effect sizes and their associated confidence intervals. Effect size, which standardises the difference between the two means by dividing the actual difference by the standard deviation, was used to quantify the difference between male and female scale means and mathematics achievement means. Since this research did not have control and experimental groups, a pooled standard deviation was most suitable. Using a pooled standard deviation required the assumption that male and female standard deviations were estimates of the same population standard deviation (Coe, 2002). Another consideration was that the sample sizes for the male and female subgroups were not the same (Olejnik & Algina, 2000). Effect size was measured using the formula in Equation 1:

$$Effect\ Size = \frac{M_1 - M_2}{\sqrt{\frac{(N_1-1){S_1}^2 + (N_2-1){S_2}^2}{N_1+N_2-2}}} \qquad (1)$$

Due to the difficulties of interpreting effect sizes on their own (Cohen, 1988), associated confidence intervals were also calculated. Confidence intervals aided interpretation and ensured that the differences between male and female means could not be accounted for by sampling variation. The standard deviation for the effect size was calculated using the standard deviation formula in Equation 2 (Hedges & Olkin, 1985):

$$\sigma[d] = \sqrt{\frac{N_F + N_M}{N_F \times N_M} + \frac{d^2}{2(N_F + N_M)}} \tag{2}$$

This standard deviation was used in Formula 3 to generate the lower and upper limits of the 95% confidences intervals:

$$\left[d - 1.96\sigma[d], d + 1.96\sigma[d]\right] \tag{3}$$

When a confidence interval included the number 0, then it was accepted any difference between the means could be accounted for by sampling, so it was not significant. If 0 was not included in the confidence interval, then the importance rather than the significance of the difference was interpreted.

3.7.5.3 Gender Differences in Structural Model Relationships

The second consideration for gender differences was to address Research Objective 4, which compares male and female path coefficients for the statistically significant paths in the final structural model.

To facilitate the investigation of this research objective, multi-group structural equation modelling (MGSEM) across gender was used. This analysis provided model fit indices for the final structural model and path coefficients and their significance for male and female students. The path coefficients could be compared if the model fit indices were satisfactory for both groups.

Relationships between factors for both male and female samples were compared to determine if they were significantly different. If the path coefficient for a sample was not significant, it indicated no relationship between that pair of factors for that group. If neither male nor female samples had a significant path coefficient for a relationship between a pair of factors, then the difference between these relationships could not be considered significant. If both male and female samples had statistically significant path coefficients for a relationship, then the difference was not considered significant. If one group had a statistically significant path coefficient for a relationship and the other group did not, then the difference in the relationships between the two groups was considered significant.

3.8 **Ethical Considerations**

Before the commencement of the study, permission to carry out the research was granted by the Human Research Committee at Curtin University (see Appendix 4 for a copy of the approval letter). Once ethics approval had been granted, permission was also sought from the Dean of Arts and Sciences and the Head of the Mathematics Department at the institution involved. Given that the researcher was a lecturer in this department, the process was generally concerned with how the research would be carried out. This section outlines the ethical considerations that were observed and addressed throughout this research. It outlines how informed consent was obtained from student participants (Section 3.8.1), the procedures followed to ensure confidentiality of the participants (Sections 3.8.2) and the considerations made to reduce any disruption to the teaching program (Section 3.8.3).

3.8.1 Informed Consent

Participants involved in the study were at least 18 years old, so they were in a position to provide informed consent. Prior to completing the surveys, the students were provided with a participant information statement, which detailed what the research was about, who was doing the research, why they were asked to participate, and the possible risks and benefits of being involved in the research (see Appendix 5 for a copy of the information sheet provided to students). The participant information statement noted that only the researcher and their supervisor would have access to the information provided and detailed how the results would be made available. It outlined the voluntary nature of their involvement and stated that they could opt not to take part, or if they decided to take part, they could withdraw at any time without explanation. The statement also informed students that opting not to participate or withdrawing would not affect their relationship with the university or faculty. Finally, the statement included contact details for further information. After having the information on the participant information statement explained to them, participants were provided with an opportunity to ask questions if they did not understand or if they required further information. If they opted to participate in the research, they were required to sign a consent form stating that they understood the information provided and agreed to take part (see Appendix 6 for a copy of the consent form).

3.8.2 Confidentiality

Ideally, participants should not include identifying information on an instrument. However, participants were required to include their student identification number to match their responses with their achievement data. Students were assured that their confidentiality would be maintained despite this identification requirement. Only the researcher and their supervisor would have access to the data and neither could identify the individual students by these numbers, and the student identification numbers would be deleted once the matching process was completed. Participants were also assured that no identifying information would be reported in any publications or this thesis. All hard copies of the surveys were stored in a locked cabinet and digital copies were password protected on the researchers' personal computer to ensure there was no unauthorised access to the data.

3.8.3 Consideration

To limit disruptions to the teaching program, a suitable time was negotiated with the Head of the Mathematics Department and then individual class teachers. Although the research involved administering three surveys, disruption was minimised by administering the instruments during a single session.

3.9 Summary

The research reported in this study used a combination of explanatory correlational and causal-comparative research designs. The data was collected by administering three surveys to a cluster sample of 426 (287 female and 139 male) first-year university-level mathematics students in the UAE. The sampling method was chosen due to the researcher's access to the students and their achievement data.

Each of the three instruments was provided to participants in a dual English/Arabic language format. The WIHIC instrument, which includes seven a priori scales with eight items each, was used to assess the students' perceptions of the mathematics learning environment. The SALEM instrument was used to provide self-reports regarding the students' motivation and self-regulation levels. The motivation construct was measured using three a priori scales with eight items each, and the self-regulation construct was measured with a single eight-item scale. Finally, the R-MANX instrument, which consists of 30 items and no a priori scales, was used to measure the level of the students' mathematics anxiety.

Evidence to support the reliability and validity of the three instruments when used at university level in the UAE was examined to increase confidence in the results of subsequent research objectives (Research Objective 1). Evidence involved examining the factor structure of each instrument (through exploratory factor analysis using principal component analysis with oblique rotation), the internal consistency reliability (Cronbach's alpha), discriminant validity (component correlation coefficients), and the ability to differentiate between classes (ANOVA).

Confirmation of the hypothesised research model (Research Objective 2) was necessary to confirm the relationships between the different constructs (mathematics learning environment, motivation, self-regulation, mathematics anxiety and mathematics achievement) so that gender differences could then be explored (Research Objectives 3 and 4). Confirmation of the research model required assessment of both the measurement and structural models. The measurement model needed to display satisfactory construct validity and model fit indices. The structural model also needed to display satisfactory model fit indices and coefficients of determination. Following confirmation of the model, path analyses provided standardised regression coefficients for each hypothesised relationship. It also determined which of these relationships were supported statistically. Only supported paths were maintained in the confirmed research model.

Gender differences in the students' perceptions of the mathematics learning environment, their reported levels of motivation, self-regulation and mathematics anxiety, and the level of mathematics achievement were examined by comparing scale means and standard deviations (Research Objective 3). Using independent sample t-tests and effect sizes with associated confidence intervals, statistical comparisons were made between scale means for male and female students.

To compare gender differences in the relationships established in the research model (Research Objective 4), the path analyses was repeated for each gender subgroup to calculate standardised regression coefficients for each relationship, which were then compared to determine whether the differences were statistically significant.

Before data collection, permission to carry out this research was granted by the Curtin University Human Research Committee and the host university. The student participants were old enough to provide informed consent to participate in the research. They were provided with information about the study and the possible risks and benefits of participating. Participants were allowed to ask questions and the voluntary nature of participation was stressed. At each stage of the research, steps were taken to ensure that the data provided by students remained confidential. The collection of the data was carried out in such a way as to limit any possible disruption to the teaching program.

Chapter 4

RESULTS: VALIDATION OF INSTRUMENTS

4.1 Introduction

As described in the previous chapter, the research reported in this study used adapted, dual English/Arabic versions of the WIHIC, SALEM and R-MANX instruments to collect the data. To use these instruments with confidence, it was first necessary to establish their reliability and validity. Validation of each instrument involved an initial process of factor analysis, which grouped the items into factors based on their shared variance. Following the formation of factor groupings, each grouping was assessed to ensure that they met three criteria: (1) they must display internal consistency reliability, which requires the items of each factor to correlate closely to one another; (2) the factors must display discriminant validity, which ensures that they are measuring a unique aspect of the construct: and (3) the factors should differentiate between the results from different classes. Providing these criteria are satisfied, the data is suitable to be used for further analysis. In this chapter, evidence to support the reliability and validity of each instrument when used with university-level students in the United Arab Emirates (UAE), is provided under the following headings:

- Validity and reliability of the WIHIC instrument (Section 4.2)
- Validity and reliability of the SALEM (Section 4.3)
- Validity and reliability of the R-MANX (Section 4.4).

4.2 Validity and Reliability of the WIHIC Instrument

The following sections provide evidence to support the reliability and validity of WIHIC when used with university-level students in the UAE (Research Objective 1). First, the results for the factor analysis are reported (Section 4.2.1), followed by the internal consistency reliability for individual scales (Section 4.2.2), discriminant validity (Section 4.2.3) and the ability to differentiate between classes (Section 4.2.4).

4.2.1 Factor Analysis

The 56 items of the WIHIC were subjected to principal axis factoring with oblique rotation, using SPSS version 22 (as detailed in Chapter 3). The Kaiser-Meyer-Olkin (KMO) measure of sampling adequacy produced a value of .932. This value exceeded the recommended value of .5 (Kaiser, 1970, 1974), which indicates that the sample size was adequate for factor analysis. Bartlett's Test of Sphericity (Bartlett, 1954) approximate chi-square value of 15973.941, with 1485 degrees of freedom, was statistically significant ($p = .000$), which supported the factorability of the correlation matrix.

The factor analysis process required a decision on the number of factors that should be retained for further analysis. As recommended by Costello and Osborne (2005), all factors with an eigenvalue greater than 1 should be retained. Given the WIHIC instrument had a seven-scale a priori factor structure and the seven highest eigenvalues were all above 1, it was decided to load seven factors. Using the recommended cut-off of .40 (Matsunaga, 2011) for an item loading onto a factor, two items were omitted from the remaining analysis (see factor loadings in Table 4.1). The deleted items were items 23 and 24 from the Involvement scale.

4.2.2 Internal Consistency Reliability

Cronbach's alpha statistic was used as an estimate of the mean of the correlation coefficients found by splitting the data in two, in every possible way (Cronbach, 1951). The Cronbach's alpha values for the seven factors, which ranged from .86 to .94 (reported in Table 4.2), were considerably higher than the recommended minimum value of .7 (Taber, 2018). These values indicate that the items that load onto each of the seven factors were sufficiently interrelated. Therefore, the instrument had acceptable internal consistency reliability.

Table 4-1: Factor Loadings for Individual Items and Eigenvalues and Percentage Variance for WIHIC Scales

Item no.	Factor loading						
	Student Cohesiveness	**Teacher Support**	**Involvement**	**Investigations**	**Task orientation**	**Collaboration**	**Equity**
1	.68						
2	.69						
3	.64						
4	.74						
5	.65						
6	.67						
7	.79						
8	.77						
9	-	.69					
10		.68					
11		.75					
12		.68					
13		.75					
14		.80					
15		.75					
16		.59					
17			.79				
18			.68				
19			.58				
20			.77				
21			.69				
22			.78				
25				.62			
26				.59			
27				.77			
28				.60			
29				.87			
30				.79			
31				.83			
32				.58			
33					.58		
34					.77		
35					.67		
36					.65		
37					.75		
38					.69		
39					.72		
40					.78		
41						.49	
42						.69	
43						.78	
44						.82	
45						.64	
46						.70	
47						.80	
48						.73	
49							.70
50							.76
51							.73
52							.89
53							.81
54							.84
55							.76
56							.82
% Variance	4.05	2.91	28.98	7.04	5.65	3.25	10.55
Eigenvalue	2.23	1.60	15.94	3.87	3.11	1.79	5.80

Factor loadings smaller than .40 were omitted.
The sample consisted of 426 students in 27 classes.
Total percentage of variance = 62.4%.

Table 4-2: Internal Consistency Reliability (Cronbach's Alpha Coefficient) for WIHIC scales

Scale	No. of items	Alpha reliability
Student cohesiveness	8	.86
Teacher support	8	.92
Involvement	6	.89
Investigation	8	.92
Task orientation	8	.86
Collaboration	8	.90
Equity	8	.94

4.2.3 Discriminant Validity

The criteria used to measure discriminant validity was that correlation coefficients greater than .8 would indicate that pairs of factors are so related they are measuring the same aspect of the construct (Cronbach, 1951; Field, 2005). All correlations between pairs of components were significant at the .01 level indicating that all components were related to each other. Along with the maximum correlation coefficient of .61, these results indicate that although the scales are related, they are still measuring unique aspects of the learning environment construct. Discriminant validity of the dual English/Arabic version of the WIHIC instrument was supported.

Table 4-3: Component Correlation Matrix For WIHIC Scales

Scales	SC	TS	IV	IN	TO	CO	EQ
Student cohesiveness (SC)	-						
Teacher support (TS)	.23**	-					
Involvement (IV)	.47**	.55**	-				
Investigation (IN)	.35**	.49**	.61**	-			
Task orientation (TO)	.31**	.30**	.34**	.40**	-		
Collaborate (CO)	.54**	.31**	.49**	.42**	.43**	-	
Equity (EQ)	.20**	.58**	.32**	.26**	.32**	.20**	-

*** $p < .001$; ** $p < .01$; * $p < .05$

4.2.4 Ability to Differentiate Between Classes

The ability of the dual English/Arabic version of the WIHIC instrument to differentiate between classes was examined by using analysis of variance (ANOVA) with class membership as the independent variable. Statistically significant results were obtained for four of the seven WIHIC scales: teacher support ($p < .001$), involvement ($p < .01$), task orientation ($p < .01$) and equity ($p < .001$). The three exceptions were student cohesiveness, investigations and collaboration.

Table 4-4: Ability to Differentiate Between Classrooms (ANOVA Results) for WIHIC Scales

Scale	No. of Items	ANOVA Eta^2
Student cohesiveness	8	.07
Teacher support	8	.28***
Involvement	6	.11**
Investigation	8	.07
Task orientation	8	.11**
Collaboration	8	.08
Equity	8	.19***

*** $p < .001$; ** $p < .01$; * $p < .05$

4.3 Validity and Reliability of the SALEM Instrument

This section examines the factor structure (Section 4.3.1), internal consistency reliability (Section 4.3.2), discriminant validity (Section 4.3.3) and the ability to differentiate between classes (Section 4.3.4) of the dual English/Arabic version of the SALEM instrument. The same procedures were used as with the validation of the dual English/Arabic language version of the WIHIC instrument described in Section 4.2.

4.3.1 Factor Analysis

As with WIHIC, the 32 items of the SALEM instrument were subjected to principal axis factoring with oblique rotation, using SPSS version 22. Following the initial process, the KMO measure of sampling adequacy produced a value of .895, which exceeded the recommended value of .5 (Kaiser, 1970, 1974) and indicated a high level of sampling adequacy. Bartlett's Test of Sphericity (Bartlett, 1954) produced an approximate chi-square value of 5680.11 with 465 degrees of freedom, which supported a significant ($p = .000$) correlation between factors.

The exploratory factor analysis process, reported in Table 4.5, revealed four factors that matched the a priori factor structure of the instrument. All four factors were retained as they all had an eigenvalue greater than the recommended value of 1 (Costello & Osborne, 2005). Item 30 from the self-regulation scale was omitted due to having a factor loading below the recommended .4 cut-off (Matsunaga, 2011). The remaining 31 items all loaded on their a priori scale at .4 or more and at less than .4 on all other scales. The four factors that loaded explained a total of 51.42% of the variance.

4.3.2 Internal Consistency Reliability

Internal consistency reliability of the dual English/Arabic SALEM was examined by calculating Cronbach's alpha for each factor. The Cronbach's alpha value for each factor, reported in Table 4.6, ranged from .82 to .88, which indicates good internal consistency reliability for all factors (Field, 2005).

4.3.3 Discriminant Validity

Discriminant validity for the dual English/Arabic version of the SALEM instrument was determined by use of the component correction matrix. The results reported in Table 4.8 indicate significant correlations between all components. The maximum correlation coefficient of .5 is well below the recommended maximum of .8 (Cronbach, 1951), which confirms that although all the components are related, they are still measuring unique aspects of the construct (Field, 2005). These results support the discriminant validity of the dual English/Arabic version of SALEM.

Table 4-5: Factor Loadings for Individual Items and Eigenvalues and Percentage Variance for SALEM scales

	Factor loadings			
Item no.	**Learning goal orientation**	**Task value**	**Self-efficacy**	**Self-regulation**
1	.58			
2	.46			
3	.53			
4	.76			
5	.66			
6	.76			
7	.84			
8	.62			
9		.74		
10		.69		
11		.69		
12		.66		
13		.72		
14		.59		
15		.66		
16		.49		
17			.73	
18			.71	
19			.73	
20			.68	
21			.74	
22			.73	
23			.76	
24			.69	
25				.73
26				.77
27				.74
28				.58
29				.60
31				.60
32				.62
% variance	6.159	27.597	10.078	7.587
Eigenvalue	1.909	8.555	3.124	2.352

Factor loadings less than .4 were omitted.
The sample consisted of 426 students in 27 classes.

Table 4-6: Internal Consistency Reliability (Cronbach's Alpha Coefficient) for SALEM Scales

Scale	No. of items	Alpha reliability
Learning goal orientation (LGO)	8	.85
Task value (TV)	8	.85
Self-efficacy (SE)	8	.88
Self-regulation (SR)	7	.82

Table 4-7: Component Correlation Matrix for SALEM Scales

Scale	LGO	TV	SE	SR
Learning goal orientation (LGO)	-	.50**	.29**	.42**
Task value (TV)		-	.41**	.36**
Self-efficacy (SE)			-	.38**
Self-regulation (SR)				-

*** $p < .001$; ** $p < .01$; * $p < .05$

4.3.4 Ability to Differentiate Between Classes

The ability of the dual English/Arabic version of the SALEM instrument to differentiate between classes was examined by using ANOVA with class membership as the independent variable. The results reported in Table 4.8 indicate that the learning goal orientation and task value scales in the questionnaire were able to adequately differentiate between classes at the 0.05 level of significance. The remaining two scales (self-efficacy and self-regulation) would have also been significant if the level had been relaxed to .10.

Table 4-8: Ability to Differentiate Between Classrooms (ANOVA results) for SALEM Scales

Scale	No. of items	ANOVA Eta^2
Learning goal orientation	8	.16***
Task value	8	.09*
Self-efficacy	8	.07
Self-regulation	7	.08

*** $p < .001$; ** $p < .01$; * $p < .05$

4.4 Validity and Reliability of the R-MANX Instrument

This section examines the factor structure (Section 4.4.1), internal consistency reliability (Section 4.4.2), discriminant validity (Section 4.4.3) and the ability to differentiate between classes (Section 4.4.4) of a dual English/Arabic version of the R-MANX. The same procedures were used as with the validation of the dual English/Arabic language version of the WIHIC and SALEM instruments described in sections 4.2 and 4.3.

4.4.1 Factor Analysis

The 30 items in the R-MANX were subjected to principal axis factoring, using SPSS version 26. As with the previous surveys, two tests were used to determine whether the data was suitable for factor analysis. The first test, the KMO measure of sampling adequacy, produced a total sample value of .916, which exceeds the .5 value recommended by Kaiser (1970, 1974). The KMO values indicate that the sample size is adequate for factor analysis. The second test, Bartlett's Test of Sphericity (Bartlett, 1954), had an approximate chi-square value of 5213.101 with 435 degrees of freedom and was statistically significant ($p = .000$), which supported the factorability of the correlation matrix.

Exploratory factor analysis results, reported in Table 4.9, required three iterations to extract a single factor. Of the 30 items, 18 items loaded onto a single factor while the remaining 12 items were omitted due to having factor loadings below the .40

recommended threshold (Matsunaga, 2011) or due to having fewer than three items loading onto a factor.

Table 4-9: Factor Loadings for Individual Items and Eigenvalues and Percentage Variance for R-MANX Items

Factor loadings	
Item no.	**Mathematics Anxiety**
2	.58
6	.60
7	.65
8	.65
10	.63
11	.66
12	.56
13	.67
15	.77
16	.79
18	.69
20	.74
21	.67
22	.63
25	.68
26	.55
27	.68
28	.64
% variance	42.40
Eigenvalue	9.32

The sample consisted of 426 students in 27 classes

4.4.2 Internal Consistency Reliability

The Cronbach's alpha value for the single mathematics anxiety factor was .93. This value was higher than the minimum recommended value of .8, which indicates that the

22 items were sufficiently related to each other (Cronbach, 1951). The R-MANX instrument was found to have acceptable internal consistency reliability.

4.4.3 Discriminant Validity

Discriminant validity tests the relationship between factors. Given that factor analysis revealed a unidimensional construct, with items loading onto a single factor, it was not necessary to examine for discriminant validity.

4.4.4 Ability to Differentiate Between Classes

ANOVA, with class membership as the independent variable, was used to examine the ability of the R-MANX instrument to differentiate between classes. The ANOVA results indicated that the single mathematics anxiety factor had an eta-squared value of .09, which was statistically significant at the .05 level. This result supports the adequacy of the R-MANX instrument in differentiating between classes.

4.5 **Summary**

This chapter provided evidence of the reliability and validity of the instruments used to assess the learning environment, motivation, self-regulation, mathematics anxiety and mathematics achievement of university-level students at in the UAE. The data collected from 426 students was used to examine each of the instruments separately for factor structure, internal consistency reliability, discriminant validity and the ability to differentiate between classes.

For the WIHIC instrument, the factor structure indicated that all but two WIHIC items (both in the Involvement scale) loaded onto their a priori factor with a factor loading greater than .4 and less than .4 on any other factor. The seven a priori factors accounted for 62.4% of the total variance. Internal consistency reliability was achieved with Cronbach's alpha values ranging from .86 to .92. Discriminant validity was also achieved as correlations between scales were all significant at the .01 level and the highest correlation of .61 was well below the recommended maximum of .8. The eta-squared values used to measure the ability to differentiate between classes ranged from .07 and .28, with four of the seven WIHIC scales significant.

The factor structure of the SALEM instrument, examined using principal axis factoring with oblique rotation, indicated that all but one item (from the self-regulation scale) loaded onto their a priori factor with a value greater than .4 and less than .4 on any other factor. The total variance explained by the factors was 51.42%. Internal consistency reliability was achieved with Cronbach's alpha values ranging from .82 to .88. Discriminant validity was also achieved as correlations between scales were all significant at least the .05 level and the highest correlation of .50 was below the recommended maximum of .80. The eta-squared values ranged from .07 to .16, with two of the scales significant.

The factor structure of the R-MANX instrument indicated that 18 of the 30 items loaded onto a single factor with loadings greater than .4 and less than .4 on any other factor. Of the remaining 11 items, eight were discarded for loading below the .4 threshold and three were discarded for loading onto a second factor, which had insufficient items. The total variance explained by the single factor was 42.40%. Internal consistency reliability was achieved with a Cronbach's alpha value of .93. The ability to differentiate between classes was also satisfied by an eta-squared value for the factor of .09, which was significant at the .05 level.

The analysis of the WIHIC, SALEM and R-MANX instruments provided strong support for each instrument, indicating that they each displayed satisfactory reliability and validity when used to assess university-level students in the UAE and confirming Research Objective 1.

Chapter 5

RESULTS: TESTING THE HYPOTHESES AND EXAMINING GENDER DIFFERENCES

5.1 Introduction

Whereas the results of the analyses used to address Research Objective 1 are reported in the previous chapter, the purpose of this chapter, Chapter 5, is to report the results of the analyses used to address the remaining research objectives (Research Objectives 2 to 4). This analyses involved the confirmation of the research model for use in the study (Research Objective 2); gender comparisons in their perceptions of the constructs (Research Objective 3); and gender comparisons in the relationships between the constructs (Research Objective 4).

These results are reported using the following headings.

- Descriptive statistics (Section 5.2)
- Confirming the research model (Section 5.3)
- Evaluating the structural model (Section 5.4)
- Gender Differences (Section 5.5)

5.2 Descriptive Statistics

As described in Chapter 3, to ensure that Research Objectives 2 and 3 could be addressed, it was necessary to generate descriptive statistics. As Research Objective 2 sought to confirm the research model, these analyses required the univariate normality of the data. The descriptive statistics therefore included the mean and standard deviation for each scale and their kurtosis and skewness values. The univariate normality was assessed by considering the data skewness and kurtosis (Hair et al., 2014; Tabachnick & Fidell, 2013). Skewness values for the scales ranged from -2.20 to 1.46, whereas kurtosis values ranged from -1.19 to 5.16 (descriptive statistics provided in Appendix 7). These results indicated that all items had skewness and kurtosis indices well within the recommended accepted levels of |3| and |10| Kline (Kline, 2010), which supported there use for further analysis.

Of the thirteen scales, only mathematics anxiety had item means that were below the mid-point of 3.0 on a 5-point Likert scale. This is acceptable given that mathematics anxiety, unlike the other constructs, is not considered a positive attribute. Only two of 13 scales had a difference in item means greater than 1.0; most were considerably less. These results indicate that the item means for each scale were similar. Scale standard deviations ranged from 0.45 to 1.40; however, the largest range of standard deviations for an individual scale was 0.48, which indicates that scale items also had a similar spread.

5.3 **Confirming the Research Model**

For confirmation of the research model it was necessary to evaluate both the measurement model (Section 5.3.1) and the structural model (Section 5.3.2). The measurement model assessed the measurement theory by demonstrating how the constructs (latent variables) were operationalised by sets of measured (indicator) variables (Tabachnick & Fidell, 2013). In contrast, the structural model consists of a set of dependence relationships linking the constructs that were hypothesised in the research model (Hair et al., 2014).

5.3.1 Assessing the Measurement Model

As described in Chapter 3, the measurement model was assessed using multi-group confirmatory factor analysis (MGCFA). This maximum likelihood estimation (MLE) procedure assumes both univariate and multivariate normality. Univariate normality was reported in Section 3.2. Mardia's coefficient (Mardia, 1970), or normalised multivariate kurtosis value, was used to assess the multivariate normality. Mardia's coefficient for the data in this study was 1192.29, which is less than the critical value of 11772 based on the calculation of the formula $p(p + 2)$ where p = the number of observed variables in the model (Raykov & Marcoulides, 2008). Therefore, multivariate normality of the data was also assumed.

The construct validity was examined by investigating, first, the convergent validity, which was used to determine the proportion of variance shared by the indicator variables of a given latent construct (reported in Section 5.3.1.1); and second, the discriminant validity, which was used to determine whether each latent construct was sufficiently distinct from other latent constructs. It captures some aspects that other constructs do not (reported in Section 5.3.1.2). Following the confirmation of the construct validity, the model fit indices were reported (Section 5.3.1.3).

5.3.1.1 Convergent Validity

Convergent validity was evaluated using factor loadings, composite reliability (CR) and average variance extracted (AVE) (Fornell & Larcker, 1981; Hair et al., 2014). It is recommended that all factor loadings should be greater than .50 (Fornell & Larcker, 1981), and that CR and AVE should be greater than .70 and .50, respectively (Nunnally & Bernstein, 1994). The results (provided in Appendix 8) demonstrate that all factor loadings satisfied the .50 criteria and that CR was greater than .70 for all constructs. The three lowest average variance extracted values were task value (.49), self-regulation (.47) and mathematics anxiety (.44). Therefore, all average variance extracted values were close to or greater than the .50 value, as suggested by Nunnally and Bernstein (1994). Considering the factor loadings, CR and AVE values, the data displayed satisfactory convergent validity.

5.3.1.2 Discriminant Validity

Discriminant validity assesses the degree to which the scales are empirically different. It was evaluated by examining the correlations between all pairs of scales. For the discriminant validity to be satisfactory, Fornell & Larcker (1981) suggested that the square root of a scale AVE should be higher than the correlations shared between that particular scale and the other scales in the model. Table 5.1 allows this comparison to be made. The bold diagonal values represent the square root of each scale AVE. The other values represent the correlations between scales. The square root of the AVE for each scale was greater than the correlation between that scale and other scales; therefore, the data satisfied the criteria, and discriminant validity was achieved.

Table 5-1: Discriminant Validity of the Measurement Model

Scale	SC	TS	IV	IN	TO	CO	EQ	LG	TV	SE	SR	MANX
Student cohesiveness (SC)	**(.71)**											
Teacher support (TS)	.23**	**(.75)**										
Involvement (IV)	.47**	.55**	**(.74)**									
Investigation (IN)	.35**	.49**	.61**	**(.76)**								
Task orientation (TO)	.31**	.30**	.34**	.40**	**(.71)**							
Collaboration (CO)	.54**	.31**	.49**	.42**	.43**	**(.71)**						
Equity (EQ)	.20**	.58**	.32**	.26**	.32**	.20**	**(.81)**					
Learning goal orientation (LGO)	.30**	.20**	.30**	.28**	.41**	.24**	.18**	**(.71)**				
Task value (TV)	.28**	.37**	.39**	.48**	.32**	.30**	.22**	.50**	**(.71)**			
Self-efficacy (SE)	.19**	.39**	.30**	.36**	.34**	.10*	.35**	.29**	.41**	**(.73)**		
Self-regulation (SR)	.31**	.21**	.32**	.36**	.64**	.29**	.21**	.42**	.36**	.38**	**(.71)**	
Mathematics anxiety (MANX)	.11*	.15**	.19**	.19**	.21**	.01	.23**	.19**	.18**	.43**	.22**	**(.63)**

* $p < .1$, ** $p < .05$, *** $p < .01$

Construct validity requires both convergent validity and discriminant validity. Since this has been achieved, construct validity is also achieved and the measurement model was suitable for further examination of its fit.

5.3.1.3 Model Fit Indices

It is recommended that model fit be assessed using a variety of fit indices (Harrington, 2009; Kline, 2010; Tabachnick & Fidell, 2007). Model fit was evaluated using the following indices: chi-square (χ^2); normed chi-square (χ^2/df); Tucker-Lewis index (TLI); comparative fit index (CFI); incremental index of fit (IFI); root-mean-square error of approximation (RMSEA); and standardised root-mean-square residual (SRMR). Chi-square, normed Chi-square, RMSEA and SRMR are absolute fit indices, which directly measure how well the hypothesised model fits the observed data, whereas TLI, CFI and IFI are incremental fit indices, which assess how well the hypothesised model fits relative to a baseline model. For a sample size greater than 250 ($N = 426$) and more than 30 observed variables ($m = 108$), Hair et al. (2014) consider TLI and CFI values greater than .90 to indicate reasonable fit. Other criteria adopted to indicate satisfactory fit are recorded in Table 5.2.

Table 5-2: Model Fit Indices of the Measurement Model

Model fit indices	**Criteria**	**Values**	**References**
χ^2	Non-significant	7800.83, significant	Jöreskog & Sörbom (1993)
df		5364	
χ^2/df	< 3	1.45	Hu & Bentler (1999); Kline (2010)
TLI	≥ .90	.903	Hu & Bentler (1999); McDonald & Ho (2002)
CF)	≥ .90	.910	Hair et al. (2014)
IFI	≥ .90	.911	Bollen (1989)
RMSEA	< .080	.033	Hair et al. (2014)
SRMR	< .080	.056	Hair et al. (2014)

The chi-square test of measurement model fit was significant ($\chi^2 = 7800.83, \text{df} = 5364, p < .000$); however, this test is sensitive to large sample sizes, such as the one reported in this thesis ($N = 426$). Additional tests, including the normed chi-square result ($\chi^2/\text{df} = 1.45$), CFI (.910), TLI (.903), IFI (.911), RMSEA (.033) and SRMR (.056), all supported a measurement model with reasonable fit; therefore, indicator variables were considered adequate representations of the latent constructs.

5.4 Evaluating the Structural Model

Research Objective 2 was to evaluate the hypothesised research model. The research model is a structural model, which builds on the measurement model by including all hypothesised relationships between the latent factors. As justified in Chapter 3, evaluating the structural model, which included 12 latent variables, required an initial structural equation modelling (SEM) analysis of the direct relationships between pairs of latent factors as part of five simple models. The statistically significant relationships supported in these simple models were combined to form a larger, more complex structural model for further SEM analysis of direct and indirect relationships. Given the complexity of the hypothesised research model, this method simplified the process by enabling relationships that were not shown to be significant in the simple models to be removed prior to the final analysis.

The section reports the results for the first of the two-part process used to confirm the appropriateness of the hypothesised research model for further analyses. This process was used to determine which of the hypothesised paths were to be included in the research model to form the structure for gender comparisons. The following subsections report the findings for the five simple models. Section 5.4.1 reports the analysis investigating the direct relationship between the learning environment factors and mathematics achievement and the indirect relationships via motivation, self-regulation and mathematics anxiety. Section 5.4.2 reports the analysis investigating the direct relationship between motivation and mathematics achievement and the indirect relationship via self-regulation. Section 5.4.3 reports the analysis investigating the direct relationship between mathematics anxiety and the indirect relationship via motivation. Section 5.4.4 reports the analysis investigating the mediating effect of learning environment factors on mathematics achievement through motivation, self-regulation and mathematics anxiety. Finally, Section 5.4.5 reviews the analyses of the models to determine whether they support the nine initial hypothesised relationships.

5.4.1 Relationships Between Learning Environment and Mathematics Achievement

This section reports the investigation of the direct relationship between learning environment (LE) and mathematics achievement (ACHT) and possible indirect relationships via motivation (MOT), self-regulation (SR) and mathematics anxiety (MANX). This initial analysis was carried out using the three simple models with relationships between learning environment (LE) and mathematics achievement (ACHT):

- Model 1: LE → MOT → ACHT
- Model 2: LE → SR → ACHT
- Model 3: LE → MANX → ACHT

Model 1: LE → MOT → ACHT

Model 1 consists of three component models:

- Model 1(a) = LE → ACHT, the direct relationship between learning environment and mathematics achievement.
- Model 1(b) = LE → MOT, the direct relationship between learning environment and motivation.
- Model 1(c) = MOT → ACHT, the direct relationship between motivation and mathematics achievement.

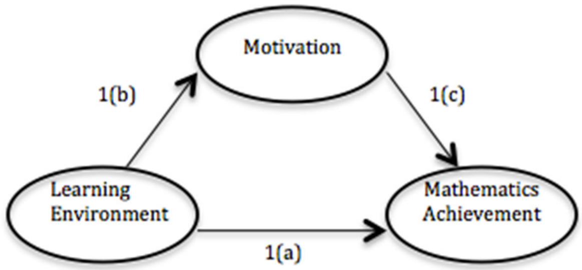

Figure 5-1: Simple Model 1

The associated model fit indices for Model 1(a) of chi-squared 2368.695 ($df = 1378, p <.001$), $RMSEA = .04$, $CFI = .919$, $TLI = .913$ and $SRMR = .056$ indicate that the model was a good fit for the data. The standardised correlation coefficients and associated t-values for the four learning environment factors found to have significant direct relationships with mathematics achievement are included in Table 5.3. The coefficient of determination (R^2) of .106 for the dependent mathematics achievement variable indicates that the student cohesiveness, investigations, task orientation and collaboration factors jointly accounted for 10.6% of the variation in mathematics achievement. These four relationships were retained as part of a more complex structural model for further analysis. The three relationships that were not statistically significant were omitted from further analysis.

Table 5-3: Results for Structural Model 1(a): LE → ACHT

Hypothesised relationships	**Standardised path coefficients**	**Standard error**	**t-values**	**Hypothesis**
SC → ACHT	.229	.090	2.433***	Supported
IV → ACHT	.216	.063	3.417***	Supported
TO → ACHT	.292	.069	4.245***	Supported
CO → ACHT	.284	.070	3.737***	Supported

* $p < .1$, ** $p < .05$, *** $p < .01$

Model 1(b), the direct relationships between learning environment and motivation, included the three motivation factors of learning goal orientation (LGO), which measures students' perceptions of their ability to focus on the learning process rather than results; task value (TV), which measures students' perceptions of the level of worth assigned to an activity; and self-efficacy (SE), which measures students' perceptions of their ability to master a new skill or task. The associated model fit indices of chi-squared 4398.337 $(df = 2849, p < .001)$, $CFI = .909$, $TLI = .904$, $SRMR = .053$ and $RMSEA = .036$ indicate that the model was a good fit for the data.

The standardised path coefficients and associated t-values of the eight significant direct relationships in Model 1(b) are recorded in Table 5.4. These eight relationships were retained as part of a more complex model for further analysis. The thirteen relationships that were not statistically significant were omitted from further analysis.

Table 5-4: Results for Structural Model 1(b): LE → MOT

Hypothesized relationships	**Standardised path coefficients**	**Standard error**	**t-values**	**Hypothesis**
SC → LGO	.173	.059	2.930**	Supported
TO → LGO	.429	.063	6.784***	Supported
TS → TV	.216	.059	3.659***	Supported
INV → TV	.330	.064	5.145***	Supported
TO → TV	.201	.063	3.189***	Supported
TS → SE	.353	.080	4.399***	Supported
TO → SE	.317	.069	4.627***	Supported
CO → SE	.292	.063	4.646***	Supported

* $p < .1$, ** $p < .05$, ***$p < .01$

The associated model fit indices for Model 1(c) of chi-squared 480.53 $(df = 260, p < .001)$, CFI=.939, TLI=.929, SRMR=.056 and RMSEA=.042 indicate that the model was a good fit for the data. The standardised estimates and associated t-values of the significant direct relationships in Model 1(c), reported in Table 5.5, indicate that all three motivation scales (LGO, TV and SE) positively correlated with mathematics achievement. A coefficient of determination (R^2) of .23 for the dependent mathematics achievement variable indicates that the motivation factors account for 23% of the variance in mathematics achievement. These three relationships were retained as part of a more complex model for further analysis. The four relationships that were not significant were omitted from further analysis.

Table 5-5: Results for Structural Model 1(c): MOT → ACHT

Hypothesised relationships	**Standardised path coefficients**	**Standard error**	**t-values**	**Hypothesis**
LGO → ACHT	.14	.06	2.12**	Supported
TV → ACHT	.28	.07	3.86***	Supported
SE → ACHT	.53	.07	8.63***	Supported

$* p < .1$, $** p < .05$, $*** p < .01$

Model 2: LE → SR → ACHT

Model 2 consists of three component models:

- Model 1(a) = LE → ACHT, the direct relationship between learning environment and mathematics achievement.
- Model 2(a) = LE → SR, the direct relationship between learning environment and self-regulation.
- Model 2(b) = SR → ACHT, the direct relationship between self-regulation and mathematics achievement.

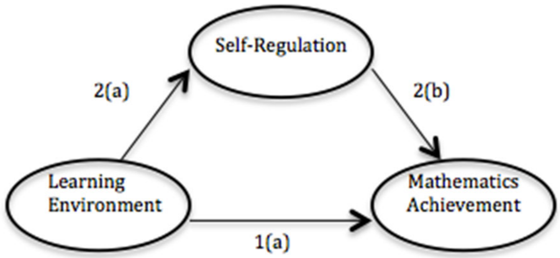

Figure 5-2: Simple Model 2

The investigation of Model 1(a) was reported above. The associated model fit indices for Model 2(a) of chi-squared 3040.774 ($df = 1771, p < .001$), CFI=.908, TLI=.902, SRMR=.058, and RMSEA=.401 indicate that the model was a good fit for the data. The standardised estimates and associated t-values of the significant direct relationships in Model 2(a), reported in Table 5.6, indicate that three of the seven scales (student cohesion, task orientation, and collaboration) had a direct positive relationship with self-regulation. These three relationships were retained as part of a more complex model for further analysis. The four relationships that were not statistically significant were omitted from further analysis. A coefficient of determination (R^2) of .638 for the dependent self-regulation variable indicates that student cohesion, task orientation and collaboration jointly accounted for 63.8% of the variance in self-regulation.

Table 5-6: Results for Structural Model 2(a): LE → SR

Hypothesised relationships	Standardised path coefficients	Standard error	t-values	Hypothesis
SC → SR	.254	.081	3.134**	Supported
TO → SR	.788	.057	13.862***	Supported
CO → SR	.221	.083	2.654**	Supported

$^* p < .1$, $^{**} p < .05$, $^{***} p < .01$

The associated model fit indices for Model 2(b) of chi-squared 24.749 ($df = 22, p < 0.001$), CFI = .997, TLI = .995, SRMR = .023 and RMSEA = .015 indicate that the model was a good fit for the data. The standardised estimates and associated t-values of the significant direct relationship in Model 2(b) is reported in Table 5.7. This relationship was retained as part of a more complex model for further analysis. A coefficient of determination (R^2) of .09 for the dependent mathematics achievement variable indicates that self-regulation accounts for 9% of the variance in mathematics achievement.

Table 5-7: Results for Structural Model 2(b): SR → ACHT

Hypothesised relationships	**Standardised path coefficients**	**Standard error**	**t-values**	**Hypothesis**
SR → ACHT	.299	.054	5.551***	Supported

* $p < .1$, ** $p < .05$, ***$p < .01$

Model 3: LE → MANX → ACHT

Model 3 consists of three component models:

- Model 1(a) = LE → ACHT, the direct relationship between learning environment and mathematics achievement.
- Model 3(a) = LE → MANX, the direct relationship between learning environment and mathematics anxiety.
- Model 3(b) = MANX → ACHT, the direct relationship between mathematics anxiety and mathematics achievement.

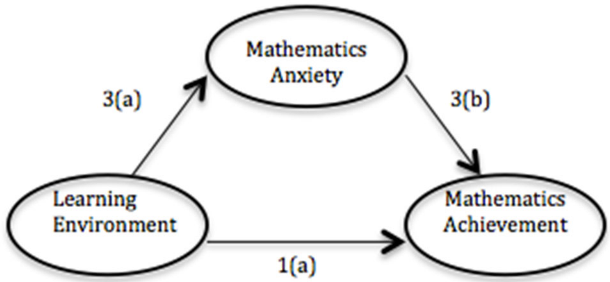

Figure 5-3: Simple Model 3

The results for Model 1(a) were reported above. The associated model fit indices for Model 3(a) of chi-squared 4892.427 $(df = 3247, p < .001)$CFI = .909, TLI = .902, SRMR = .061 and RMSEA = .034 indicate that the model was a good fit for the data. The standardised estimates and t-values of the significant direct relationships, reported in Table 5.8, indicate that task orientation, collaboration and equity had a significant negative relationship with mathematics anxiety. These three relationships were retained as part of a more complex model for further analysis. The four relationships that were not statistically significant were omitted from further analysis. A coefficient of determination (R^2) of .108 for the dependent mathematics anxiety variable indicated that task orientation, collaboration and equity accounted for 10.8% of the variance in mathematics anxiety.

Table 5-8: Results for Structural Model 3(b): LE → MANX

Hypothesised relationships	Standardised path coefficients	Standard error	t-values	Hypothesis
TO → MANX	-.232	.073	-3.200***	Supported
CO → MANX	-.132	.063	-2.107*	Supported
EQ → MANX	-.203	.057	-3.588***	Supported

* $p < .1$, ** $p < .05$, ***$p < .01$

The associated model fit indices for Model 3(b) of chi-squared 271.979 $(df = 135, p < .001)$, CFI = .956, TLI = .944, SRMR = .038 and RMSEA = .049 indicate that the model was a good fit for the data. The standardised path coefficient and t-value of the significant direct relationship, reported in Table 5.9, indicate that mathematics anxiety had a negative relationship with mathematics achievement. This relationship was retained as part of the more complex model for further analysis. A coefficient of determination (R^2) of .185 for the dependent mathematics achievement variable indicates that mathematics anxiety accounted for 18.5% of the variance in mathematics achievement.

Table 5-9: Results for Structural Model 3(b): MANX → ACHT

Hypothesised relationships	Standardised path coefficients	Standard error	t-values	Hypothesis
MANX → ACHT	-.430	.048	-9.003***	Supported

$* p < .1, ** p < .05, ***p < .01$

5.4.2 Motivation Related to Mathematics Achievement

This section reports the investigation of the direct relationship between motivation and mathematics achievement and the possible indirect relationship via self-regulation. This required the analysis of the single model that included relationships between motivation (MOT) and mathematics achievement (ACHT).

Model 4: MOT → SR → ACHT

Model 4 consists of three component models:

- Model 1(c) = MOT → ACHT, the direct relationship between motivation and mathematics achievement.
- Model 4(a) = MOT → SR, the direct relationship between motivation and self-regulation.
- Model 2(b) = SR → ACHT, the direct relationship between self-regulation and mathematics achievement.

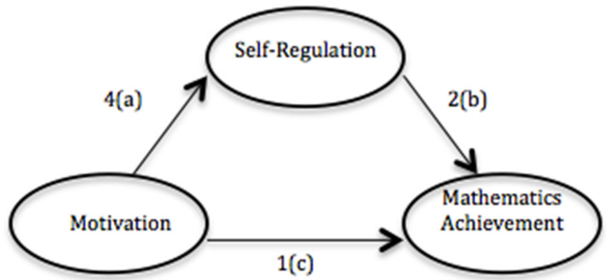

Figure 5-4: Simple Model 4

The results of models 1(c) and 2(b) are reported above. The associated model fit indices for Model 4(a) of chi-squared 757.313 ($df = 447, p < 0.001$), CFI = .934, TLI = .926, SRMR = .054 and RMSEA = .040 indicate that the model was a good fit for the data. The standardised path coefficients and t-values of the significant direct relationships between motivation and self-regulation, reported in Table 5.10, indicate that learning goal orientation and self-efficacy were positively related to self-regulation. These two relationships were retained as part of a more complex model for further analysis. The relationship that was not statistically significant was omitted from further analysis. A coefficient of determination (R^2) of .443 for the dependent self-regulation variable means that learning goal orientation and self-efficacy accounted for 44.3% of the variance in self-regulation.

Table 5-10: Results for Structural Model 4(a): MOT → SR

Hypothesised Relationships	Standardised Path Coefficients	Standard error	t-values	Hypothesis
LGO → SR	.362	.065	5.585***	Supported
SE → SR	.459	.058	7.928***	Supported

* $p < .1$, ** $p < .05$, ***$p < .01$

5.4.3 Mathematics Anxiety Related to Mathematics Achievement

This section reports the investigation of the direct relationship between mathematics anxiety and mathematics achievement and the possible indirect relationship via motivation. This required the analysis of the single model that included relationships between mathematics anxiety (MANX) and mathematics achievement (ACHT).

Model 5: MANX → MOT → ACHT

Model 5 consists of three component models:

- Model 3(b) = MANX → ACHT, the direct relationship between mathematics anxiety and mathematics achievement.
- Model 5(a) = MANX → MOT, the direct relationship between mathematics anxiety and motivation.
- Model 1(c) = MOT → ACHT, the direct relationship between motivation and mathematics achievement.

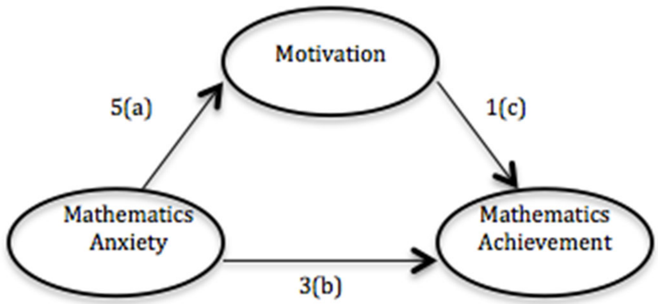

Figure 5-5: Simple Model 5

The results for Models 3(b) and 1(c) are reported above. The associated model fit indices for Model 5(a) of chi-squared 1391.799 ($df = 786, p < .001$), CFI = .916, TLI = .908, SRMR = .051 and RMSEA=.043 indicate that the model was a good fit for the data.

The standardised path coefficients and t-values of the significant direct relationships between mathematics anxiety and motivation, reported in Table 5.11, indicate that mathematics anxiety was negatively related to all three motivation scales. These three relationships were retained as part of a more complex model for further analysis. Coefficients of determination (R^2) of .038, .048 and .241, respectively, for the dependent motivation variables of learning goal orientation, task value and self-efficacy indicate that mathematics anxiety accounted for 3.8%, 4.8% and 24.1% of their respective variances.

Table 5-11: Results for Structural Model 5(a): MANX → MOT

Hypothesised relationships	Standardised Path Coefficients	Standard error	t-values	Hypothesis
MANX → LGO	-.195	.058	-3.339***	Supported
MANX → TV	-.219	.061	-3.569***	Supported
MANX → SE	-.491	.058	-8.474***	Supported

$* p < .1$, $** p < .05$, $***p < .01$

Model 6: Final Mediated Structural Model

This section reports the construction and assessment of Model 6, which is the final structural model consisting of all significant paths in Models 1 to 5, as described in the two sections above.

The twenty-eight significant paths, established in Models 1 to 5, were combined into a single model (Model 6) to undergo a second round of SEM. The model fit indices for Model 6 of chi-squared 8109.926 ($df = 5249, p < .001$), CFI=.923, TLI=.906, SRMR=.054 and RMSEA=.034 indicate that the model was a good fit for the data. Figure 5.6 illustrates the twenty-four paths that continued to be significant after the second round of SEM. The standardised path coefficients and t-values of these statistically significant paths are reported in Table 5.12.

Coefficients of determination (R^2) for the dependent variables provided the following results:

- Student cohesiveness and task orientation accounted for 28.0% of the variance in learning goal orientation.
- Teacher support, investigation and task orientation accounted for 36.2% of the variance in task value.
- Teacher support, task orientation, collaboration and mathematics anxiety accounted for 43.2% of the variance in self-efficacy.
- Student cohesiveness, task orientation, collaboration and self-efficacy accounted for 67.8% of the variance in self-regulation.
- Task orientation, collaboration and equity accounted for 9.6% of the variance in mathematics anxiety.
- Student cohesiveness, involvement, task value, self-efficacy, self-regulation and mathematics anxiety accounted for 31.7% of the variance in mathematics achievement.

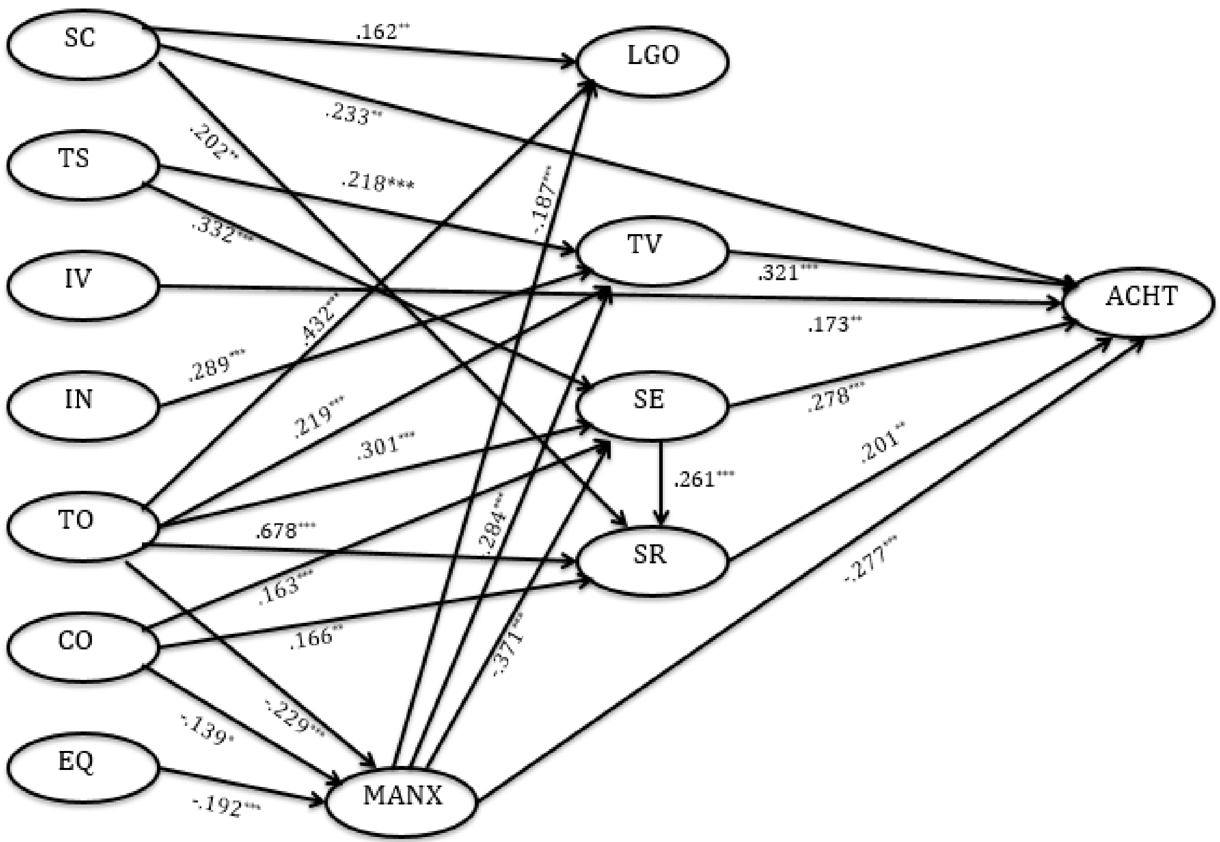

Figure 5-6: Final Structural Model

Table 5-12: Results for Final Mediated Structural Model

Hypothesised relationships	Standardised path coefficients	Standard error	t-values	Hypothesis
SC → ACHT	.233	.086	2.712**	Supported
IV→ ACHT	.173	.062	2.792**	Supported
SC → LGO	.162	.059	2.755**	Supported
TO → LGO	.432	.063	6.811***	Supported
TS → TV	.218	.058	3.773***	Supported
IN → TV	.289	.063	4.566***	Supported
TO → TV	.219	.065	3.367***	Supported
TS → SE	.332	.062	5.332***	Supported
TO → SE	.301	.069	4.350***	Supported
CO → SE	.163	.060	2.715***	Supported
TV → ACHT	.321	.071	4.549***	Supported
SE → ACHT	.278	.086	3.224***	Supported
SC → SR	.202	.074	2.716**	Supported
TO → SR	.678	.069	9.828***	Supported
CO → SR	.166	.079	2.115**	Supported
SR → ACHT	.201	.065	2.812**	Supported
TO → MANX	-.229	.074	-3.071***	Supported
CO → MANX	-.139	.073	-2.431*	Supported
EQ → MANX	-.192	.056	-3.411***	Supported
MANX → ACHT	-.277	.060	-4.653***	Supported
SE → SR	.261	.058	4.519***	Supported
MANX → LGO	-.187	.054	-2.412***	Supported
MANX → TV	-.214	.060	-2.635***	Supported
MANX → SE	-.371	.060	-6.147***	Supported

$* p < .1$, $** p < .05$, $*** p < .01$

5.4.4 Mediating Effects of Learning Environment Factors on Mathematics Achievement through Motivation, Self-Regulation and Mathematics Anxiety

The following section presents the results of the investigation of the mediation of the relationship between learning environment factors and mathematics achievement by motivation (task value and self-efficacy), self-regulation and mathematics anxiety. Collier (2020) recommended the standardised effects, and the lower and upper bounds of the 95% confidence intervals (CI) for both the direct and indirect effects are presented in Table 5.13.

Table 5-13: Test for Mediation Using Bootstrap Analysis with 95% CI

Hypothesised relationships	Direct effect	Indirect effect	CI (Direct effect)		CI (Indirect effect)	
			Low	High	Low	High
SC → SR → ACHT	-.14*	.02ns	-0.27	-.02	-0.02	0.05
TS →TV → ACHT	-.05 ns	-.05*	-0.19	0.10	-0.08	-0.01
TS → SE → ACHT	-.05 ns	.10**	-0.19	0.10	0.03	0.16
IN → TV → ACHT	.09 ns	-.07**	-0.04	0.21	-0.11	-0.02
TO → TV → ACHT	.08 ns	-.05*	-0.14	0.29	-0.08	-0.01
TO → SE → ACHT	.08 ns	0.05 ns	-0.14	0.29	-0.03	0.14
TO → SR → ACHT	.08 ns	.09 ns	-0.14	0.29	-0.01	0.26
TO → MANX → ACHT	.08 ns	.06**	-0.14	0.29	.02	0.11
CO → SE → ACHT	0.05 ns	-0.02 ns	-0.10	0.19	-0.08	0.03
CO → SR → ACHT	0.05 ns	-.01 ns	-0.10	0.19	-0.05	0.02
CO → MANX → ACHT	0.05 ns	-.04*	-0.10	0.19	-0.08	-.01
EQ → MANX → ACHT	-.07 ns	.05**	-0.21	0.07	0.02	0.09
SE → SR → ACHT	.35***	-.01 ns	0.19	0.50	-0.04	0.02

* $p < .1$, ** $p < .05$, *** $p < .01$

- The direct relationship between student cohesion and mathematics achievement was found to be significant based on the standardised direct effect (β = -.14, p< 0.10; 95% CI [-0.27, -.02]); however, it was also found that the relationship was not mediated by self-regulation (β = .02, p >.1; 95% CI [-0.02, 0.05]).
- The relationship between teacher support and mathematics achievement was mediated by task value (β = -.05, p < 0.10; 95% CI [-0.08, -0.01]) and self-efficacy (β = .10, p < .05; 95% CI [0.03, 0.16]); however, the direct relationship was not significant.

- The relationship between investigation and mathematics achievement was mediated by task value (β = -.07, p = .05; 95% CI [-0.11, -0.02]); however, the direct relationship was not significant.
- The relationship between task orientation and mathematics achievement was mediated by task value (β = -.05, p = .10; 95% CI [-0.08, -0.01]) and mathematics anxiety (β = .06, p = .05; 95% CI [0.02, 0.11]); however, the direct relationship was not significant.
- The relationship between collaboration and mathematics achievement was mediated by mathematics anxiety (β = -.04, p = .10; 95% CI [-0.08, -0.01]); however, the direct relationship was not significant.
- The relationship between equity and mathematics achievement was mediated by mathematics anxiety ($\beta = .05, p = .05, 95\%$CI [0.02, 0.09]); however, the direct relationship was not significant.
- The direct relationship between self-efficacy and mathematics achievement was found to be significant ($\beta = .35, p = .01, 95\%$CI [0.19, 0.50]).

5.4.5 Hypothesis Testing

To develop the final structural model, nine relationships were hypothesised between the learning environment, motivation, self-regulation, mathematics anxiety and mathematics achievement constructs. These relationships were based on a review of the literature and the personal experience of the researcher. The relationships were not considered to be an absolute representation of all relationships between the constructs. The data collected was cross-sectional, which restricted the hypotheses to a one-way relationship. This section reviews the analysis in terms of the hypothesised relationships.

Hypothesis 1: Mathematics learning environment is related to motivation.

The learning environment and motivation constructs consisted of seven and three latent factors, respectively; of the 21 possible relationships, eight (SC → LGO; TO → LGO; TS → TV; IV → TV; TO → TV; TS → SE; TO → SE; CO → SE) were statistically significant.

Hypothesis 2: Mathematics learning environment is related to self-regulation.

Self-regulation was a single factor construct; of the seven possible relationships, three (SC → SR; TO → SR; CO → SR) were statistically significant.

Hypothesis 3: Mathematics learning environment is related to mathematics anxiety.

Mathematics anxiety was a single factor construct; of the seven possible relationships, three (TO → MANX; CO → MANX; EQ → MANX) were statistically significant.

Hypothesis 4: Mathematics learning environment is related to mathematics achievement.

Mathematics achievement was a single factor construct; of the seven possible relationships, two (SC → ACHT; IN → ACHT) were statistically significant.

Hypothesis 5: Motivation is related to self-regulation.

Self-regulation was a single factor construct; of the three possible relationships with motivation, one (SE → SR) was statistically significant.

Hypothesis 6: Mathematics anxiety is related to motivation.

Mathematics anxiety was a single factor construct; of the three possible relationships with motivation, all three (MANX → LGO; MANX → TV; MANX → SE) were statistically significant..

Hypothesis 7: Motivation is related to mathematics achievement.

Mathematics achievement was a single factor construct; of the three possible relationships, two (TV → ACHT; SE → ACHT) were statistically significant.

Hypothesis 8: Self-regulation is related to mathematics achievement.

This relationship between two single factor constructs (SR → ACHT) was statistically significant.

Hypothesis 9: Mathematics anxiety is related to mathematics achievement.

This relationship between two single factor constructs (MANX → ACHT) was statistically significant.

The results above included at least one statistically significant relationship between the scales of each pair of constructs in each hypothesised relationship. These results justify the selection and use of the nine hypothesised relationships as part of the initial conceptual model and the subsequent development of the structural model. The structural model provides a trimmed framework that allows the comparison of male and female relationships to be carried out effectively.

5.5 **Gender Differences**

This section reports the results of the analyses used to address Research Objectives 3 and 4 by making gender comparisons of (1) their perception of the mathematics learning environment, their reported levels of motivation, self-regulation, mathematics anxiety, and their level of mathematics achievement; and (2) the relationships between these constructs.. Research Objective 3 sought to determine whether gender differences existed in students' perceptions of the constructs involved. The comparisons were made between male and female mean scores for each scale (reported in Section 5.5.2). Research Objective 4 sought to determine whether gender differences existed, in terms of strength and direction, for the supported relationships between the constructs involved (reported in Section 5.5.3).

As a first step, MGCFA was used to ensure psychometric equivalence, or invariance, of the constructs across groups (Putnick & Bornstein, 2016). Establishing psychometric equivalence confirms that constructs have the same meaning to both groups (in this case, male and female). Psychometric equivalence is necessary to make a meaningful comparison of construct means, or relationships between constructs, which is discussed in Section 5.4.1.

5.5.1 Multi-Group Confirmatory Factor Analysis by Gender

The configural, metric and scalar invariance models were specified in order to assess measurement invariance across the male and female groups (van de Schoot et al., 2012). First, following the specification of each of these models, model fit indices were used to assess how well the data fits each model. Second, each of the three models was compared with the other two to determine if there was significant deterioration in model fit between pairs of models. This process was repeated for (1) learning environment factors; (2) motivation factors; (3) self-regulation; and (4) mathematics anxiety.

Model fit indices for the configural, metric and scalar invariance models of the WIHIC instrument are reported in Table 5.14. These indices indicate that all three models were a good fit for the data. One-to-one comparisons of the indices for these models, reported in Table 5.15, did not reveal any significant deterioration in model fit. This result demonstrated that the learning environment construct had the same meaning for both the male and female groups and that further investigation into differences between the groups would be meaningful.

Table 5-14: Fit Indices of the MGCFA Models for WIHIC by Gender

Model	$\chi^2(df)$	**CFI**	**TLI**	**RMSEA**	**SRMR**	**AIC**	**BIC**
Configural	7127.220 (2712)*	0.944	0.940	0.047	0.055	57344.015	58827.940
Metric	7372.220 (2759)*	0.943	0.930	0.049	0.057	57533.407	58826.773
Scalar	7575.208 (2806)*	0.941	0.924	0.049	0.058	57643.670	58746.478

Table 5-15: Comparisons of the MGCFA Models for WIHIC by Gender

Model	$\triangle \chi^2$	**△ CFI**	**△ RMSEA**	**△ SRMR**	**Decision**
Configural vs. metric	11.132	.001	.002	.003	Accept (△< .01)
Configural vs. scalar	38.094	.003	.002	.003	Accept (△< .01)
Metric vs. scalar	28.894	.002	.002	.001	Accept (△< .01)

Model fit indices of the invariance models for the SALEM instrument, reported in Table 5.16, found the data to be a reasonable fit for each model. A one-to-one comparison of the indices for these models, reported in Table 5.17, did not reveal any significant deterioration of model fit. This result demonstrated that the motivation construct had the same meaning for both the male and female groups.

Table 5-16: Fit Indices of the MGCFA Models for SALEM by Gender

Model	$\chi^2(df)$	CFI	TLI	RMSEA	SRMR	AIC	BIC
Configural	1688.277 (798)*	0.910	0.903	0.052	0.065	23756.335	24534.787
Metric	1695.403 (824)*	0.914	0.904	0.050	0.068	23735.295	24408.331
Scalar	1747.941 (850)*	0.908	0.904	0.055	0.066	23735.142	24302.763

Table 5-17: Comparisons of MGCFA Models for SALEM by Gender

Model	$\triangle \chi^2$	△ CFI	△ RMSEA	△ SRMR	Decision
Configural vs. metric	20.540	.004	.002	.003	Accept (△< .01)
Configural vs. scalar	66.355	.002	.003	.001	Accept (△< .01)
Metric vs. scalar	52.448	.006	.005	.002	Accept (△< .01)

Model fit indices of the invariance models for the RMANX instrument, reported in Table 5.18), found the data to be a good fit for each of the models. A one-to-one comparison of the indices for these models did not reveal any significant deterioration of model fit (Table 5-19). This result demonstrated that the mathematics anxiety construct had the same meaning for both the male and female groups.

Table 5-18: Fit Indices of the MGCFA Models for R-MANX by Gender

Model	$\chi^2(df)$	CFI	TLI	RMSEA	SRMR	AIC	BIC
Configural	1573.892 (418)*	0.921	0.881	0.054	0.055	27644.927	28180.113
Metric	1592.122 (439)*	0.922	0.902	0.051	0.059	27617.838	28067.881
Scalar	1732.714 (460)*	0.918	0.881	0.055	0.051	27719.244	28084.143

Table 5-19: Comparisons of MGCFA Models for R-MANX by Gender

Model	$\triangle \chi^2$	△ CFI	△ RMSEA	△ SRMR	Decision
Configural vs. metric	14.072	.001	-.003	.004	Accept (△< .01)
Configural vs. scalar	158.908	.004	.001	.006	Accept (△< .01)
Metric vs. scalar	153.711	.004	.004	.008	Accept (△< .01)

These results demonstrate that the WIHIC, SALEM and RMANX instruments all provided strong evidence of equivalence across the male and female groups for the configuration of the constructs, factor loadings and intercepts (means). Given these results, further investigation of differences between male and females groups in terms of construct means and relationships between constructs would be meaningful.

5.5.2 Gender Differences Between Scale Means

Research Objective 3 was to determine whether male and female students in university-level mathematics classes in the UAE differ in their perceptions of the mathematics learning environment; their reported levels of motivation, self-regulation and mathematics anxiety; and mathematics achievement. The scale means and standard deviations are presented for learning environment factors (Table 5-20); motivation factors (Table 5-21); self-regulation, mathematics anxiety and mathematics achievement (Table 5-22). Independent samples t-tests were conducted to compare learning environment, motivation, self-regulation, mathematics anxiety and mathematics achievement scale means for males and females (Section 5.4.2.1). They were also used to compare gender differences at Pre-calculus and Calculus levels (Section 5.4.2.2) and differences between Pre-calculus and Calculus by gender (Section 5.4.2.3).

5.5.2.1 Comparison of Male and Female Scale Means

For the learning environment, there was a statistically significant difference in teacher support mean scale scores for males (M = 3.42, SD = 1.00) and females (M = 3.75, SD = 0.94; t (424) = -3.27, *p* = .00, two-tailed). The magnitude of the differences in the means (mean difference = -0.33; 95% CI = -0.53 to -0.14) was of medium size (effect size = .30) (Putnick & Bornstein, 2016). Other learning environment scales that had statistically significant differences between male and female mean scores were collaboration ($p < .01$), task orientation ($p < .001$) and equity ($p < .001$). With effect sizes ranging from .34 to .47, these differences were also considered to be of medium size (Shipley, 2000). Learning environment scales that did not exhibit a statistically significant difference between male and female mean scores were involvement and investigation. With higher mean scores for all statistically significant scales, female students consistently perceived their learning environment more favourably than male students.

Table 5-20: Mean, Standard Deviation, Effect Size and *T*-test for Independent Samples for the Differences between Male And Female Students in Learning Environment

WIHIC Scale	**Mean**		**Standard deviation**		**Difference**	
	Male	**Female**	**Male**	**Female**	**Effect size**	***T***
Student cohesiveness (SC)	3.99	4.06	0.65	0.67	0.10	-1.14
Teacher support (TS)	3.42	3.75	1.00	0.94	0.34	-3.27**
Involvement (IV)	2.41	2.52	0.60	0.72	0.17	-1.61
Investigation (IN)	3.14	3.31	0.88	0.92	0.19	-1.75
Task orientation (TO)	4.09	4.34	0.59	0.56	0.44	-4.29***
Collaboration (CO)	3.51	3.78	0.85	0.91	0.31	-2.84**
Equity (EQ)	4.00	4.39	0.90	0.76	0.47	-4.63***

**p*<.05 ***p*<.01 ****p*<.001 *N* = 426

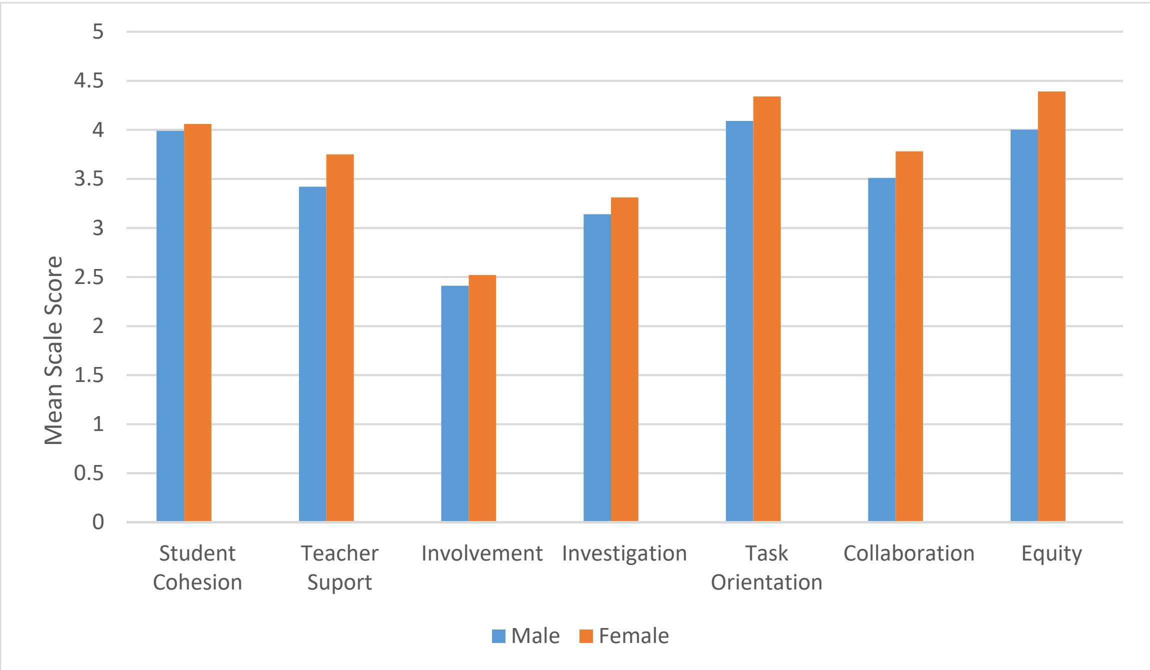

Figure 5-7: Comparison of Learning Environment Scale Means by Gender

For motivation, there was a statistically significant difference in learning goal orientation scale means for males (M = 4.59, SD = 0.42) and females (M = 4.69, SD = 0.36: t(424) = -2.38*, *p* = .018, two tailed) and task value mean scores for males (M = 3.69, SD = 0.63) and females (M = 3.86, SD = 0.59, t(424) = -2.78**, *p*= .007, two tailed). The magnitude of differences in means for learning goal orientation (difference = -0.10, 95% CI = -0.17 to -0.16) and task value (difference = -0.17, 95% CI = -0.29 to -0.05) were small, with effect sizes of .23 and .28, respectively. There was no statistically significant difference in the self-efficacy scale for motivation. As with learning environment, female students consistently reported higher levels of motivation.

Table 5-21: Mean, Standard Deviation, Effect Size and *T*-test for independent samples for the differences between male and female students in motivation.

SALES Scale	Mean		Standard deviation		Difference	
	Male	**Female**	**Male**	**Female**	**Effect size**	***T***
Motivation						
Learning goal orientation (LGO)	4.59	4.68	0.42	0.36	0.23	-2.38*
Task value (TV)	3.69	3.86	0.63	0.59	0.28	-2.73**
Self-efficacy (SE)	4.23	4.21	0.52	0.53	0.04	-1.11

**p*<.05 ***p*<.01 ****p*<.001 $N = 426$

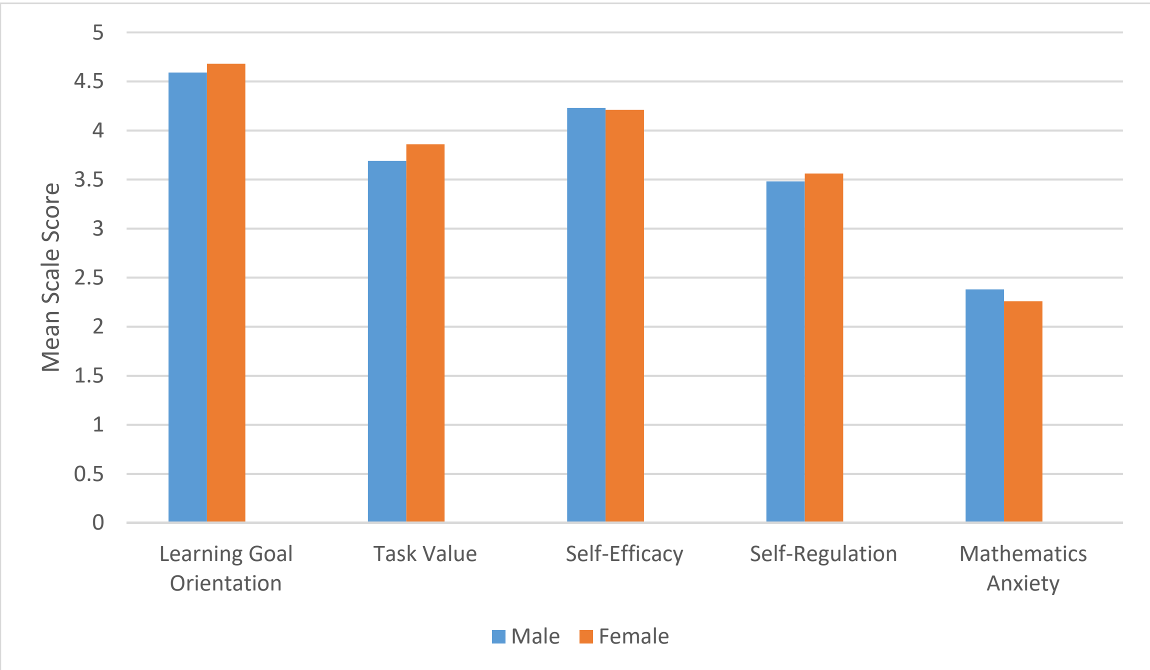

Figure 5-8: Comparison of Motivation Levels, Self-Regulation and Mathematics Anxiety Scale Means by Gender

There were no statistically significant differences in mean male scale scores and mean female scale scores for self-regulation, mathematics anxiety or mathematics achievement scores.

Table 5-22: Mean, Standard Deviation, Effect Size and *T*-test Results for Differences Between Male and Female Students in Self-Regulation, Mathematics Anxiety and Mathematics Achievement

Scale	Mean		Standard deviation		Difference	
	Male	**Female**	**Male**	**Female**	**Effect size**	***T***
Self-regulation (SR)	3.48	3.56	0.49	0.46	0.17	-1.63
Mathematics anxiety (MANX)	2.38	2.26	0.79	0.76	0.16	1.54
Mathematics achievement (ACHT)	69.25	72.22	18.42	15.82	0.17	-1.72

$^*p<.05$ $^{**}p<.01$ $^{***}p<.001$ $N = 426$

Of the thirteen scales (seven for learning environment, three for motivation and one each for self-regulation, mathematics anxiety and mathematics achievement), female students reported statistically significantly ($p < .10$) higher scores for six scales (teacher support, task orientation, collaboration, equity, learning goal orientation and task value) than male students. For the remaining seven scales (student cohesion, involvement, investigations, self-efficacy, self-regulation, mathematics anxiety and mathematics achievement), the differences were not statistically significant.

5.5.2.2 Gender Differences Between Scale Means by Course Level

Analysis of the Pre-calculus sub-sample found the difference in the teacher support scale mean scores for males (M = 3.15, SD = 0.99) and females (M = 3.84, SD = 0.93); t (300) = -5.81, $p = 0.00$, two-tailed) to be statistically significant. The magnitude of the difference in the means was (mean difference = -0.69 ; 95% CI = -0.92 to -0.45) of medium size (effect size = 0.34). Other Pre-calculus sub-sample learning environment scales which had statistically significant differences between male and female means were, involvement ($p < .05$), task orientation ($p < .001$), collaboration ($p < .05$) and equity ($p < .001$). For the Pre-calculus students, there were statistically significant differences between male and female means for two motivation scales; learning goal orientation ($p < .05$) and task value ($p < .01$). As with the learning environment scale means, the motivation scale means were scored more positively by female students.

Further, for Pre-calculus students, the differences for male and female students for self-regulation, mathematics anxiety and mathematic achievement were not statistically significant.

For the Calculus sub-sample the only statistically significant difference was for teacher support, with males (M = 3.95, SD = 0.79) scoring more positively than females (M = 3.45, SD = 0.92; t (124) = -2.87, p = 0.04, two-tailed). The magnitude of the difference was (mean difference = -0.46; 95% CI = -0.78 to -0.14) of medium size (effect size = 0.54). Other learning environment scales were found not to have statistically significant gender differences, nor were scale means for motivation, self-regulation and mathematics anxiety, however, female students were found to have a statistically significantly ($p < .05$) higher level of mathematics achievement than their male counterparts.

5.5.2.3 Difference Between Pre-Calculus and Calculus Scale Means by Gender

For the learning environment scales, analysis of the female sub-sample found two statistically significant differences between the scores of Pre-calculus and Calculus students. The first was teacher support ($p < .05$), with Pre-calculus students reporting more favourably (M = 3.84, SD = 0.93) than Calculus students (M = 3.49, SD = 0.92; t (285) = 2.89, p = .00, two-tailed). The magnitude of the difference was (mean difference = 0.35; 95% CI = 0.11 to 0.59) of medium size (effect size = 0.38). The second learning environment scale with a statistically significant difference for students in Pre-calculus and Calculus was equity ($p < .05$), also with Pre-calculus students reporting more favourably. For the male sub-sample, the differences for Pre-calculus and Calculus students were statistically significant for three learning environment scales, these being teacher support ($p < .05$), involvement ($p < .05$) and equity ($p < .01$). Each of these differences involved Pre-calculus students reporting less favourably.

For the motivation scales, for the female sub-sample, analysis found a statistically significant ($p < .05$) difference between the Pre-calculus and Calculus student scores for task value, with Calculus students reporting less favourably. There were no statistically significant differences between Pre-calculus and Calculus student scores for the male sub-sample. Further, there were no statistically significant differences between the Pre-calculus and Calculus scale means for self-regulation or mathematics anxiety, for either the male or female sub-samples.

These results indicate that, (Research Objective 3) overall, female students perceive their learning environment to be more positive and report higher levels of motivation. When considering the Pre-calculus and Calculus students separately, the gender differences were found to be more extensive at Pre-calculus level. At this level five out of seven learning environment and two out of three motivation scales were found to have statistically significant differences between male and female scale means, whereas, at Calculus level a single scale (teacher support) was found to have a statistically significant difference. Both, overall and at course level, the differences in the reported levels of self-regulation and mathematics anxiety for male and female students were statistically non-significant.

The comparison of female Pre-calculus and Calculus scale means revealed statistically significant differences for two learning environment scales (teacher support and equity), as well as a single motivation scale (task value). All three scale means were reported to be lower at Calculus level. The same comparison of male Pre-calculus and Calculus scale means also revealed three statistically significant differences. These diffences were all for learning environment scales (teacher support, involvement and equity) and were all reported to be higher at Calculus level.

5.5.3 Gender Differences in Relationships Between Learning Environment, Motivation, Self-Regulation, Mathematics Anxiety and Mathematics Achievement

Research Objective 4 was to determine whether relationships existed between the students' perception of their mathematics learning environment; their reported levels of motivation, self-regulation and mathematics anxiety; and their level of mathematics achievement, and to determine whether any relations that existed differed for male and female students. Whereas Section 5.3 addressed the first part of this objective by providing SEM results for the entire sample, this section extends the SEM process to multi-group models across gender to test the difference in structural coefficients between male and female groups. Making these comparisons using multi-group structural equations modelling (MGSEM) across gender was dependent on the establishment of measurement invariance (Guenole & Brown, 2014), which was done successfully in Section 5.4.1. Section 5.4.3.1 reports the use of MGSEM to assess the structural model for male and female groups. Section 5.4.3.2 compares the relationship for male and female groups that were established in Section 5.4.3.1.

5.5.3.1 Multi-Group Structural Equation Modelling Across Gender

The first step of this process was to assess the final structural model fit for the male and female groups. The model fit indices indicate that the data as a good fit for the overall, male and female models, the statistics for which are reported in Table 5.23.

Table 5-23: Fit Indices for the Research Model

Model fit index	**Recommended guidelines**	**Overall model**	**Female**	**Male**
χ^2	Non-significant at *p* < .05	7333.305*	7076.51*	6847.32*
χ^2/df	< 5	1.41	1.63	1.59
CFI	≥ .90	.91	.94	.91
TLI	≥ .90	.91	.93	.92
RMSEA	≤ .08	.031	.047	.056
SRMR	≤ .08	.053	.071	.077

*p < .05

Path coefficients for each group were provided using MGSEM with male and female group data on the final structural model. These path coefficients and their significance are reported in Table 5.24. For the male and female groups, separate structural models with path coefficients are provided in Figures 5.9 and 5.10. It should be noted that only the statistically significant paths were retained in these structural models.

Table 5-24: Comparison of male and Female Coefficients

Hypothesised Relationship	Sex						Difference
	Male			Female			
	β	*SE*	CI	*β*	*SE*	CI	
SC → LGO	.15 ns	.103	[-.052, .352]	.49***	.073	[.347, .633]	Significant
TO → LGO	.63***	.104	[.426, .834]	.38***	.077	[.229, .531]	Not significant
TS → TV	.39***	.103	[.188, .592]	.13 ns	.065	[.003, .257]	Significant
IN → TV	.16 ns	.107	[-050, .367]	.40***	.084	[.235, .565]	Significant
TO → TV	.24*	.119	[.007, .473]	.27***	.079	[.115, .425]	Not significant
TS → SE	.20 ns	.139	[-.072, .472]	.23**	.065	[.103, .357]	Significant
TO → SE	.28*	.141	[.004, .556]	.40***	.081	[.241, .559]	Not significant
CO → SE	.14ns	.259	[-.368, .648]	.44***	.076	[.291, .589]	Significant
MANX → SE	-.28***	.055	[-.388, -.172]	-.32***	.078	[-.473, -.167]	Not significant
TO → SR	.58***	.185	[.217, .943]	.55***	.082	[.389, .711]	Not significant
SE → SR	.30**	.120	[.065, .535]	.29***	.080	[.133, .447]	Not significant
SC → SR	.14 ns	.165	[-.183, .463]	.12*	.058	[.176, .404]	Significant
CO → SR	.02 ns	.229	[-.429, .469]	.13*	.064	[.005, .255]	Significant
EQ → MANX	-.09 ns	.108	[-.302, .122]	-.24**	.062	[-.362, -.118]	Significant
CO → MANX	-.19 ns	.225	[-.631, .251]	-.42***	.074	[-.565, -.275]	Significant
TO → MANX	-.09 ns	.235	[-.551, .371]	-.27**	.085	[-.437, -.103]	Significant
TV → ACHT	.22**	.086	[.051, .389]	.21*	.067	[.079, .341]	Not significant
SE → ACHT	.47***	.089	[.230,.644]	.12*	.052	[.018, .222]	Not significant
MANX → ACHT	-.19**	.086	[-.359, -.021]	-.44***	.075	[-.587, -.293]	Not significant
SC → ACHT	.17 ns	.125	[-.075, .415]	.25*	.084	[.085, .415]	Significant
IV → ACHT	.27*	.112	[.050, .490]	.27*	.086	[.101, .439]	Not significant
SR → ACHT	.19*	.058	[.076, .304]	.23*	.060	[.112, .348]	Not significant

**p*<.05 ***p*<.01 ****p*<.001

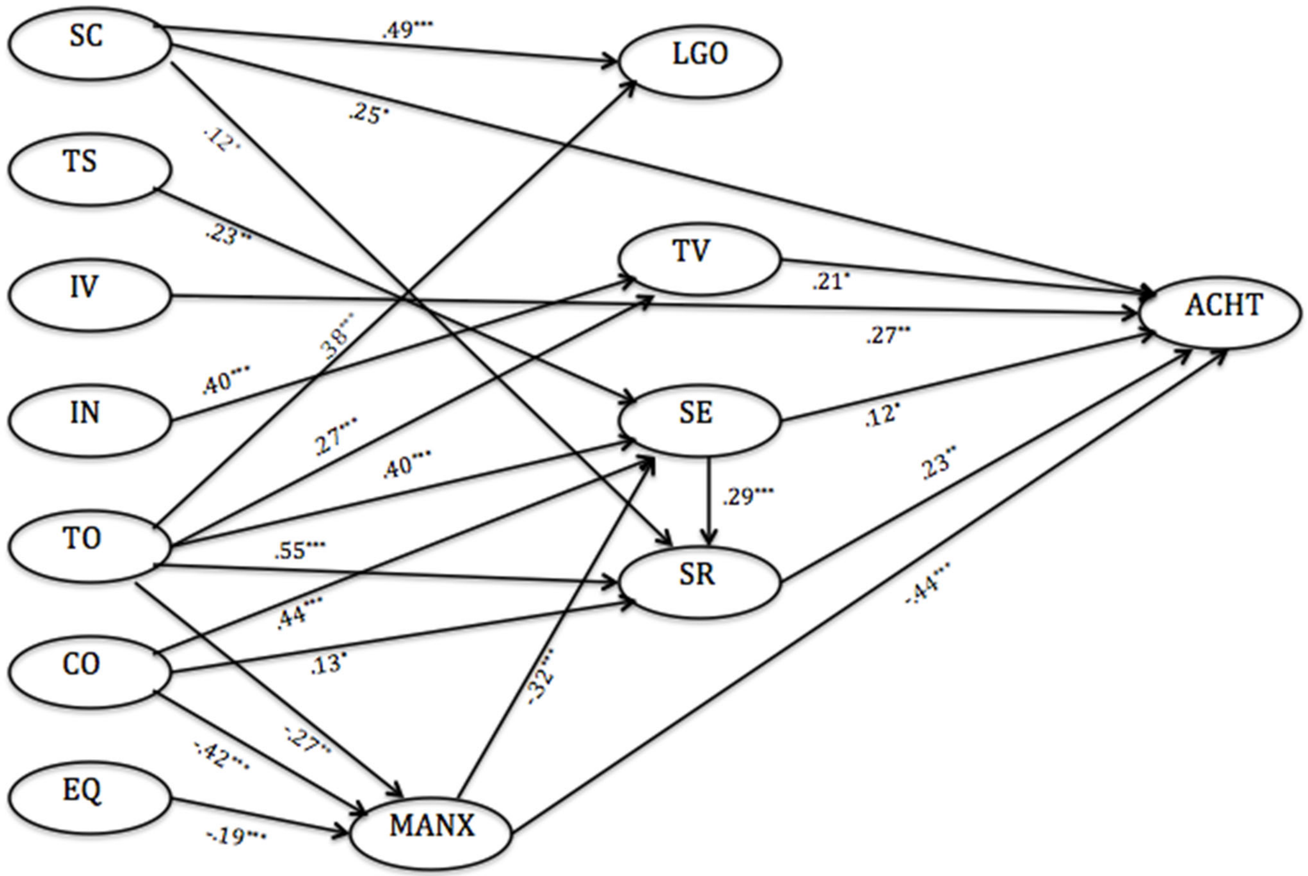

Figure 5-9: Final Female Structural Model

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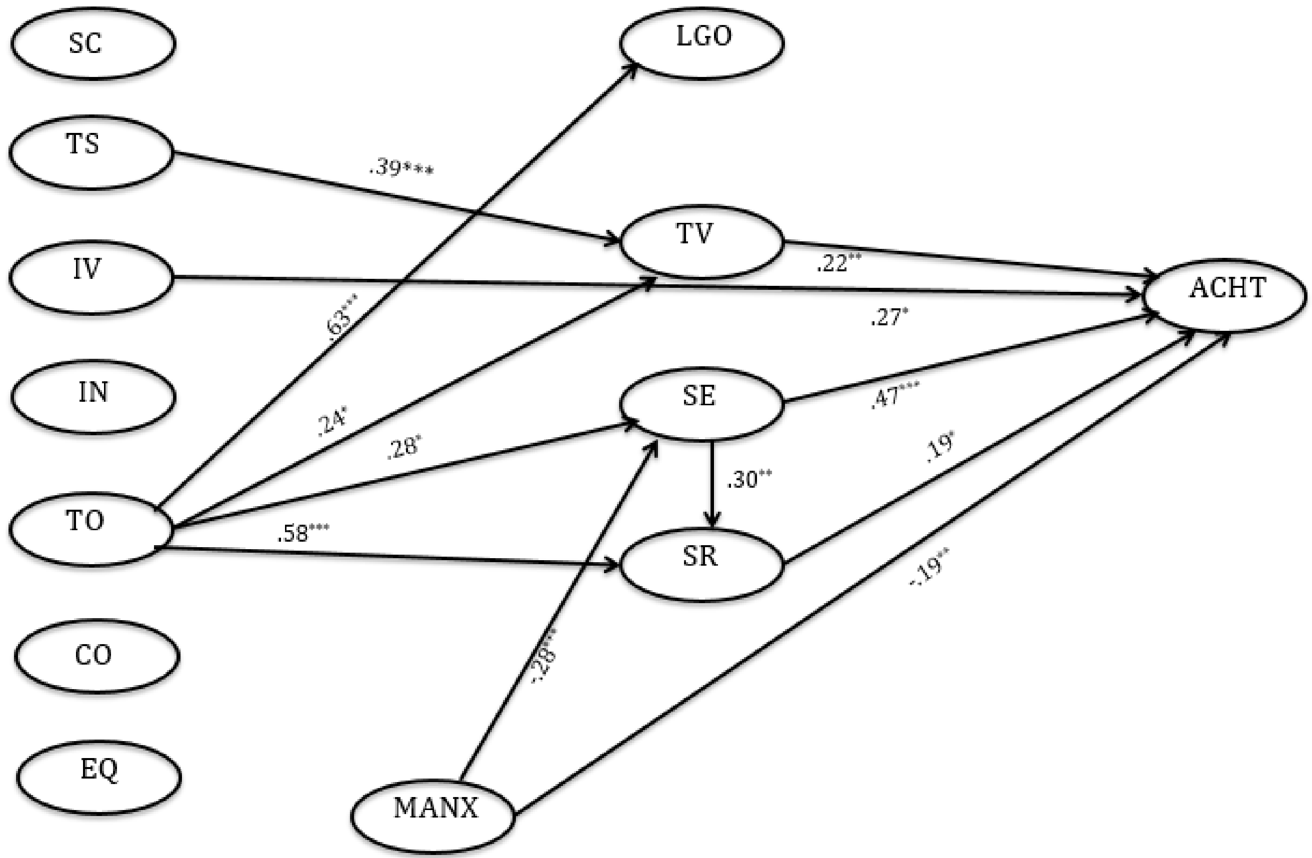

Figure 5-10: Final Male Structural Model

5.5.3.2 Gender Differences in Relationships

This section evaluates the difference in path coefficients between male and female students. The final structural model contained 22 relationships that were tested for significance. Of these 22 relationships, 11 had significant differences in between their correlation coefficients and 11 did not.

To compare the path coefficients for male and female subgroups, when one of the subgroup had a significant path coefficient and the other did not, the difference was considered to be significant (Cumming, 2009). When both groups had significant path coefficients, the difference was not considered to be significant. Table 5.24 reports the path coefficients, their level of significance, their confidence intervals and whether there was a significant difference between correlation coefficients (Cumming, 2009; Teo et al., 2008).

Hypothesis 1: Mathematics learning environment is related to motivation.

- Student cohesion was significantly and positively related to learning goal orientation for the female sample ($\beta = .49$, $p < .001$), but not the male sample ($\beta = .15$, ns).
- Task orientation was significantly and positively related to learning goal orientation for the female sample ($\beta = .38$, $p < .001$) and for the male sample ($\beta = .63$, $p < .001$).
- Teacher support was significantly and positively related to task value for the male sample ($\beta = 0.39, p < 0.001$), but not for the female sample ($\beta = 0.13, ns$).
- Investigation was significantly and positively related to task value for the female sample ($\beta = 0.40, p < 0.001$), but not for the male sample ($\beta = 0.16, ns$).
- Task orientation was significantly and positively related to task value for the female sample ($\beta = 0.27, p < 0.001$) and for the male sample ($\beta = 0.24, p < .1$).
- Teacher support was significantly and positively related to self-efficacy for the female sample ($\beta = .23, p < .05$), but not for the male sample ($\beta = .20, ns$).
- Task orientation was significantly and positively related to self-efficacy for the female sample ($\beta = .40, p < .001$) and for the male sample ($\beta = .28, p < .1$).

- Collaboration was significantly and positively related to self-efficacy for the female sample ($\beta = .44, p < .01$), but not for the male sample ($\beta = .14, ns$).

Hypothesis 2: Mathematics learning environment is related to self-regulation.

- Student cohesion was significantly and positively related to self-regulation for the female sample ($\beta = .12, p < .1$), but not for the male sample ($\beta = .14, ns$).
- Task orientation was significantly and positively related to self-regulation for the female sample ($\beta = .55, p < .01$) and for the male sample ($\beta = .58, p < .01$).
- Collaboration was significantly and positively related to self-regulation for the female sample ($\beta = .13, p < .1$), but not for the male sample ($\beta = .02, ns$).

Hypothesis 3: Mathematics learning environment is related to mathematics anxiety.

- Task orientation was significantly and negatively related to mathematics anxiety for the female sample ($\beta = -.27, p < .05$), but not for the male sample ($\beta = -.09, ns$).
- Collaboration was significantly and negatively related to mathematics anxiety for the female sample ($\beta = -.42, p < .01$), but not for the male sample ($\beta = -.19, ns$).
- Equity was significantly and negatively related to mathematics anxiety for the female sample ($\beta = -.24, p < .05$), but not for the male sample ($\beta = -.09, ns$).

Hypothesis 4: Mathematics learning environment is related to mathematics achievement.

- Student cohesion was significantly and positively related to mathematics achievement for the female sample ($\beta = 0.25, p < .1$), but not for the male sample ($\beta = .17, ns$).
- Involvement was significantly and positively related to mathematics achievement for the female sample ($\beta = 0.27, p < .1$) and the male sample ($\beta = .27, p < .1$).

Hypothesis 5: Motivation is related to self-regulation.

- Self-efficacy was significantly and positively related to self-regulation for the female sample ($\beta = .29, p < .01$) and for the male sample ($\beta = .30, p < .05$).

Hypothesis 6: Mathematics anxiety is related to motivation.

- Mathematics anxiety was significantly and negatively related to self-efficacy for the female sample ($\beta = -.32, p < .01$) and for the male sample ($\beta = -.28, p < .01$).

Hypothesis 7: Motivation is related to mathematics achievement.

- Task value was significantly and positively related to mathematics achievement for the female sample ($\beta = .21, p < .1$) and for the male sample ($\beta = .22, p < .05$).
- Self-efficacy was significantly and positively related to mathematics achievement for the female sample ($\beta = .12, p < .1$) and for the male sample ($\beta = .47, p < .01$).

Hypothesis 8: Self-regulation is related to mathematics achievement.

- Self-regulation was significantly and positively related to mathematics achievement for the female sample ($\beta = .23, p < .05$) and for the male sample ($\beta = .19, p < .1$).

Hypothesis 9: Mathematics anxiety is related to mathematics achievement.

- Mathematics anxiety was significantly and negatively related to mathematics achievement for the female sample ($\beta = -.44, p < 0.01$) and for the male sample ($\beta = -.19, p < .05$).

In summary, 10 relationships were statistically significant for female students and not male students, and one relationship was statistically significant for male students and not female students. The remaining 10 relationships were statistically significant for both female and male students. Generally, if a relationship was statistically significant for male students, then it was also statistically significant for female students. There was only one exception. However, the converse was not true, as there were 10 relationships that were only significant for female students.

5.6 Summary

Chapter 5 reports the results relating to Research Objectives 2, 3 and 4. To address Research Objective 2, initially five simple three-construct models were used. All hypothesised relationships were included in one or more of the five simple models. The five simple models investigated the relationship between the learning environment factors and mathematics achievement, and possible mediation via motivation, self-regulation and mathematics anxiety. Each simple model was broken down into its three component models and SEM was used to evaluate the direct relationships at this level. Of the 53 possible direct relationships between factors in the five simple models, 25 were statistically significant. These were combined to form a single, more complex structural model. This structural model was subject to the second round of SEM, which left 22 relationships in the final structural model to be used to investigate Research Objective 4.

To address Research Objectives 3 and 4, separate male and female samples were used to examine differences in learning environment, motivation, self-regulation, mathematics anxiety and mathematics achievement (Research Objective 3), and the relationships between the constructs established in the final structural model (Research Objective 4). Psychometric equivalence (between male and female students' responses) was established by confirming measurement invariance. MGCFA was used to construct and compare configural, metric and scalar models to determine whether there was significant deterioration between models. Given levels of deterioration were within the required limits, it was deemed that the learning environment, motivation, self-regulation and mathematics anxiety constructs held a similar meaning to both groups.

Investigating Research Objective 3 required t-tests to determine whether differences in male and female means for the thirteen scales were significant. Overall, for the seven learning environment scales, females perceived higher levels in four (teacher support, task orientation, collaboration and equity). There was no significant difference in means for the remaining three scales (student cohesion, investigation and involvement). When considering only Pre-calculus students five scales were statistically significant (teacher support, involvement, task orientation, collaboration and equity), whereas, when considering only Calculus students four scales were statistically significant (involvement, task orientation, collaboration and equity). Of the three motivation scales, the overall results showed that females perceived higher levels for two (learning goal orientation and task value) and there was no significant difference in the mean for the remaining scale (self-efficacy). These results were replicated for Pre-calculus students, however, no motivation scales were statistically significant for Calculus students. There was no significant difference between the means for self-regulation, mathematics anxiety and mathematics achievement, which were all single factor constructs. Overall, females perceived higher levels for six scales, and for the remaining seven scales there was no significant difference.

The final structural model was used to investigate Research Objective 4. MGSEM across gender was used to evaluate path coefficients for male and female groups, and determine their level of significance. Females had significant path coefficients for 21 of the 22 relationships evaluated, whereas males only had 11 significant path coefficients. There was a significant difference between females and males in 10 relationships simply because the relationship was significant for females and not significant for males. Only one relationship had a significant difference between males and females, due to the relationship being significant for males and not significant for females. For the remaining 10 relationships, both male and female students had significant path coefficients, meaning these relationships were not statistically significantly different.

Chapter 6

DISCUSSION AND CONCLUSIONS

6.1 Introduction

The focus of this research was to identify differences in the learning process for male and female university-level mathematics students in the United Arab Emirates (UAE). These gender differences were examined in terms of differences in learning environment perceptions and reported levels of motivation, self-regulation, mathematics anxiety and level of mathematics achievement, and in terms of the relationships between these constructs.

To address the research objectives (see Section 3.4), data was collected from 426 students in 27 mathematics classes at a single university level in Abu Dhabi in the UAE. Of these students, 287 (67%) were female and 139 (33%) were male. Male and female students were studying at separate, single-sex campuses and were enrolled in either Pre-calculus (70%) or Calculus 1 (30%). The majority of the students (approximately 95%) were aged between 18 and 22.

The data was collected using three instruments: What Is Happening In this Class (WIHIC), which assesses the students' perceptions of the learning environment; Students' Adaptive Learning Engagement in Mathematics (SALEM), which assesses student engagement and self-regulation in mathematics classes; and Revised Mathematics Anxiety Scale (R-MANX), which measures student anxiety when studying mathematics. Mathematics achievement was measured using the students' final course grade for the semester. All three instruments were provided to students in a dual English/Arabic format.

This chapter concludes the thesis using the following headings.

- Discussion of the results (Section 6.2
- Limitations of the study (Section 6.3)
- Recommendations (Section 6.4)

- Significance of the study (Section 6.5)
- Concluding remarks (Section 6.6).

6.2 Discussion of the Results

This discussion is based on the results reported in Chapters 4 and 5. The organisation of this section is based on the research objectives, including validation of the dual English/Arabic version of the instruments for use at university level in the UAE (Section 6.2.1) and confirmation of the research model (Section 6.2.2) by testing the hypothesised relationships (Section 6.2.3). It also includes analysis of gender differences in the students' perceptions of the learning environment and reported levels of motivation, self-regulation, mathematics anxiety; level of mathematics achievement (Section 6.2.4); and gender differences in the supported relationships in the research model (Section 6.2.5).

6.2.1 Validation of Instruments

Research Objective 1 sought to provide evidence of the validity and reliability of the instruments used to assess students' perception of their learning environment and their reported levels of motivation, self-regulation and mathematics anxiety for use at university level in the UAE. Evidence for the reliability and validity of the instruments included the factor structure, internal consistency reliability, discriminant validity and ability to differentiate between classes. The results relating to the three instruments are reviewed below: WIHIC (Section 6.2.1.1), SALEM (Section 6.2.1.2) and R-MANX (Section 6.2.1.3).

6.2.1.1 Validity and Reliability of the WIHIC Instrument

To assess the validity and reliability of WIHIC, first, exploratory factor analysis in the form of principal axis factoring with oblique rotation was used to examine its factor structure. Second, Cronbach's alpha was used to assess the internal consistency reliability of individual scales. Third, the component correlation matrix was used to assess the correlation between scales as an indication of discriminant validity. Finally, analysis of variance (ANOVA) results (using class membership) was used to examine the ability of the WIHIC scales to differentiate between classes. The results are summarised below:

- Of the 56 WIHIC items, 54 had satisfactory factor loadings of .40 or higher on their a priori scale and less than .40 on other scales, as recommended by Pituch and Stevens (2016). The two exceptions were omitted from all further analysis.
- All seven WIHIC scales had eigenvalues greater than the minimum recommended level of one (Kaiser, 1960) and, together, they explained a total of 62.4% of variance.
- Internal consistency reliability (using Cronbach's alpha coefficient) ranged from .86 to .92 for individual scales. All values exceeded the recommended minimum of .60 (Cohen et al., 2011), which indicated strong reliability.
- The component correlation matrix (generated during oblique rotation) demonstrated that the highest correlation between scales was .61. Therefore, all correlations were below the .80 cut-off recommended by Brown (2015) and provided evidence for the discriminant validity of WIHIC.
- The ANOVA results, which are used to examine the ability of scales to differentiate between classes, demonstrated that the eta-squared values ranged from .07 to .28 and that the responses to four of seven scales statistically significantly differentiated between classes (teacher support ($p < .001$), investigation ($p < .01$), task orientation ($p < .01$) and equity ($p < .001$)). The three scales that were not significant at the .05 level had eta-squared values of .07 and .08, which is considered to be medium effect sizes.

The results (reported in Chapter 4 and summarised above) provide strong evidence to suggest that the dual English/Arabic version of WIHIC is reliable and valid when used at university level in the UAE. Prior to the study reported in this thesis, WIHIC had been widely used in numerous contexts and these findings generally support those of many of these studies (see, e.g., Afari et al., 2013; Alzubaidi et al., 2016; MacLeod & Fraser, 2010). Of note is that the findings generally support those of other studies that have used dual English/Arabic versions of WIHIC (see, e.g., Afari et al. (2013); Alzubaidi et al., 2016); MacLeod & Fraser, 2010). Note, however, that only two of these studies were carried out at the tertiary level.

The results reported in this thesis differed to other studies regarding the ability to differentiate between classes. Unlike previous studies, the results for this study indicated that only four of the seven WIHIC scales were able to differentiate between classes. This difference might be because a number of these studies were not at tertiary level and tertiary-level classes predominantly adopt a lecture style, which makes classes similar and differentiation more difficult.

The results outlined above support the reliability and validity of the WIHIC instrument for use with university-level students in the UAE. This evidence supports the use of WIHIC with this sample and provides confidence in the reliability of the subsequent results.

6.2.1.2 Validity and Reliability of the SALEM Instrument

As with the WIHIC instrument, to provide support for the validity and reliability of the SALEM instrument, principal axis factoring with oblique rotation was used to examine the factor structure; the Cronbach's alpha coefficient was used to support the internal consistency reliability; the component correlation matrix was used support the discriminant validity; and the ANOVA results were used to support the ability of the SALEM scales to differentiate between classes. The results are summarised below:

- Satisfactory factorial validity was achieved, as recommended by Pituch and Stevens (2016), with 31 of the 32 SALEM items having a factor loading of .40 or greater on their a priori scale and less than .40 on any other scale. The item which did not have a factor loading greater than .40 on any scale was omitted from further analysis.
- All four SALEM scales had eigenvalues greater than the minimum value of one (Kaiser, 1960) and together explained a total of 51.4% of the variance in the construct.
- Cronbach's alpha values between .82 and .88 were well above the minimum value of .60, as recommended by Cohen et al. (2011), which indicated a strong correlation between items measuring the same scale.

- The component correlation matrix indicated that the correlations between the SALEM scales all were less than .50, which was well below the recommended .80 cut-off (Brown, 2015) and provided evidence of discriminant validity.
- The ANOVA results, used to support the ability of the scales to differentiate between the responses of students in different classes, ranged from .07 to .16, with two out of four scales (learning goal orientation ($p < .01$) and task value ($p < .05$)) statistically significantly differentiating between classes. The two scales that were not statistically significant at the .05 level had eta-squared values of .07 and .08, which are considered to be medium effect sizes (Cohen, 1988).

As a relatively new instrument, SALEM has not been widely used. The evidence (reported above and in Chapter 4) supports the reliability and validity of a dual English/Arabic version of the SALEM instrument for use at university level in the UAE. These results are comparable with those reported in other studies using either the same instrument (Chipangura & Aldridge, 2017), or the equivalent instruments used in other subjects such as the Students' Adaptive Learning Engagement in Science (SALES) (Velayutham et al., 2011) and the Engagement in English Language Learning and Self-Regulation (EELLS) (Alzubaidi et al., 2016) .

The results outlined above are the first to support the reliability and validity of the SALEM instrument for use with university-level students in the UAE. Data obtained from the use of the SALEM instrument can be used with confidence in further analyses.

6.2.1.3 Validity and Reliability of the R-MANX Instrument

As with both WIHIC and SALEM, evidence to support the validity and reliability of the R-MANX instrument included principal axis factoring with oblique rotation to examine its factor structure; Cronbach's alpha to assess internal consistency reliability; and ANOVA to assess the ability to differentiate between classes. Given the unidimensional nature of R-MANX, it was unnecessary to examine the discriminant validity. The results are summarised and discussed below:

- A refined version of the R-MANX displayed satisfactory factorial validity with 18 of the 30 items loading onto a single factor. The 18 retained items had factor loadings of .40 or more on this factor and less than .40 on any other factor, as recommended by Pituch & Stevens (2016). The remaining 12 items were omitted, either for having factor loadings less than .40, or loading onto a second factor with fewer than three items.
- The single factor had an eigenvalue of 9.32, which far exceeded the recommended cut-off value of one (Kaiser, 1960). The factor explained 42.2% of the variance in the construct.
- The Cronbach's alpha coefficient of .93 indicated a strong correlation between the 18 retained items.
- The ANOVA result for the single scale indicated an eta-squared value of .09, which was significant ($p < .05$) and meant that the scale showed the ability to differentiate between the responses of student in different classes.

These results support the reliability and validity of the R-MANX instrument for use with university-level students in the UAE. Data obtained from the use of R-MANX can be used with confidence in further analyses. These results support earlier studies that provided evidence of the validation of the R-MANX instrument (Al Mutawah, 2015; Erktin & Oner, 1990). Al Mutawah (2015) used an Arabic version of the instrument with middle and high school students in Bahrain. The difference between the studies was that the study by Al Mutawah (2015) found three indicator variables, whereas the current study found a single indicator variable. This difference could be explained by the difference in the age of the study participants.

6.2.2 Confirmation of the Research Model

Research Objective 2 required confirmation of the research model to provide a structure upon which to compare relationships between constructs for male and female students. The research model consisted of two components: the measurement model and the structural model. The measurement model used manifest indicator variables to operationalise the latent constructs. The research model was developed from nine hypothesised relationships between the five latent constructs (see Section 3.3 for more information). To confirm the research model, both the measurement model (discussed in Section 6.2.2.1) and the structural model (discussed Section 6.2.2.2) needed to satisfy a set of predetermined criteria.

6.2.2.1 Measurement Model

Assessment of the measurement model required all three instruments to be assessed concurrently to determine whether their indicator variables are reasonable predictors of the latent factors representing the constructs. The measurement model displayed factor loadings above .50 for all 107 items. Construct validity was achieved by assessing convergent validity and discriminant validity. Convergent validity required both composite reliability and average variance extracted. All scales met the recommended composite reliability minimum standard of .70, but only nine out of 12 scales were able to satisfy the recommended minimum standard of .50 for discriminant validity; however, the scales below .50 were reasonably close, ranging from .44 to .49.

The model fit indices all supported the confirmation of the measurement model. Although the chi-squared value was significant, it was noted that this is common for large sample sizes. All other model fit indices supported the adequacy of the indicator variables in measuring the latent variables. These results indicate that this research was able to use the three instruments in the knowledge that the scales (indicator variables) used to measure each construct (latent factor) were sufficiently related to each other to be measuring the same construct, but not so related as to be measuring the same aspect of the construct (Hair et al., 2014).

6.2.2.2 Structural Model

The structural model was developed from five simple models (see Chapter 3, Section 3.7.3.2 for information related to each model). Each of these models included the factors from three constructs and the direct relationships between them. These direct relationships were based on each of the nine hypothesised relationships, with each hypothesised relationship included in at least one of the simple models. The direct relationships between construct factors were first assessed using model fit indices, which indicated that each direct relationship was a good fit for the data. Subsequent structural equation modelling (SEM) analysis was used to determine which relationships between factors were significant. There were a total of 53 possible relationships, constructed from seven factors in mathematics learning environment, three factors in motivation, and one factor in each of self-regulation, mathematics anxiety and mathematics achievement. Of these 53 relationships, 28 had significant path coefficients and were included in the larger structural model, which underwent a second round of SEM. Of these 28 paths, 22 of the relationships remained statistically significant. Discussion of these relationships is provided in the following section.

6.2.3 Testing the Hypotheses

The development of the structural model (Research Objective 2) was based on nine hypothesised relationships (see Section 3.3) between the mathematics learning environment, motivation, self-regulation, mathematics anxiety and mathematics achievement constructs. The following section summarises and discusses the findings for each of these hypotheses.

6.2.3.1 Hypothesis 1: Mathematics Learning Environment is Related to Motivation

Hypothesis 1 was that students' perceptions of the learning environment would be related to their motivation. Of the 21 possible relationships between the mathematics learning environment (seven factors) and motivation (three factors), eight were statistically significant and retained in the final structural model. All eight relationships were positive and the coefficients of determination indicated that:

- Student cohesiveness and task orientation jointly accounted for 27.2% of the variance in learning goal orientation.
- Teacher support, involvement and task orientation jointly accounted for 36.0% of the variation in task value.
- Teacher support, task orientation and collaboration jointly accounted for 34.6% of the variance in self-efficacy.

These results indicate that the more positive a student's perception of the learning environment in mathematics classes, the higher their level of motivation. Specifically, students reported higher levels of motivation in learning environments where the teacher helps, trusts and shows an interest in students and promotes student's self-belief in their ability to master a new skill or task; students stay on task and complete activities, and cooperate with each other.

This relationship is one of the most frequently studied in learning environment research and the results reported in this study support the results of earlier research, which remained consistent across primary (Koul et al., 2018; Lim & Fraser, 2018), secondary (Gilbert et al., 2013; Tosto et al., 2016) and tertiary (Afari et al., 2013; Alzubaidi et al., 2016; Peters, 2013) levels. This result is valuable as it supports the importance of the learning environment in motivating students in mathematics classes to want to fulfil their potential. Based on these findings, for those instructors wishing to enhance student motivation, it is recommended that they pay close attention to aspects of the learning environment such as teacher expectations and support (Gilbert et al., 2013), quality of teaching (Winheller et al., 2013), teacher caring and interpersonal relationships (Koul et al., 2018; Telli et al., 2010).

Recommendation 1: It is recommended that to improve levels of motivation in male mathematics students in the UAE, instructors provide an environment that is welcoming and inclusive and has high expectations.

6.2.3.2 Hypothesis 2: Mathematics Learning Environment is Related to Self-Regulation

Hypothesis 2 was that students' perceptions of the learning environment would be related to their self-regulation. The results confirmed that:

- Three out of the seven possible relationships were statistically significant and were retained in the final structural model. All three relationships were positive.
- The coefficients of determination indicated that student cohesiveness, task orientation and collaboration jointly accounted for 63.8% of the variance in self-regulation.

These results indicate that the more positive a student's perception of their mathematics learning environment the greater their use of self-regulatory strategies.

The findings suggest that in learning environments where students help and support one another, stay on task to complete activities and cooperate with one another, they are more likely to use self-regulatory strategies. These findings support other research that has reported the same relationship (Boekaerts & Cascallar, 2006; Cleary & Platten, 2013; Perels et al., 2009). Based on these findings, it is recommended that instructors seeking to improve students' self-regulation create a learning environment that promotes student cohesiveness, provides opportunities for students to collaborate and is task oriented. Further, teachers could introduce self-regulatory skills, either integrated into the program (Dignath-van Ewijk & van der Werf, 2012) or as a directed intervention (Cleary & Platten, 2013; Perels et al., 2009).

Recommendation 2: It is recommended that to increase levels of self-regulation in students, instructors use a positive mathematics learning environment to introduce self-regulatory skills, either integrated into the program or as a directed intervention.

6.2.3.3 Hypothesis 3: Mathematics Learning Environment is Related to Mathematics Anxiety

Hypothesis 3 was that students' perceptions of the learning environment would be related to their levels of mathematics anxiety. The results confirmed that:

- Three out of seven possible relationships were statistically significant and retained in the final structural model. All three relationships were negative.
- The coefficient of determination indicated that these three learning environment factors (task orientation, collaboration and equity) jointly accounted for 10.8% of the variance in mathematics anxiety.

These results indicate that the more positively a student perceives their learning environment, the lower their level of mathematics anxiety. The fact that the three relationships accounted for only a small amount of the variance in mathematics anxiety suggests that other factors such as past experience (Brady & Bowd, 2005) and family background (Lee, 2009), which are outside the scope of this study, might be more important in the context of this study. Even so, the results demonstrate that a significant relationship exists between learning environment and mathematics anxiety and that it could be possible to strengthen the relationship with a more focused approach. It is recommended, therefore, that future mixed method research further investigates the level of mathematics anxiety and possible causes by collecting qualitative data.

Recommendation 3: It is recommended that future mathematics anxiety research in this context collects qualitative data to provide possible explanations for the low levels of mathematics anxiety for both male and female students.

This result supports a number of other studies, which found learning environment to be an important determinant of mathematics anxiety (Taylor & Fraser, 2013). Although the focus of these studies differed to the focus of this study, they found that the teaching style (Ashcraft, 2002) , the degree to which the environment was caring and challenging (Chang & Beilock, 2016), and the attitudes and self-efficacy instilled by the teacher reduced mathematics anxiety. Other studies reported that mathematics anxiety issues suffered by pre-service elementary teachers affected their confidence to teach the subject, and this filtered down to their students (Mizala et al., 2015). Generally, students in the current study reported a low level of mathematics anxiety (M = 2.30). Whether or not the mathematics learning environment had an impact on the level of mathematics anxiety at a lower level of education, these students were successful enough to meet the entry criteria for a course that required them to study mathematics at university level. Their relatively high mathematics achievement might have alleviated the potential for a high level of mathematics anxiety.

6.2.3.4 Hypothesis 4: Mathematics Learning Environment is Related to Mathematics Achievement

Hypothesis 4 was that the mathematics learning environment would be related to mathematics achievement. The results confirmed that:

- Two of the seven possible relationships between learning environment and mathematics achievement were statistically significant and retained as part of the final structural model.

- Analysis of indirect relationships between the two constructs (student cohesiveness and involvement) revealed that the five learning environment scales without a direct relationship with mathematics achievement were all indirectly related to mathematics achievement.
- The relationship between task orientation and mathematics achievement was mediated by task value, self-efficacy, mathematics anxiety and self-regulation.
- The relationship between collaboration and mathematics achievement was mediated by self-efficacy, mathematics anxiety and self-regulation.
- The relationship between equity and mathematics achievement was mediated by mathematics anxiety.
- The relationship between student cohesiveness and mathematics achievement was mediated by self-regulation.
- Student cohesiveness was the only mathematics learning environment factor to have both a direct and indirect relationship with mathematics achievement.
- The coefficient of determination indicated that student cohesiveness and involvement accounted for 10.6% of the variance in mathematics achievement.

Even though the variance in mathematics achievement accounted for by student cohesiveness and involvement was modest, the results also indicated that all seven learning environment factors are related to mathematics achievement, either directly or indirectly, which means that the more positive a student's perception of their mathematics learning environment, the higher their level of mathematics achievement. Numerous studies have reported a relationship between learning environment and student achievement (Chionh & Fraser, 2009; Cohn & Fraser, 2016; Stronge et al., 2015). The results reported here add some support to the results from this earlier research. Stronge et al. (2015) suggest that tangible components such as the teachers' degree level, certification, content and pedagogical knowledge, experience and verbal ability account for only 3% of the learning environment's impact on achievement, whereas intangible components such as teacher disposition, attitude, classroom practices, caring, efficacy and enthusiasm account for the remaining 97%.

Adding to the complexity of this issue is the indirect nature of the relationships through either motivation (Fast et al., 2010; Winheller et al., 2013), self-regulation (G. Brown et al., 2016; Cleary & Platten, 2013) or mathematics anxiety. In this study, all of the factors that did not have a direct relationship with mathematics achievement had an indirect relationship, either through motivation or mathematics anxiety. Task value mediated the negative relationships between teacher support, investigation and task orientation, and mathematics achievement; and mathematics anxiety mediated the relationships between task orientation, collaboration and equity, and mathematics achievement (Chang & Beilock, 2016).

Based on these findings, it is recommended that instructors wishing to improve the level of mathematics achievement focus first on creating a positive learning environment.

Recommendation 4: It is recommended that to improve the level of mathematics achievement, instructors focus on creating a positive mathematics learning environment.

6.2.3.5 Hypothesis 5: Motivation is Related to Self-Regulation

Hypothesis 5 was that motivation would be related to self-regulation. The results confirmed that:

- One of the three possible relationships between motivation and self-regulation was statistically significant and was retained in the final structural model. The relationship was positive.
- The coefficient of determination indicated that self-efficacy accounted for 44.3% of the variation in self-regulation.

This result indicated that the more students believe in their ability to master a new task or skill, the more likely they are to use self-regulatory strategies. It also supports the results of previous studies reporting the relationship between self-efficacy and the use of self-regulatory strategies (Diseth, 2011; Lee, Lee, & Bong, 2014; Velayutham et al., 2012; Wolters & Rosenthal, 2000) and extends the context of this relationship to include university-level mathematics students in the UAE. It is important as it emphasises that any attempt to improve the awareness of self-regulatory strategies, either integrated into the program (Perels et al., 2009) or as a stand-alone course

(Cleary & Platten, 2013), will struggle to be successful unless the issue of motivation is also addressed. Students require motivation not only to initiate and persist in the use of self-regulatory strategies but also to learn the necessary strategies when made available (Cleary & Platten, 2013). Studies considering the implementation of self-regulation have reported the importance of motivation in both learning and using self-regulatory strategies (Boekaerts & Corno, 2005; Vanthournout et al., 2012). Pintrich (1995) stressed that self-regulation is as important at college as it is at lower levels of education as students at this level have increased freedom. With more than a decade of experience teaching students in the UAE, it is apparent that the majority of students arrive at university ill-equipped for the challenge ahead. It is clear from their entry examination results that they do not have the necessary content knowledge, but what is less obvious is that they are also lacking in the necessary self-regulatory skills to maximise their learning. In addition to this, many of the mathematics instructors are either not aware of the importance of self-regulatory strategies, or feel that it not their job to teach them. Since the use of self-regulatory activities has been shown to have a positive impact on student outcomes (Dignath-van Ewijk & van der Werf, 2012), it is important that this avenue to educational improvement is used.

Based on these findings, it is recommended that instructors wishing to enhance students' self-regulatory skills first look to maximise the level of student motivation by improving self-efficacy.

Recommendation 5: It is recommended that to enhance students' self-regulatory skills, instructors maximise the level of student motivation by improving self-efficacy.

6.2.3.6 Hypothesis 6: Mathematics Anxiety is Related to Motivation

Hypothesis 6 was that mathematics anxiety would be related to motivation. The results confirmed that:

- All three possible relationships between motivation and mathematics anxiety were significant and retained in the final structural model. All three relationships were negative.

- The coefficients of determination indicated that mathematics anxiety accounted for 3.8% of the variation in learning goal orientation, 4.8% in task value and 24.1% in self-efficacy.

These results indicate that the higher the level of mathematics anxiety, the lower the levels of learning goal orientation, task value and self-efficacy. These findings support the results of earlier studies reporting a negative relationship between mathematics anxiety and motivation (Chang & Beilock, 2016; Ramirez et al., 2018). A number of other studies have also reported the relationship to be reciprocal in nature by finding a negative relationship between motivation, or its components, and mathematics anxiety (Akin, 2012; Goetz et al., 2010; Hoffman, 2010). However, this was beyond the scope of this study. Based on these findings it is recommended that any effort to improve the motivation level of mathematics students be accompanied or proceeded by efforts to reduce mathematics anxiety.

Recommendation 6: It is recommended that any effort to improve the motivation level of mathematics students be accompanied by or proceeded by efforts to reduce mathematics anxiety.

6.2.3.7 Hypothesis 7: Motivation is Related to Mathematics Achievement

Hypothesis 7 was that student motivation would be related to mathematics achievement. The results confirmed that:

- Two of the three possible relationships between motivation and mathematics achievement were statistically significant and retained in the final structural model. Both relationships were positive.
- Learning goal orientation, task value and self-efficacy jointly accounted for 23.0% of the variation in mathematics achievement.

These results indicate that higher levels of motivation were related to higher levels of achievement, which supports the large number of studies that have reported motivation to be the most significant predictor of achievement (Briley et al., 2009; Grigg et al., 2018; Lee et al., 2014). The results also support the opportunity to use the mathematics learning environment to foster higher levels of mathematics achievement by improving student motivation (see indirect relationships in Hypothesis 4). It is, therefore, recommended that instructors wishing to improve student achievement first examine how malleable aspects of the learning environment can be leveraged to maximise student motivation.

Recommendation 7: It is recommended that to improve student achievement, instructors use the mathematics learning environment to maximise student motivation.

6.2.3.8 Hypothesis 8: Self-regulation is Related to Mathematics Achievement

Hypothesis 8 was that self-regulation would be related to mathematics achievement. The results confirmed that:

- The sole relationship between the two single factor constructs was statistically significant and retained in the final structural model. The relationship was positive.
- The coefficient of determination indicated that self-regulation accounted for 9.0% of the variance in mathematics achievement.

These results indicate that the greater a students' use of self-regulatory strategies, the higher their level of mathematics achievement. This supports the results from earlier studies reporting a positive relationship between self-regulation and achievement (Altun & Erden, 2014; Azar et al., 2010; Brown et al., 2016; Nett et al., 2012; Nota et al., 2004). A positive relationship between self-regulation and mathematics achievement in the current context provides an avenue for educational improvement through the inclusion of strategies or programs aimed at improving student knowledge of self-regulatory activities (Cleary & Platten, 2013; Perels et al., 2009). Based on these findings, it is recommended that instructors wishing to improve the level of student achievement assess the level of self-regulation in their students and address any shortfalls by including relevant remedial activities in the program (Recommendation 8).

Recommendation 8: It is recommended that to improve the level of student achievement, instructors assess the level of self-regulation in their students and address any shortfalls by including relevant remedial activities in the program.

6.2.3.9 Hypothesis 9: Mathematics Anxiety is Related to Mathematics Achievement

Hypothesis 9 was that mathematics anxiety would be related to mathematics achievement. The results confirmed that:

- The sole relationship between these two single factor constructs was statistically significant and retained in the final structural model. The relationship was negative.
- The coefficient of determination indicated that mathematics anxiety accounted for 18.5% of the variance in mathematics achievement.

This relationship suggests that the higher a students' level of mathematics anxiety, the lower their level of mathematics achievement. This supports previous studies reporting the relationship between mathematics anxiety and mathematics achievement (Carey et al., 2016; Chang & Beilock, 2016). Although prior research has also supported a reciprocal relationship between these constructs (Ma & Xu, 2004; Rubinsten & Tannock, 2010), creating a two-way relationship, also referred to as reciprocal theory (Carey et al., 2016) was beyond the scope of this research. It has been reported that in Japan and Korea, students have a high level of mathematics achievement despite a high level of mathematics anxiety (Chang & Beilock, 2016; Lee, 2009); however, this was not the case in this study. A scatter graph of the data collected in this research revealed that a total of 20 students reported a mathematics anxiety level of at least 4.0, with five students also achieving a grade of 80% or more. Although one of these five students had an achievement score of 100%, the low numbers involved indicate that this event was an exception rather than the norm as reported in Korea and Japan.

Based on these findings it is recommended that instructors wishing to improve mathematics achievement make efforts to assess and reduce mathematics anxiety.

Recommendation 9: It is recommended that to improve mathematics achievement, instructors focus on reducing mathematics anxiety.

6.2.4 Analysis of Gender Differences

The final two research objectives sought to examine the differences between male and female students. Research Objective 3 examined gender differences in students' perceptions of the learning environment; reported levels of motivation, self-regulation and mathematics anxiety; and the level of mathematics achievement. Research Objective 4 examined gender differences in the relationships between the learning environment, motivation, self-regulation, mathematics anxiety and mathematics achievement constructs, which were supported in the final structural model.

To address Research Objective 3, students' responses to the WIHIC, SALEM and R-MANX instruments and student achievement data were used. Effect size and t-tests were used to make comparisons. This analysis allowed a male–female comparison of the scale means for each of the 13 scales (see Section 3.7.5.2 for more details regarding methods used). These results are discussed in Section 6.2.4.1. To address Research Objective 4, multi-group structural equations modelling (MGSEM) was used to examine gender differences in the relationships in the final structural model. Discussion of the results comparing these relationships is provided in Section 6.2.4.2.

6.2.4.1 Gender Differences Between Scale Means

This section summarises the results comparing the mean scores for male and female students. These results are compared separately for the mean scores for students' perceptions of the learning environment, motivation, self-regulation and mathematics anxiety, and mathematics achievement.

Gender Differences in the Perception of the Learning Environment

The differences between the scale means for male and female students' perceptions of the learning environment are summarised below:

- Overall, female students perceived their mathematics learning environment to be more positive than male students.
- Female students reported statistically significantly higher scores for four out of the seven WIHIC scales (teacher support, task orientation, collaboration and equity).
- The difference in means for the remaining three WIHIC scales (student cohesiveness, involvement and investigation) were not statistically significant.
- Gender differences in the perception of the learning environment were more extensive at Pre-calculus level than Calculus level.
- Students in female Pre-calculus classes reported statistically significant higher mean scores than students in male Pre-calculus classes for five of the seven learning environment scales (teacher support, involvement, task orientation, collaboration and equity), whereas, students in female Calculus classes reported mean scores that were statistically significantly higher than students in male Calculus classes for only one out of seven learning environment scales (teacher support).
- Female Calculus students perceived their learning environment less favourably than those at Pre-calculus level, whereas, male Calculus students perceived their learning environment more favourably than those at Pre-calculus level.
- The responses of female Calculus students were statistically significantly ($p < .05$) lower for two learning environment scales (teacher support and equity) than female Pre-calculus students, whereas, the responses of male Calculus students were statistically significantly ($p < .05$) higher for three learning environment scales (teacher support, involvement and equity) than male Pre-calculus students.

Previous studies reporting that female students perceive a learning environment more positively than male students were focused on coeducational classrooms (Levy et al., 2003; Telli et al., 2009). It is acknowledged, however, that the results in this study might not directly support the results in these earlier studies, as in this study the classes all were single-sex and on different campuses. The results reported in this thesis do, however, extend earlier research carried out in the UAE by Ridge (2009), who reported the learning environment in male students' classes at secondary school level in the Emirate of Ras al-Khaimah to be different to those of female students. In this study, the male students' classes were described as lacking warmth, creativity and engagement, with teachers expecting little from the students, whereas the female students' classes were described welcoming and engaging, with high expectations of the students. The disparities reported in this study at university level were not as great as those reported by Ridge at secondary school level, but it is notable that female students at tertiary level reported they were more likely than male students to complete the work and seek support from each other and their instructor.

Although beyond the scope of this study, it is possible that upon entry into first year mathematics classes, many male students have experienced relatively poor mathematics learning environments, which makes them ill-equipped to play their part in creating a positive learning environment. It is therefore recommended that instructors of male mathematics classes in the UAE will need to be aware of this and make a conscious effort to provide a learning environment that is welcoming, inclusive and has high expectations (Recommendation 1).

Gender Differences in Motivation Level

The gender differences in the reported levels of motivation are summarised below:

- Overall, female students reported higher levels of motivation.
- Female students reported statistically significantly higher levels of motivation for both learning goal orientation and task value scales.
- Both genders reported high levels of self-efficacy, but the difference between the male and female levels was not statistically significant.
- The learning goal orientation scale means were the highest of all scale means for both male and female students.
- Female Pre-calculus students reported statistically higher levels of motivation (learning goal orientation and task value) than male Pre-calculus students, whereas, there were no statistically significant differences between male and female Calculus students reported levels of motivation.
- Female Calculus students reported a lower level of motivation (task value) when compared to female Pre-calculus students, whereas, there was no significant difference when making this comparison for male students.

It is recommended that future research into motivation at university level in the UAE use a mixed methods approach to provide causal data, which can then be used to explain the inclusion of a learning goal orientation as an overriding approach that students employ during the learning process (Elliott & Dweck, 1988). It is recommended that instructors, especially of male students, emphasise the utility and enjoyment aspects of learning mathematics. It is also recommended that a mixed method approach is used to provide causal data to explain the existence of a gender difference in learning goal orientation and task value for Pre-calculus students, but not for Calculus students.

Recommendation 10: It is recommended that future research into motivation at university level in the UAE uses a mixed methods approach to collect qualitative data to confirm that a learning goal orientation is an overriding approach that students employ during the learning process.

Recommendation 11: It is recommended that instructors, especially of male students, emphasise the utility and enjoyment aspects of learning mathematics.

Recommendation 12: It is recommended that a mixed method approach is used to provide causal data to explain the existence of a statistically significant difference in reported levels of motivation (learning goal orientation and task value) for Pre-calculus level students, but not for Calculus level students.

As a university instructor in the UAE, I have noticed that many students, especially male students, display limited intrinsic value for the program they have enrolled in. Male students in particular are attracted to the program by the substantial stipend and benefits offered while studying and the high salaries for graduates (Ainane et al., 2019). For many Emirati males, especially those from the poorer emirates, there is also a cultural responsibility to provide for their extended family, which adds to their need to pursue options that provide an income (Abdulla & Ridge, 2011). University is not the only option for males as they are also able to join the military or if they are from the wealthier emirates, there is the attraction of well paid, often low skilled jobs in the public sector (Abdulla & Ridge, 2011).

The higher level of motivation reported by female students may, at least in part, be explained by their different reasons for entering the program and their different circumstances compared with male students. Ainane et al. (2019) reported that the main reason for female students to study engineering was to serve their country. Also, for cultural reasons female students frequently do not have the same freedom as male students (Abdulla & Ridge, 2011). At this university, a large number of female students were transported by bus from home to the campus each the morning, where they stay until they are transported home again at the end of the day. Female students do not have the same options as males in terms of employment in the public sector or the military. University is one of the few options available to females, which, at least in part, explains the predominance of female students enrolled in the university (Ridge & Farah, 2012) and their desire to be successful so that they might continue to attend.

At the university involved in this study, following acceptance into the program, new students wishing to enter directly into first year mathematics were required to pass a mathematics entrance test. The entrance test is necessary as student results from individual schools cannot be relied upon. Despite arriving at the university with the required mathematics entry grades, few students are able to pass the entry test and therefore have to complete a mathematics foundation program prior to starting their degree (Ashour, 2020). Despite the inability of students to meet the standard for direct entry into the degree program, the self-efficacy scale means remain high. It is possible that because the majority of students do the foundation program, it is seen as the norm and does not adversely affect self-efficacy. It is therefore recommended that further qualitative research be carried out to determine the cause of the high levels of self-efficacy despite the low levels of achievement.

Recommendation 13: It is recommended that further qualitative research be carried out to provide an explanation for the high levels of self-efficacy despite the low levels of achievement.

Gender Differences in Self-Regulation

The difference between the male and female students' reports of self-regulation (scale means) was not statistically significant overall, for the whole sample, nor either of the

Pre-calculus, or Calculus sub-samples. Male and female students report similar use of self-regulatory strategies in their learning. This result supports the few previous studies that found few differences between male and female use of self-regulation at tertiary level (Shmais, 2003; Szoke & Sheorey, 2002); however, the results differed from the majority of studies, which found that female students were more active in monitoring the learning process (Bidjerano, 2005; Garrison & Akyol, 2015; van Tetering et al., 2020).

Gender Differences in Mathematics Anxiety

The difference between the levels of mathematics anxiety reported by the male and female students was not statistically significant for the whole sample, nor either of the Pre-calculus or Calculus sub-samples. The levels of mathematics anxiety reported by both genders was low, with scale means for male and female students 2.38 and 2.26, respectively.

The low levels of mathematics anxiety are surprising given the majority of the students entering the university are not well prepared academically (Ashour, 2020). It is therefore recommended that a future study focus on mathematics anxiety and include the collection of qualitative data in an effort to explain this result.

Recommendation 14: It is recommended that a future study focuses on mathematics anxiety and includes the collection of qualitative data to explain the low levels of mathematics anxiety.

Gender Differences in Mathematics Achievement

The difference between the mean achievement scores of male and female students was not statistically significant for the whole sample, nor for the Pre-calculus sub-sample, however it was for the Calculus sub-sample. It must be noted that the ratio of female students to male students at university level is 2:1, with fewer males opting to undertake university study. Abdulla and Ridge, (2011) found that one of the reasons males are not enrolling in university in the same numbers as females is due to the poor results gained at school. This finding suggests that the comparison being made is between the top male students and a larger more complete group of female students. Despite this, the female mean achievement score is on a par with the male scores.

6.2.4.2 Gender Differences in Relationships Between Constructs

The aim of this section is to address Research Objective 4, which sought to investigate whether differences exist between the relationships supported in the final structural model for male and female students. This objective is important as it provides instructors working with male and female students with valuable information that can assist them in differentiating their classrooms to make the classes more equitable. Analysis using multi-group confirmatory factor analysis (MGCFA) across gender was used to determine which relationships were significant for male students and which for female students.

Prior research has generally examined gender differences in perceptions of the learning environment and levels of motivation, self-regulation, mathematics anxiety and mathematics achievement as well as the relationships between these constructs. Scarcely any prior research has examined gender differences in the relationships between these constructs and no research has done so at university level in the UAE. As a result, it was necessary to make comparisons between the results from the current study and studies done at other levels, in other subject areas or in other regions. The gender differences in these relationships found in this study are summarised and discussed below. They are organised according to the hypothesis they relate to.

(1) Learning Environment – Motivation Relationships

The results, reported in Chapter 5, suggest that there were differences for the relationships between perceptions of the learning environment and motivation for male and female students. For female students, the relationships between learning environment perceptions and motivation were statistically significant for seven of the eight relevant paths in the final structural model:

- student cohesiveness → learning goal orientation ($\beta = .49, p < .01$)
- task orientation → learning goal orientation ($\beta = .38, p < .01$)

- investigation → task value ($\beta = .40, p < .01$)
- task orientation → task value ($\beta = .27, p < .01$)
- teacher support → self-efficacy ($\beta = .23, p < .05$)
- task orientation → self-efficacy ($\beta = .40, p < .01$)
- collaboration → self-efficacy ($\beta = .44, p < .01$).

In contrast, for male students, only four of the eight possible relationships were statistically significant:

- task orientation → learning goal orientation ($\beta = .63, p < .01$)
- teacher support → task value ($\beta = .39, p < .001$)
- task orientation → task value ($\beta = .24, p < .10$)
- task orientation → self-efficacy ($\beta = .28, p < .10$).

The results reported above support prior research that found learning environment to be related to motivation (Aldridge & Rowntree, 2021; Alzubaidi et al., 2016; Koul et al., 2012). The study by Alzubaidi et al. (2016) also found task orientation to be the only learning environment factor to be related to a learning goal orientation, task value and self-efficacy; however, this study did not make gender comparisons in these relationships. The study by Aldridge and Rowntree (2021) also did not consider gender differences in these relationships; however, as its sample only included female students from the UAE, it could be directly compared with the female subsample in the current study. Although both studies found that the female learning environment was related to motivation, the study by Aldridge and Rowntree (2021) found teacher support to be the only learning environment factor to be related to all three components (learning goal orientation, task value and self-efficacy) of the motivation construct, but it must be noted that this study did not include task orientation as a learning environment factor. The Aldridge and Rowntree (2021) study involved younger students who due to their age, probably require more teacher support than the students in the current study.

The results outlined above provide instructors with opportunities to manipulate or improve aspects of the learning environment to make gains in terms of student motivation, for both male and female students.

Task orientation: Task orientation is the expectation that students will stay on task and complete assigned activities (Aldridge et al., 1999). Of the seven learning environment scales considered in the current study, task orientation has been shown to have the widest influence across motivation, self-regulation, mathematics anxiety and, indirectly, mathematics achievement. In terms of motivation, the findings suggest that, if an instructor focuses on task orientation, both male and female students are likely to be more motivated, and completing assigned activities will increase the likelihood and desire to master the new skills (learning goal orientation). By expecting a task to be completed, the instructor places an increased level of importance on that task (task value) and the more assigned tasks that students are able to complete, the more confident they are to complete future tasks (self-efficacy).

Student cohesiveness: One of the results highlighted here is the importance of the social aspects of the learning environment to female students. Student cohesiveness is one of these social aspects and suggests that if instructors provide opportunities for students to get to know, help and support one another, they are likely to enhance the learning goal orientation component of motivation by supporting the desire to master new skills, but for female students only.

Teacher support: The findings suggest that teacher support is an important aspect of the learning environment in determining motivation levels for both male and female students (Aldridge & Rowntree, 2021), albeit in different ways. Instructors able to help, trust and show an interest in their students are likely to enhance the students' levels of motivation. For male students, the level of teacher support affects the value that is placed on assigned tasks (task value); however, for female students, it affects their belief in their ability to perform a task (self-efficacy).

Collaboration: Supporting the importance of the social aspects of the learning environment to female students, collaboration was found to be related to self-efficacy, but for female students only (Aldridge & Rowntree, 2021). The findings suggest that if instructors provide female students with opportunities to collaborate on tasks, their self-efficacy will be enhanced. It is possible that this relationship reflects the combined ability of a group of students as compared to an individual student.

Investigation: Investigation was related to task value, but only for female students. This finding suggests that when instructors provide female students with opportunities to problem solve and investigate as part of a discovery approach to learning, they can expect a high value to be placed on the tasks they set. This relationship could also support the importance of the social aspects of the learning environment to female students because learning environments that focus on investigation and problem solving also tend to require students to work collaboratively.

It is recommended that instructors of both male and female students provide a structured mathematics learning environment with high expectations to maximise student motivation levels.

Recommendation 15: It is recommended that to maximise student motivation levels, instructors provide a structured mathematics learning environment with high expectations.

(2) Learning Environment – Self-Regulation Relationships

The results indicate that relationships between the learning environment and self-regulation were different for male and female students. For female students, all three relevant relationships in the final structural model were statistically significant:

- student cohesiveness → self-regulation ($\beta = .12, p < .10$)
- task orientation → self-regulation ($\beta = .55, p < .01$)
- collaboration → self-regulation ($\beta = .13, p < .10$).

In contrast, only one of the three relationships was statistically significant for male students:

- task orientation → self-regulation ($\beta = .58, p < .01$).

The results above differed from those of the study carried out by Aldridge and Rowntree (2021), which involved female secondary school students in Abu Dhabi and found no direct relationship between learning environment and self-regulation.

Although the context of the Aldridge and Rowntree study was similar to the current study because it involves single-sex education in the UAE, it must also be noted that the students in the study were younger and might not have had the opportunity to develop the same level of self-regulatory skills. A study by Alzubaidi et al. (2016) at university level in Jordan reported that all seven WIHIC learning environment scales were related to self-regulation. The current study is able to support this earlier research for the student cohesiveness, task orientation and collaboration scales, but not for the other four scales. Although the study in Jordan did involve university students, these students were from 13 different schools within the university, whereas the current study focused solely on mathematics students in the School of Engineering.

The results add to the importance of task orientation as a mathematics learning environment factor, as not only was it the only common learning environment factor with a relationship with self-regulation for both male and female students but also the only mathematics learning environment factor with a relationship with self-regulation for male students.

These results provide instructors with opportunities to manipulate or improve aspects of the learning environment to increase the use of self-regulatory practices.

Task orientation: Task orientation was the only learning environment scale that was related to self-regulation for both male and female students. This finding suggests that if instructors provide a learning environment that focuses on staying on task and completing the assigned activities, they are likely to encourage students to use self-regulatory skills. In a structured learning environment where the expectation is that assigned activities will be completed, students are more or less forced to regulate their effort to meet the requirements of the class.

Student cohesiveness: The relationship between student cohesiveness and self-regulation supports the importance of the social aspects of the learning environment to female students. Instructors able to provide female students with opportunities to know, help and support each other are likely to also encourage these students to self-regulate.

Collaboration: The relationship between collaboration and self-regulation was significant for female students only. This finding supports the importance of the social aspects of the learning environment to female students. The finding suggests that when instructors provide opportunities for female students to work together rather than compete against each other, they promote the use of self-regulatory activities by these students. When a group of students collaborate, they will have the accumulation of the self-regulatory skills of its members at their disposal, which would explain the higher level of its use.

Many university-level students do not have the self-regulatory skills needed to learn effectively (Khusainova & Ivutina, 2016), even when they have the motivation to do so. Many students lack organisational skills, time management and learning strategies, and the situation is more extreme for male students. Although relationships existed between aspects of the learning environment and self-regulation, these relationships could be stronger if the learning environment was modified to directly promote these skills. It is therefore recommended that the mathematics learning environment be used to impart the necessary self-regulatory skills and knowledge either as part of an introductory program or as a course information booklet.

Recommendation 15: It is recommended that the mathematics learning environment be used to impart the necessary self-regulatory skills and knowledge either as part of an introductory program or as a course information booklet.

(3) Learning Environment – Mathematics Anxiety Relationships

The results of the gender comparisons of the relationships between learning environment and mathematics anxiety were different for male and female students. Whereas none of the three relevant relationships in the final structural model were statistically significant for male students, all three were statistically significant for female students:

- task orientation → mathematics anxiety ($\beta = -.27, p < .05$)
- collaboration → mathematics anxiety ($\beta = -.42, p < .01$)
- equity → mathematics anxiety ($\beta = -.24, p < .05$).

Finding task orientation and collaboration to be related to mathematics anxiety supported an earlier study by (Taylor & Fraser, 2013), which also found these scales to be related to mathematics anxiety. However, the results differed to those of a study by McMinn and Aldridge (2020), which reported that only involvement had a relationship with mathematics anxiety. Although the study by McMinn and Aldridge included both male and female trainee teachers in the UAE, the sample only included eight male trainees, so it was reasonable to make a comparison with the female group in the current study. McMinn and Aldridge (2020) suggested that the greater a trainee's level of involvement, the more comfortable they became and the lower their level of learning mathematics anxiety. This differs from the current study because the learning environment in a university mathematics classroom involves few questions and little discussion.

Task orientation was once again an important learning environment factor, but this time as a determinant of mathematics anxiety and only for female students. The importance of the social aspects of the learning environment to female students was again highlighted. Encouraging female students to stay on task and complete activities and to help each other, and having an instructor who treats students equally, can also reduce levels of mathematics anxiety.

Overall, these results suggest that the relationship between mathematics learning environment and mathematics anxiety is more extensive for female than male students. It is therefore recommended that instructors with female students provide structure (task orientation), treat students equally (equity) and provide opportunities for students to work together (collaboration) to reduce their level of mathematics anxiety.

Recommendation 16: It is recommended that to reduce levels of mathematics anxiety in female students, instructors focus on providing structure, collaboration and equity.

No studies have examined gender differences in the relationship between learning environment and mathematics anxiety. By finding that task orientation, collaboration and equity were related to mathematics anxiety, but only for female students, the current study extends prior research in this area.

The results reported above provide instructors with opportunities to manipulate or improve aspects of the learning environment to reduce the level of mathematics anxiety.

Task orientation: Task orientation had a negative relationship with mathematics anxiety; however, for this construct the relationship existed for female students only. This finding suggests that if instructors provide a structured learning environment that focuses on staying on task and completing assigned tasks, the level of mathematics anxiety experienced by female students could be reduced. A learning environment with high task orientation includes high expectations for punctuality, being ready to work, using time productively and completing tasks has already been shown to get the best out of students in many areas. Students doing their best are more likely to be successful and less likely to feel anxious.

Collaboration: The results indicate that collaboration has a negative relationship with mathematics anxiety, but only for female students. This is another example of a social aspect of the learning environment being important to female students. Instructors able to provide female students with opportunities to collaborate are likely to assist these students in lowering their levels of mathematics anxiety (Koçak et al., 2009). When collaborating, group members have the combined resources of its members at their disposal, which allows them to be more successful. Collaboration also means that the focus is not on one individual when accounting for poor results.

Equity: The equity scale assesses the degree to which students are treated equally by the instructor. The results found that equity was negatively related to mathematics anxiety, but only for female students. Equity is a measure of the relationship between the instructor and the students and, as such, it is consistent with similar relationships, which were important only for female students. The results indicate that instructors who treat their students equally are likely to minimise levels of anxiety for female students.

(4) Learning Environment – Mathematics Achievement Relationships

The fourth supported relationship was between the mathematics learning environment and mathematics achievement. This relationship was supported for two learning environment factors by the final structural model. Both supported relationships were statistically significant for female students:

- student cohesiveness → mathematics achievement ($\beta = .25, p < .10$)
- involvement → mathematics achievement ($\beta = .27, p < .10$).

Only one relationship was statistically significant for male students:

- Involvement → mathematics achievement ($\beta = .27, p < .10$).

In this study, the relationship between involvement and mathematics achievement was found to be statistically significant for both male and female students. Involvement as part of the learning environment consists of sharing ideas and opinions and discussing how to solve problems. This finding is important as it supports the idea that knowledge is constructed and skills developed during social interactions. This form of social constructionism (Vygotsky, 1978) focuses on learning by discovery and exploration. Instructors wishing to use this relationship to improve mathematics achievement for both male and female students should ask students questions and draw out responses by providing scaffolding. Just as importantly, they should encourage students to ask questions. This type of student participation will require the instructor to provide a safe learning environment where ideas are shared without judgement. This finding highlights the limitations of the traditional large lecture style that most universities adopt. However, it must add support to the need for smaller tutorial type interactions to be included.

Overall, the results show that for female students, the mathematics learning environment has a more extensive relationship with mathematics achievement than the equivalent relationship for male students. Despite this result, and the fact that female students had a more positive perception of their learning environment, female student achievement was not significantly different than the achievement of male students.

However, to put this result into perspective, it must be noted that enrolment of female students outnumber male student enrolments in a ratio of 2:1, as many males gain employment in the public sector or military. The availability of employment options might act as a screening process for less able or at least less educationally motivated male candidates, which could mean that achieving parity in achievement, under these circumstances, is a positive result for female students.

The results reported above provide instructors with opportunities to manipulate or improve aspects of the learning environment to improve mathematics achievement.

Student cohesiveness: The significant relationship between student cohesiveness and mathematics achievement, for female students only, once again supported the importance of the social aspects of the learning environment for female students. The findings suggest that if instructors provide opportunities for female students to get to know, help and support one another (student cohesiveness) they are likely to also improve their mathematics achievement.

Involvement: Involvement was related to mathematics achievement for both male and female students. This result supported numerous other studies that have found the learning environment was related to achievement (Chionh & Fraser, 2009;Fraser & Kahle, 2007). However, the current study extends beyond the scope of these studies by examining gender differences in the relationship between learning environment and achievement.

(5) Motivation – Self-Regulation Relationships

The fifth relationship supported by the final structural model was that motivation was related to self-regulation. Of the three possible relationships, the final structural model supported a single relationship between motivation and self-regulation. The relationship was statistically significant for female students:

- self-efficacy → self-regulation ($\beta = .29, p < .01$)

and for male students:

- self-efficacy → self-regulation ($\beta = .30, p < .05$).

This result indicates that both male and female students are unlikely to self-regulate if they do not feel that they will succeed. It supports prior research that found students with high levels of self-efficacy will select more challenging goals, self-monitor and self-evaluate (Zimmerman et al., 1992). These findings suggest that efforts to improve student self-efficacy could lead to an increased uptake of self-regulatory strategies. These findings support the studies, or parts of studies, reporting positive relationships between self-efficacy and self-regulation (Pajares, 2002; Velayutham et al., 2012).

Learning goal orientation failed to have a significant relationship with self-regulation despite it having the highest scale mean for both male (M = 4.63) and female students (M = 4.59). The high scores for this scale could potentially have created a ceiling effect, which artificially grouped a large percentage of the scores and prevented a significant relationship. This could explain why the results of the current study differed from those of previous studies, which found that self-regulation was influenced by learning goal orientation (Fadlelmula et al., 2015; Velayutham et al., 2012),

The lack of importance of task value as a determinant of self-regulation could be attributed to the overall lack of perceived importance or interest in assigned tasks by the students in the program from which the sample for the current study was taken. The difference between this program and most others is the high level of remuneration provided to its participants, which means that interest in the subject is less likely to be the driving force for enrolment in the program. These findings differed from past studies, which found that task value was related to self-regulation (O'Keefe & Linnenbrink-Garcia, 2014; Velayutham et al., 2012).

(6) Mathematics Anxiety – Motivation Relationships

The sixth supported relationship was that mathematics anxiety was related to motivation. Out of the three possible relationships, the final structural model supported a single negative relationship between mathematics anxiety and self-efficacy. This relationship was statistically significant for female students:

- mathematics anxiety → self-efficacy ($\beta = -.32, p < .01$)

and for male students:

- mathematics anxiety → self-efficacy ($\beta = -.28, p < .01$).

This result supports those of other studies that have consistently found mathematics anxiety to have a negative relationship with motivation (Al Majali, 2020; Hopko et al., 2005; Pollack et al., 2021). Few studies have considered gender differences for this relationship. However, the current study supported studies that found a negative relationship between mathematics anxiety and motivation for male students (Z. Wang et al., 2020) and for "predominantly" female students (Zakaria & Nordin, 2008), but differed from the study by Wang et al.(2020), as it also found the relationship to be significant for female students. Jointly, the results indicate that mathematics anxiety can have a negative influence on motivation and that the relationship might differ for male and female students. The lack of consistency in these results may be attributed to context, or differences in the study participants. The current study involved university-level mathematics students in the UAE, whereas the participants in the other studies were high school students in Italy and mathematics education students in Malaysia (Zakaria & Nordin, 2008). Despite these differences, the current study adds to a limited database that considers gender differences in the mathematics anxiety–motivation relationship.

This result suggests that an instructor adopting strategies to reduce levels of mathematics anxiety is likely to also strengthen student self-efficacy. However, it is noted that in the current study, both male and female students had lower means for mathematics anxiety than any of the other 12 scales involved in the study.

(7) Motivation – Mathematics Achievement Relationships

The seventh supported relationship was that motivation was related to mathematics achievement. The final structural model supported two positive relationships between motivation and mathematics achievement. Both relationships were statistically significant for female students:

- task value → mathematics achievement ($\beta = .21, p < .10$)
- self-efficacy → mathematics achievement ($\beta = .12, p < .10$)

and for male students:

- task value → mathematics achievement ($\beta = .21, p < .10$)
- self-efficacy → mathematics achievement ($\beta = .47, p < .01$).

This result differs from the majority of the research on the influence of motivation on achievement, which concentrated on the influence of learning goal orientation and found a positive relationship with achievement (Chen & Wong, 2015; Hutagalung et al., 2020; Ruishi et al., 2021). The current study did not include a relationship between learning goal orientation and mathematics achievement in the final structural model, even though learning goal orientation was the highest scale mean for both male (M = 4.63) and female students (M = 4.59). Once again, the high scores for this scale mean could potentially have created a ceiling effect, which artificially grouped a large percentage of the scores and prevented a significant relationship. The current study did, however, support the result of studies that found task value (Zhang & Wang, 2020) and self-efficacy to be related to mathematics achievement (Arens et al., 2020). Few studies have considered gender differences in the relationship between motivation and achievement; however, the current study was consistent with Arens et al.(2020), who found gender invariance in the relationship between self-efficacy and achievement.

Task value was related to mathematics achievement for both male and female students, which suggests that when instructors take the time to explain the importance of the task, they are likely to promote higher levels of mathematics achievement. Self-efficacy was also related to mathematics achievement for both male and female students. This result suggests that any actions taken by the instructor to build student confidence could also promote higher levels of mathematics achievement.

(8) Self-Regulation – Mathematics Achievement Relationships

The eighth supported relationship was that self-regulation was related to mathematics achievement. The final structural model supported this relationship, which was between two single factor constructs. The relationship was positive and statistically significant for female students:

- self-regulation → mathematics achievement ($\beta = .23, p < .05$)

and for male students:

- self-regulation → mathematics achievement ($\beta = .19, p < .10$).

The results reported above support previous studies that have found self-regulation to be related to achievement at primary (Sayedi et al., 2017), secondary (Tee et al., 2021) and university (Alotaibi, 2017; Sahranavard et al., 2018) levels. However, the results were not consistent with those of the studies that considered gender differences in these relationships. These studies found that female students exhibited higher levels of positive self-regulatory strategies and therefore higher achievement (Duckworth & Seligman, 2006; Weis et al., 2013). The difference in the relationship for male and female students was explained as being due to the female students having higher behaviour regulation or self-discipline. The difference between these studies and the current study was the age of the students involved. The current study involved university students, who have sufficient self-regulatory strategies to achieve at a high enough level to be accepted into university. This could be a contributing reason for the 2:1 ratio of females to males at university in the UAE.

These results suggest that integrating the development of self-regulatory strategies into the program is likely to have a positive impact on mathematics achievement for both male and female students (Dignath-van Ewijk & van der Werf, 2012).

(9) Mathematics Anxiety – Mathematics Achievement Relationships

The ninth supported relationship was that mathematics anxiety was related to mathematics achievement. The final structural model supported this relationship, which was between two single factor constructs. The relationship was negative and was statistically significant for female students:

- mathematics anxiety → mathematics achievement ($\beta = -.44, p < .01$)

and for male students:

- mathematics anxiety → mathematics achievement ($\beta = -.19, p < .05$).

The results support studies that found a negative relationship between mathematics anxiety and mathematics achievement (Al Mutawah, 2015; Hamid et al., 2013; Pourmoslemi et al., 2013). Studies that consider gender differences in this relationship either found that the relationship was stronger for female students (Devine et al., 2012), or significant for female students only (Van Mier et al., 2019). The current study found the relationship to be significant for both male and female students and it also found the relationship to be stronger for female students ($\beta = -.44$) compared with male students ($\beta = -.19$) (Cumming, 2009).

The results suggest that if instructors adopt strategies to reduce mathematics anxiety, they could promote higher levels of mathematics achievement for both male and female students.

6.3 Limitations of the Study

The research reported in this study, as with all research, has some limitations that should be considered when interpreting the results. This section discusses the limitations and, where applicable, offers recommendations that will reduce the likelihood and impact of limitations in future research.

A major limitation of the study was the sample that was selected from a single university in the Emirate of Abu Dhabi. Although the students at the university are drawn from across all seven emirates, generalising the results to other universities in other emirates of the UAE should be done with caution. It is recommended, therefore, that future research include participants from across a number of universities from a number of emirates.

A further limitation of the study is the use of convenience sampling. The selection of this university provided a large number of mathematics students and the collection of mathematics achievement scores (as the researcher was a member of the mathematics department faculty). Although this data might not be available from other institutions, this limitation is acknowledged. It is recommended, therefore, that future studies involve a random selection of universities.

An important limitation of this study is the comparison of students (males and females) taught in separate single-sex classes. This limits the possible generalisation of the results to the few countries that still offer this form of segregated education.

Even as the UAE transitions towards a coeducational model of education, caution must be taken when attempting to generalise the results beyond this unique context. The university involved in the current study had recently merged with another university, which was “coeducational”. This model is not quite as the label implies, as it has male and female students separated in the classroom, with male students on one side and female students on the other. Despite this limitation, when generalising it is recommended that future research in this area could investigate whether male and female students prefer the traditional single-sex model or the newer transitional coeducational model, and which sex benefits more from this change.

Recommendation 17: It is recommended that future research in this region investigates whether students prefer the traditional single-sex model or the newer transitional coeducational model, and whether male or female students benefit more from this change.

A further limitation was the lack of causal explanations for the findings. While the collection of qualitative data was outside the scope of the current study, it is acknowledged that the study lacks the interpretive benefits that could be provided by the collection of qualitative data in a mixed methods approach (Cresswell, 2012). Although the study provides important information about the relationships that were examined, it is recommended that future research use a mixed methods approach to add greater depth to the interpretation of the data (Recommendations 3, 10, 12 and 13).

Another limitation was related to the restriction to one-way relationships in the hypothesised research model. The model was initially based on Bandura's model of reciprocal determinism (Bandura, 1989) and the existence of previous research that described a number of relationships in both directions; however, to determine the existence of reciprocal relationships, as proposed by Bandura, would require the collection of longitudinal data. This was outside the scope of the current study, which was restricted to the collection of cross-sectional data to limit disruption to the university and its students. Results of previous research was used to determine the direction of the relationships to be included in the model. To allow an investigation of the two-way relationships, it is therefore recommended that future research consider the collection of longitudinal data (Recommendation 18).

Recommendation 18: It is recommended that future research collects longitudinal data to allow an investigation of two-way relationships.

The current research made gender comparisons for differences in the students' perceptions of the learning environment and reported levels of motivation, self-regulation and mathematics anxiety, and mathematics achievement as well as the relationships between these constructs. Although gender was the only independent variable, it can only be presumed that any differences in perceptions of these constructs and the relationships between them were caused by gender. This study does not provide definitive evidence that the differences were caused by gender (Gay et al., 2009); however, that was not the goal of this research. The goal was to extend the existing database by including data describing gender differences in mathematics at university level in the UAE. Little research has been done at this level and even less in this context. To help address this limitation, it is recommended that future research use a mixed methods approach to provide causal explanation to findings (Recommendations 3, 10, 12 and 13).

Given that threats to internal validity influence the accuracy of perceived causation (Cresswell, 2012), opting for this research design required several threats to validity to be addressed to reduce rather than eliminate their impact. Firstly, given that qualitative data was not collected, as outlined above, causal explanations could not be provided; however, the researcher was an active participant in the study's setting, thereby providing contextual information to assist with the interpretation of the data. Secondly, although the researcher used cluster sampling, due to access to achievement data, the sample can still be considered representative of single-sex public universities in the UAE. Thirdly, care was taken to ensure that students responded to the instruments simultaneously to avoid the potential of participants responding in different ways, with the data collected over three days. Finally, the timing for administration of the survey coincided with the release of the achievement data to allow matching between the two sets of data.

A potential limitation was ecological validity. To maintain ecological validity, the data needed to represent a practical in-class setting (Bryman, 2012). To maximise ecological validity, efforts were made to ensure that students were focused on their mathematics classroom. All students completed the instruments in their mathematics classroom during one of their scheduled sessions and were provided with clear instructions that reinforced the focus of the study.

6.4 Recommendations

The recommendations identified in this discussion are summarised as follows:

Recommendation 1	It is recommended that to improve levels of motivation in male mathematics students in the UAE, instructors provide an environment that is welcoming and inclusive and has high expectations.
Recommendation 2	It is recommended that to increase levels of self-regulation in students, instructors use a positive mathematics learning environment to introduce self-regulatory skills, either integrated into the program or as a directed intervention.

Recommendation 3 It is recommended that future mathematics anxiety research in this context collects qualitative data to provide possible explanations for the low levels of mathematics anxiety for both male and female students.

Recommendation 4 It is recommended that to improve the level of mathematics achievement, instructors focus on creating a positive mathematics learning environment.

Recommendation 5 It is recommended that to enhance students' self-regulatory skills, instructors maximise the level of student motivation by improving self-efficacy.

Recommendation 6 It is recommended that any effort to improve the motivation level of mathematics students be accompanied by or proceeded by efforts to reduce mathematics anxiety.

Recommendation 7 It is recommended that to improve student achievement, instructors use the mathematics learning environment to maximise student motivation.

Recommendation 8 It is recommended that to improve the level of student achievement, instructors assess the level of self-regulation in their students and address any shortfalls by including relevant remedial activities in the program.

Recommendation 9 It is recommended that to improve mathematics achievement, instructors focus on reducing mathematics anxiety.

Recommendation 10 It is recommended that future research into motivation at university level in the UAE uses a mixed methods approach to collect qualitative data to confirm that a learning goal orientation is an overriding approach that students employ during the learning process.

Recommendation 11	It is recommended that instructors, especially of male students, emphasise the utility and enjoyment aspects of learning mathematics.
Recommendation 12	It is recommended that a mixed method approach is used to provide causal data to explain the existence of a statistically significant difference in reported levels of motivation (learning goal orientation and task value) for Pre-calculus level students, but not for Calculus level students
Recommendation 13	It is recommended that further qualitative research be carried out to provide an explanation for the high levels of self-efficacy despite the low levels of achievement.
Recommendation 14	It is recommended that a future study focuses on mathematics anxiety and includes the collection of qualitative data to explain the low levels of mathematics anxiety.
Recommendation 15	It is recommended that to maximise student motivation levels, instructors provide a structured mathematics learning environment with high expectations.
Recommendation 16	It is recommended that the mathematics learning environment be used to impart the necessary self-regulatory skills and knowledge either as part of an introductory program or as a course information booklet.
Recommendation 17	It is recommended that to reduce levels of mathematics anxiety in female students, instructors focus on providing structure, collaboration and equity.
Recommendation 18	It is recommended that future research in this region investigates whether students prefer the traditional single-sex model or the newer transitional coeducational model,

and whether male or female students benefit more from this change.

Recommendation 19 It is recommended that future research collects longitudinal data to allow an investigation of two-way relationships.

Recommendation 20 Although it is outside the focus of this study it is recommended that future research in this region at this level investigate the differences in the perception of the learning environment and reported levels of motivation, self-regulation and anxiety, as well as achievement between foundation programme mathematics (Pre-calculus) and English (zero-credit) language courses.

Recommendation 21 Although it is outside the focus of this study it is recommended that future research at this level investigate differences in the perception of learning environment and reported levels of motivation, self-regulation and mathematics anxiety for each university mathematics year level.

6.5 Significance of the Study

The significance of the study is separated into three categories: theoretical (Section 6.3.1), methodological (Section 6.3.2) and practical (Section 6.3.3).

6.5.1 Theoretical

Theoretically the study reported in this thesis has made contributions to the fields of learning environment research, mathematics education and gender studies. This study has made a number of theoretical contributions to the field of learning environment research. First, is the development of a complex model. There have been numerous studies that have investigated the relationships between learning environment and motivation, self-regulation, mathematics anxiety and mathematics achievement. Usually these studies were limited to two or three variables. The complex model developed in this research initially analysed five models containing three variables, which were then combined in supported relationships and followed by further analysis. As a result, the current study builds on each of these simpler models by considering the same relationships as part of a more complex situation, which has more variables interacting. The results of this research add to the body of knowledge of research in this area.

The second theoretical contribution made by this study was that it was able to examine both direct and indirect relationships. The complexity of the model meant that it was able to examine the mediating effect of motivation, self-regulation and mathematics anxiety on the relationship between learning environment and mathematics achievement. This is the first research to examine all of these indirect relationships in a single model, particularly at university level. The results of this research add to the body of knowledge on the importance of learning environment on student outcomes.

The third theoretical contribution made by this study was that not only did it examine the relationships between learning environment and motivation, self-regulation, mathematics anxiety and mathematics achievement, it also compared these relationships for male and female students.

Most educational research in the UAE is at primary or secondary level. Research at tertiary level tends to focus on trainee teachers. This study adds to a limited body of knowledge about university students in the UAE studying science, technology, engineering and mathematics (STEM) related courses.

The study not only provides evidence to support previous studies that found female students had a more positive perception of their mathematics learning environment, it also extended this research by examining the differences in relationships between factors. The study found that the relationships the mathematics learning environment had with the other constructs in the research model were more extensive for female students than they were for male students, possibly, or at least in part, because female students had a more positive perception of their mathematics learning environment.

6.5.2 Methodological

The research in this study used three instruments. First, WIHIC was used to measure students' perceptions of the mathematics learning environment. The students were bilingual, with varying ability in English and Arabic, so a dual English/Arabic version of the instrument was developed and used. The dual-language version, with each question presented in English with the Arabic translation below, allowed participants to use one or both languages to interpret each question. A parallel English/Arabic version had been used previously in the UAE (MacLeod & Fraser, 2010); however, this format included separate English and Arabic instruments and allowed participants to choose which one to use. This study was the first to use and provide evidence to support the reliability and validity of the full version of the dual English/Arabic instrument in the UAE, although some scales had been used in this format previously (Afari, 2012). The results obtained allow other researchers with participants who speak both English and Arabic, as is the case in the UAE, to use the instruments confident in the knowledge that all three instruments have satisfactorily met the recommended criteria for validity and reliability and have been successfully used with university-level mathematics students in this context.

The SALEM instrument was used to measure motivation and self-regulation. It had been modified from the SALES instrument (Velayutham et al., 2011) by Chipangura (2014) specifically for use in mathematics classrooms. This study translated the instrument into Arabic to produce an English/Arabic version of the instrument. The results provided support for the reliability and validity of the dual-language instrument for use with university-level mathematics students in the UAE. This study was the first to use the SALEM instrument in any form at tertiary level and also makes the Arabic version of the instrument accessible to researchers in the Arab speaking Middle East and North Africa (MENA) region.

The R-MANX instrument was used in this study to measure mathematics anxiety. The instrument had previously been translated into Arabic and used in middle and high school students in Bahrain. This study was the first to use a dual English/Arabic version of the instrument and to validate it for use at university level in the UAE.

6.5.3 Practical

Improving educational achievement is one goal, if not the main goal, of most educational institutes. The confirmation of direct relationships between the mathematics learning environment and mathematics achievement, and those mediated by motivation, self-regulation and mathematics anxiety, at university level not only provides avenues for improving mathematics achievement but also increases the benefits in adapting the mathematics learning environment to initiate improvements in motivation, self-regulation and mathematics anxiety. The results of the current research provides direction for efforts to improve mathematics achievement standards at university level in the UAE and other regions with similar educational contexts.

A comparison of gender differences in the mathematics learning environment scale means has revealed that female students perceive their mathematics learning environment to be more positive than male students. Given that in the current study male and female learning environments are separate, this result cannot solely be attributed to female students having a more positive outlook. It is just as likely, and also the experience of the researcher, that the female mathematics learning environment is more positive than that of the male students. Female students also report higher levels of motivation than male students. The relationship between the mathematics learning environment and motivation is stronger and more extensive for female students than it is for male students. These results suggest the need for intervention to improve male students' perceptions of their learning environment and level of motivation. Practical options for improving the mathematics learning environment for both male and female students are included below.

Improving mathematics achievement can be done by adapting the mathematics learning environment to improve levels of student motivation, self-regulation and mathematics anxiety. As in a number of other studies, motivation was identified as an important factor in determining the level of mathematics achievement for students (Cleary & Kitsantas, 2017; Michaelides et al., 2019). This study found that the value that students place on a task and their self-belief in their capability to perform a task were strong predictors of mathematics achievement for both male and female students. An instructor who is friendly and helpful to students (teacher support) and provides structure and has high expectations of students (task orientation) will foster higher levels of motivation. When instructors deem tasks important enough to demand completion, students place a higher value on these tasks. When students complete tasks, their level of self-efficacy increases.

Instructors able to create interest, encourage participation and enjoyment (involvement) in their classes are able to directly promote higher levels of mathematics achievement for both male and female students. This type of involvement encourages students to work harder to achieve at a higher level.

This study found self-regulation to be a determinant of mathematics achievement for both male and female students. Students who are involved in their learning and able to adapt their effort to meet new challenges achieve at a higher level. Instructors able to encourage students to be helpful, supportive and cooperative (student cohesiveness and collaboration) are able to increase the student's level of self-regulation, which can form the basis of higher levels of mathematics achievement.

The relationship between the mathematics learning environment and mathematics achievement was found to be mediated by mathematics anxiety. Mathematics anxiety was also found to have an inverse relationship with mathematics achievement for both male and female students. Students with low levels of mathematics anxiety are better able to achieve at a higher level. Instructors able to provide female students with a mathematics learning environment that focuses on collaboration and fairness (equity) are able to reduce levels of mathematics anxiety and thereby promote higher levels of mathematics achievement.

6.6 Concluding Remarks

The research in this study has met all research objectives and made recommendations in a number of key areas. Theoretical, methodological and practical contributions have also been made.

The theoretical contribution includes developing a complex model, involving direct and indirect relationships between five constructs, which few studies have attempted. This approach was important as the relationship between pairs of constructs does not happen in isolation. Prior research has reported relationships between constructs, or gender differences in scale means. Few studies have reported gender differences in relationships between constructs. The current study adds to the limited database in this developing area. Methodological contributions include the translation of instruments into Arabic (WIHIC and SALEM) and the development of dual English/Arabic versions of the WIHIC, SALEM and R-MANX instruments for use with bilingual students. The results validated the use of these instruments in a new context. The practical contribution involved providing recommendations for instructors to improve the mathematics learning environment for both male and female students.

The current study has looked at mathematics education in a unique context; nevertheless, the outcomes of the study should interest a number of different groups. Future researchers in the region, and beyond, should be interested in the theoretical and methodological contributions as well as the recommendations that have been made. The practical contribution should be of interest to educationists, from instructor level to policy-making level.

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APPENDIX 1

Dual Language Version (Arabic – English) of the What Is Happening In this Class? (WIHIC)[1]

[1] Used with permission of the authors Fraser, McRobbie and Fisher (1996)

WHAT IS HAPPENING IN THIS CLASS?
ما الذي يحدث في هذا الصف؟

☐ I have received information regarding this research and had an opportunity to ask questions. I believe I understand the purpose, extent and possible risks of my involvement in this project and I voluntarily consent to take part.

لقد تلقت معلومات بشأن هذا البحث، وكان لدي فرصة لطرح الأسئلة. أعتقد أنني أفهم الغرض، ومدى المجازفة المحتملة لمشاركتي في هذا المشروع البحثي وأنا موافق على المشاركة.

Directions

1 This questionnaire contains statements about practices which could take place in this class. You will be asked **how often** each practice takes place.

يتضمن هذا الاستبيان عبارات حول الممارسات و الأنشطة الدراسية التي يمكن أن تحدث في هذا الصف الدراسي.

سوف تسأل عن عدد المرات التي تحدث فيها هذه الأنشطة و الممارسات.

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.

لا توجد إجابات "صحيحة" أو "خاطئة ".المطلوب هو فقط رأيك. عليك فقط التفكير في كيفية وصف كل عبارة لما يحدث في الصف من وجهة نظرك.

2 Draw a circle around

1 if the practice takes place **Almost Never** تقريباً لا يحدث هذا أبداً
2 if the practice takes place **Seldom** نادراً ما يحدث
3 if the practice takes place **Sometimes** يحدث أحياناً
4 if the practice takes place **Often** غالباً ما يحدث
5 if the practice takes place **Almost Always** تقريباً يحدث طوال الوقت

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

تأكد من الإجابة عن جميع الأسئلة. إذا قمت بتغيير رأيك حول جواب معين ، يمكنك شطب الاختيار و وضع دائرة أخرى .

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

بعض العبارات في هذا الاستبيان متشابهة إلى حد ما مع عبارات أخرى . لا داعي للقلق حول هذا الموضوع. ببساطة أعطي رأيك في جميع العبارات .

		Almost Never تقريباً أبداً	Seldom نادراً	Some-times أحياناً	Often غالباً	Almost Always تقريباً دائماً
In this mathematics class ... **في صف الرياضيات هذا.........**						
1.	I make friendships among students in this class. أكوّن صداقات مع الطلاب في هذا الصف	1	2	3	4	5
2.	I know other students in this class. أعرف طلاب آخرون في هذا الصف	1	2	3	4	5
3.	I am friendly to members of this class. أكون ودوداً مع المشاركين في هذا الصف	1	2	3	4	5
4.	Members of this class are my friends. المشاركين في هذا الصف هم أصدقائي	1	2	3	4	5
5.	I work well with other class members. أعمل بشكل جيد مع الزملاء في هذا الصف	1	2	3	4	5
6.	I help other class members who are having trouble with their work. أساعد الزملاء الذين يواجهون صعوبات	1	2	3	4	5
7.	Students in this class like me. يحبني الطلاب في هذا الصف	1	2	3	4	5
8.	In this class, I get help from other students. يساعدني الطلاب الآخرون في هذا الصف	1	2	3	4	5
9.	The teacher takes a personal interest in me. يهتم المعلم بي شخصياً	1	2	3	4	5
10.	The teacher goes out of his/her way to help me. يقوم المعلم بأكثر من المتطلب لمساعدتي	1	2	3	4	5
11.	The teacher considers my feelings. يراعي المعلم مشاعري	1	2	3	4	5
12.	The teacher helps me when I have trouble with the work. يقوم المعلم بمساعدتي عندما أواجه صعوبات	1	2	3	4	5
13.	The teacher talks with me. يتحدث المعلم معي	1	2	3	4	5
14.	The teacher is interested in my problems. يهتم المعلم بمشاكلي	1	2	3	4	5
15.	The teacher moves about the class to talk with me. يتحرك المعلم حول الصف ليتحدث معي	1	2	3	4	5
16.	The teacher's questions help me to understand. تساعدني أسئلة المعلم على الفهم	1	2	3	4	5

		Almost Never تقريباً أبداً	Seldom نادراً	Some-times أحياناً	Often غالباً	Almost Always تقريباً دائماً
In this mathematics class ... **في صف الرياضيات هذا....**						
17.	I discuss ideas in class. أناقش الأفكار	1	2	3	4	5
18.	I give my opinion during class discussion. أعطي آرائي أثناء المناقشة	1	2	3	4	5
19.	The teacher asks me questions. يوجه لي المعلم أسئلة	1	2	3	4	5
20.	My ideas and suggestions are used during classroom discussions. تستخدم أفكاري واقتراحاتي أثناء المناقشة	1	2	3	4	5
21.	I ask the teacher questions. أوجه أسئلة للمعلم	1	2	3	4	5
22.	I explain my ideas to other students. أشرح أفكاري للطلاب الآخرين	1	2	3	4	5
23.	Students discuss with me how to go about solving problems. يناقش الطلاب كيفية حل المسائل	1	2	3	4	5
24.	I am asked to explain how I solve problems. يطلب مني أن أشرح كيف أحل المسائل	1	2	3	4	5
25.	I carry out investigations to test my ideas. أجري تحقيقات لاختبار أفكاري	1	2	3	4	5
26.	I am asked to think about the evidence for statements. يطلب مني أن أفكر في الأدلة	1	2	3	4	5
27.	I carry out investigations to answer questions coming from discussions. أجري تحقيقات لاجابة الأسئلة الناجمة عن المناقشات	1	2	3	4	5
28.	I explain the meaning of statements, diagrams and graphs. أشرح معاني العبارات و الرسوم و الأشكال	1	2	3	4	5
29.	I carry out investigations to answer questions which puzzle me. أجري تحقيقات لاجابة الأسئلة المحيّرة	1	2	3	4	5
30.	I carry out investigations to answer teacher's questions. أجري تحقيقات لاجابة أسئلة المعلم	1	2	3	4	5
31.	I find out answers to questions by doing investigation. لاجابة الأسئلة, أجري تحقيقات	1	2	3	4	5

		Almost Never تقريباً أبداً	Seldom نادراً	Some-times أحياناً	Often غالباً	Almost Always تقريباً دائماً
In this mathematics class ... **في صف الرياضيات هذا....**						
32.	I solve problems by using information obtained from my own investigations. أحل المسائل باستخدام المعلومات التي حصلت عليها من تحقيقاتي الخاصة	1	2	3	4	5
33.	Getting a certain amount of work done is important to me. إنهاء كم معين من العمل مهم لي	1	2	3	4	5
34.	I do as much as I set out to do. أنهي ما أنوي عمله	1	2	3	4	5
35.	I know the goals for this class. أعرف أهداف الصف	1	2	3	4	5
36.	I am ready to start this class on time. أكون مستعد للصف في الوقت المحدد	1	2	3	4	5
37.	I know what I can accomplish in this class. أعرف ما يجب أن أنجزه	1	2	3	4	5
38.	I pay attention during this class. أصغي باهتمام	1	2	3	4	5
39.	I try to understand the work in this class. احاول أن أفهم	1	2	3	4	5
40.	I know how much work I have to do. أعرف كم العمل الذي يجب أن أنجزه	1	2	3	4	5
41.	I cooperate with other students when doing assignment work. أتعاون مع الآخرين في ما يلقى على عاتقنا من عمل	1	2	3	4	5
42.	I share my books and resources with other students when doing assignment. أشارك الآخرين الكتب و المراجع عند العمل	1	2	3	4	5
43.	When I work in groups in this class, there is teamwork. عند العمل كمجموعة, توجد لدينا روح الفريق	1	2	3	4	5
44.	I work with other students on projects in this class. أعمل مع الطلاب في مشاريع هذا الصف	1	2	3	4	5
45.	I learn from other students in this class. أتعلم من الزملاء في هذا الصف	1	2	3	4	5

		Almost Never تقريباً أبداً	Seldom نادراً	Some-times أحياناً	Often غالباً	Almost Always تقريباً دائماً
In this mathematics class ... **في صف الرياضيات هذا....**						
46.	I work with other students in this class. أعمل مع الطلاب الآخرين في هذا الصف	1	2	3	4	5
47.	I cooperate with other students on class activities. أتعاون مع الطلاب الآخرين في أنشطة الصف	1	2	3	4	5
48.	Students work with me to achieve class goals. يعمل معي الطلاب الآخرون لنحقق أهداف هذا الصف	1	2	3	4	5
49.	The teacher gives me as much attention to my questions as to other students' questions. يوليني المعلم نفس قدر الاهتمام الذي يولي الطلاب الآخرين	1	2	3	4	5
50.	I get the same amount of help from the teacher as do other students. أتلقى من المعلم نفس قدر المساعدة مثل الطلاب الآخرين	1	2	3	4	5
51.	I have the same amount of say in this class as other students. أتلقى نفس الفرص للمشاركة في القرارات مثل الطلاب الآخرين	1	2	3	4	5
52.	I am treated the same as other students in this class. تتم معاملتي بنفس الطريقة مثل الطلاب الآخرين	1	2	3	4	5
53.	I receive the same amount of encouragement from the teacher as other students do. أتلقى من المعلم نفس قدر التشجيع الذي يعطي الطلاب الآخرين	1	2	3	4	5
54.	I get the same opportunity to contribute to class discussions as other students. أتلقى نفس الفرص للمشاركة في النقاش مثل الطلاب الآخرين	1	2	3	4	5
55.	My work receives as much praise as other students' work. يتلقى عملي نفس قدر المديح الذي يعطي للطلاب الآخرين	1	2	3	4	5
56.	I get the same opportunity to answer questions as other students أتلقى نفس فرص الإجابة عن الأسئلة مثل الطلاب الآخرين	1	2	3	4	5

APPENDIX 2

Dual Language Version (Arabic – English) of the Students' Adaptive Learning Engagement in Mathematics Survey (SALEM)[2]

[2] Used with the permission of the authors Chipangura and Aldridge (2017)

Curtin University

Students' Adaptive Learning Engagement in Mathematics

☐ I have received information regarding this research and had an opportunity to ask questions. I believe I understand the purpose, extent and possible risks of my involvement in this project and I voluntarily consent to take part.
لقد تلقت معلومات بشأن هذا البحث، وكان لدي فرصة لطرح الأسئلة. أعتقد أنني أفهم الغرض، ومدى المجازفة المحتملة لمشاركتي في هذا المشروع البحثي وأنا موافق على المشاركة.

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 these statements.
فيما يلي بعض العبارات عن كونك طالب في هذا الصف. يرجى قراءة كل عبارة بعناية و وضع دائرة حول الرقم الذي يعبر عن رأيك في تلك العبارات.

There are no 'right' or 'wrong' answers. Your opinion is what is wanted.
لا توجد أجوبة صحيحة أو خاطئة. المطلوب هو رأيك فقط.

For each statement, draw a circle around
لكل عبارة, ضع دائرة حول

1 if you **Strongly Disagree** with the statement أعارض بشدة
2 if you **Disagree** with the statement أعارض
3 if you **Are Not Sure** about the statement غير متأكد
4 if you **Agree** with the statement أوافق
5 if you **Strongly Agree** with the statement أوافق بشدة

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.
تأكد من الإجابة عن جميع الأسئلة. إذا قمت بتغيير رأيك حول جواب معين ، يمكنك شطب الاختيار و وضع دائرة أخرى . بعض العبارات في هذا الاستبيان متشابهة إلى حد مع عبارات أخرى . لا داعي للقلق حول هذا الموضوع. ببساطة أعطي رأيك في جميع العبارات .

Practice Example مثال

Suppose you were given the statement "I think learning mathematics is fun." You would need to decide whether you 'Strongly Disagree', 'Disagree', 'Not Sure', 'Agree' or 'Strongly Agree' that learning mathematics is fun. If you selected 'Agree' then you would circle the number 4 on your questionnaire.
لنفترض أعطيت لك العبارة "اعتقد أن تعلم الرياضيات ممتع." سيكون عليك أن تقرر ما إذا كنت ' لا أوافق بشدة '، ' موافق '، ' غير متأكد '، ' أوافق ' أو ' أوافق بشدة " أن تعلم الرياضيات ممتع . إذا قمت بتحديد " موافق " يجب أن تضع دائرة حول الرقم 4 على الاستبيان.

		Strongly Disagree أعارض بشدة	Disagree أعارض	Not Sure غير متأكد	Agree أوافق	Strongly Agree أوافق بشدة
1.	I think learning mathematics is fun.	1	2	3	(4)	5

LEARNING GOAL ORIENTATION		Strongly Disagree أعارض بشدة	Disagree أعارض	Not Sure غير متأكد	Agree أوافق	Strongly Agree أوافق بشدة
In this mathematics class ... **في صف الرياضيات هذا........**						
1.	One of my goals is to learn as much as I can. أحد أهدافي هو أن أتعلم قدر ما أستطيع	1	2	3	4	5
2.	One of my goals is to learn new mathematics contents. أحد أهدافي هو أن أتعلم محتويات الجديدة في الرياضيات	1	2	3	4	5
3.	One of my goals is to master new mathematics skills. أحد أهدافي هو إتقان مهارات الجديدة في الرياضيات	1	2	3	4	5
4.	It is important that I understand my work. من المهم أن أفهم عملي.	1	2	3	4	5
5.	It is important for me to learn the mathematics content that is taught. من المهم بالنسبة لي معرفة محتوى الرياضيات التي يتم تدريسها .	1	2	3	4	5
6.	It is important to me that I improve my mathematics skills. . من المهم بالنسبة لي تحسين مهاراتي في الرياضيات	1	2	3	4	5
7.	It is important that I understand what is being taught to me. من المهم أن أفهم ما يتم تدريسه لي	1	2	3	4	5
8.	Understanding mathematics ideas is important to me. فهم الأفكارفي الرياضيات مهم بالنسبة لي	1	2	3	4	5

TASK VALUE		Strongly Disagree أعارض بشدة	Disagree أعارض	Not Sure غير متأكد	Agree أوافق	Strongly Agree أوافق بشدة
In this mathematics class ... **في صف الرياضيات هذا........**						
9.	What I learn can be used in my daily life. يمكن استخدام ما أتعلمه في حياتي اليومية.	1	2	3	4	5
10.	What I learn is interesting. أتعلم أشياء شيقة	1	2	3	4	5
11.	What I learn is useful for me to know. ما أتعلمه مفيد لي	1	2	3	4	5
12.	What I learn is helpful to me. ما أتعلمه يساعدني	1	2	3	4	5
13.	What I learn is relevant to me. ما أتعلمه متعلق بي	1	2	3	4	5
14.	What I learn is of practical value. ما أتعلمه ذو قيمة عملية	1	2	3	4	5
15.	What I learn satisfies my curiosity. ما أتعلمه يشبع فضولي	1	2	3	4	5
16.	What I learn encourages me to think. ما أتعلمه يشجعني على التفكير	1	2	3	4	5
SELF-EFFICACY		**Strongly Disagree** أعارض بشدة	**Disagree** أعارض	**Not Sure** غير متأكد	**Agree** أوافق	**Strongly Agree** أوافق بشدة
In this mathematics class ... **في صف الرياضيات هذا........**						
17.	I can master the skills that are taught. أستطيع أن أتمكن من المهارات التي تدرس	1	2	3	4	5
18.	I can figure out how to do difficult work. يمكنني فهم كيفية القيام بالعمل الصعب	1	2	3	4	5
19.	Even if the mathematics work is hard, I can learn it. حتى لو محتوى الرياضيات صعب , أستطيع أن أتعلمه	1	2	3	4	5
20.	I can complete difficult work if I try. يمكنني انهاء العمل الصعب إذا حاولت	1	2	3	4	5
21.	I will receive good grades. سأحصل على علامات جيدة	1	2	3	4	5
22.	I can learn the work we do. أستطيع تعلم ما نقوم به	1	2	3	4	5
23.	I can understand the content taught. أفهم المحتوى الذي يدرس	1	2	3	4	5
24.	I am good at this subject. أنا جيد في هذه المادة	1	2	3	4	5

SELF-REGULATION		Strongly Disagree أعارض بشدة	Disagree أعارض	Not Sure غير متأكد	Agree أوافق	Strongly Agree أوافق بشدة
In this mathematics class ... **في صف الرياضيات هذا........**						
25.	Even when tasks are uninteresting, I keep working. أستمر في العمل حتى لو كانت الأنشطة غير شيقة	1	2	3	4	5
26.	I work hard even if I do not like what I am doing. أستمر في العمل بجدية حتى لو لم يعجبني ما أفعله	1	2	3	4	5
27.	I continue working even if there are better things to do. أستمر في العمل حتى لو كانت هناك أشياءأخرى أفضل	1	2	3	4	5
28.	I concentrate so that I won't miss important points. أركز حتى لا تفوتني النقاط الهامة	1	2	3	4	5
29.	I finish my work and assignments on time. أنجز عملي في الوقت المحدد	1	2	3	4	5
30.	I don't give up even when the work is difficult. لا أستسلم حتى عندما يكون العمل صعباً	1	2	3	4	5
31.	I concentrate in class. أركز في الصف	1	2	3	4	5
32.	I keep working until I finish what I am supposed to do. أستمر في العمل حتى أنهي كل المطلوب مني	1	2	3	4	5

APPENDIX 3

Dual Language Version (Arabic – English) of the Revised Mathematics Anxiety Survey (R-MANX)[3]

[3] Used with the permission of the authors Bursal and Paznokas (2006)

Curtin University

☐ I have received information regarding this research and had an opportunity to ask questions. I believe I understand the purpose, extent and possible risks of my involvement in this project and I voluntarily consent to take part.

مقياس قلق الرياضيات -Math Anxiety Scales

		Almost Never تقريبا أبدا	Seldom نادرا	Some-times أحيانا	Often غالبا	Almost Always تقريبا دائما
1.	I feel happy if one of my friends was called upon to answer a mathematics question instead of me. أكون سعيدًا جدًا إذا تم اختيار أحد أصدقائي للإجابة عن سؤال في الرياضيات و لم يتم اختياري.	1	2	3	4	5
2.	I panic once I start the mathematics component of a standard test. أشعر بالذعر عندما أبدأ الجزء المتعلق بالرياضيات من الإختبار التحصيلي الموحد.	1	2	3	4	5
3.	I cannot ask any question about what I did not understand in mathematics class. لا أسأل أي سؤال عما لم أفهمه في فصل الرياضيات.	1	2	3	4	5
4.	I like doing mathematics homework أفضل عمل الواجبات المنزلية لمادة الرياضيات.	1	2	3	4	5
5.	I do not like the equations in science courses. لا أحب المعادلات في المواد العلمية.	1	2	3	4	5
6.	I panic when I get math homework consisting of many problems. أشعر بالذعر عندما أجد في الواجب المنزلي لمادة الرياضيات الكثير من المسائل.	1	2	3	4	5
7.	When I hold a mathematics textbook to study I start feeling stomach ache. أشعر بالغثيان عندما أمسك بكتاب الرياضيات بهدف الاستذكار.	1	2	3	4	5
8.	I cannot concentrate on anything before a mathematics exam. لا أستطيع التركيز على أي شيء قبل امتحان مادة الرياضيات.	1	2	3	4	5
9.	I want to be the treasurer of the school clubs which I participate in. أريد أن أكون أمين صندوق النوادي المدرسية التي أشترك فيها.	1	2	3	4	5
10.	I am afraid of learning my mathematics grade. أخشى معرفة الدرجة التي أحرزتها في الرياضيات.	1	2	3	4	5

		Almost Never تقريبا أبدا	Seldom نادرا	Some-times أحيانا	Often غالبا	Almost Always تقريبا دائما
11.	I am afraid to show all the mathematics problems I am unable to solve to the mathematics teacher. أخشى من عرض المسائل التي يمكنني حلها على المعلم.	1	2	3	4	5
12.	I would refuse to help a younger student with solving their mathematics homework since I am afraid of facing a question, which I cannot solve. يمكنني رفض مساعدة طفل في حل واجباته المنزلية، لأنني أخشى أن أواجه بأسئلة يصعب عليَّ حلها.	1	2	3	4	5
13.	I am afraid of taking unannounced mathematics quizzes in my mathematics courses. أخشى من أخذ الإمتحان القصير المفاجئ في مادة الرياضيات.	1	2	3	4	5
14.	Every year I attend the first day of my mathematics class with a hopeful attitude. أحضر اليوم الأول من فصل مادة الرياضيات من بداية كل عام بأمل كبير.	1	2	3	4	5
15.	I cannot study well for math exams because I worry about my grade. لا أستطيع الدراسة جيدًا لامتحانات مادة الرياضيات لشعوري بالقلق من نتيجة الإختبار.	1	2	3	4	5
16.	When I open my mathematics book and look at the pages, I fear I will fail the course. عندما أفتح كتاب الرياضيات وأنظر إلى صفحاته أشعر بالخوف من الفشل في هذه المادة.	1	2	3	4	5
17.	I can ask my teacher about a concept, which I did not understand well, after a mathematics class. يمكنني أن أسال المعلم عن إحدى المفاهيم الرياضية التى لم أفهمها جيدًا بعد الدرس.	1	2	3	4	5
18.	I feel anxious and pessimistic while waiting for the result of a mathematics exam. أشعر بالقلق والتشاؤم أثناء انتظار نتيجة إمتحان الرياضيات.	1	2	3	4	5
19.	I prefer learning a subject, which is taught or demonstrated using numbers and pictures instead of words. أفضل تعليم المادة التي يتم عرضها بالأرقام والرسومات بدلا من الكلمات.	1	2	3	4	5
20.	When I think about all the topics required for passing a mathematics course, I feel I cannot complete my school requirements. عندما أفكر في المواد المطلوبة لاجتياز دورة دراسية في الرياضيات، أشعر بعدم استطاعتي على استكمال متطلبات المدرسة.	1	2	3	4	5

		Almost Never تقريبا أبدا	Seldom نادرا	Some-times أحيانا	Often غالبا	Almost Always تقريبا دائما
21.	I do not like dealing with numbers. لا أحب التعامل مع الأرقام.	1	2	3	4	5
22.	I feel anxious when one of my friends notices that I did not understand the solution to a mathematics problem. أشعر بالتوتر عندما يلاحظ أحد أصدقائي أنني لم أفهم حل إحدى مسائل الرياضيات.	1	2	3	4	5
23.	I have problems listening to my mathematics teachers. لدي مشاكل في الاستماع لمدرسي الرياضيات.	1	2	3	4	5
24.	My favorite parts of different subjects are those related to mathematics. أفضل مافي المواد الأخرى الجوانب المتعلقة بالرياضيات.	1	2	3	4	5
25.	I feel anxious as soon as I realize that my next class is a mathematics class. أشعر بالقلق عندما أعلم أن الدرس القادم هو لمادة الرياضيات.	1	2	3	4	5
26.	I dislike performing arithmetic operations in my daily life. لا أحب ممارسة العمليات الحسابية في الحياة اليومية.	1	2	3	4	5
27.	I misunderstand concepts in mathematics courses. أسيء فهم المفاهيم في مادة الرياضيات.	1	2	3	4	5
28.	I panic when I cannot remember the equation required to solve some mathematics problems. أصاب بالذعر عندما لا أستطيع تذكر المعادلة المطلوبة لحل مسئلة ما.	1	2	3	4	5
29.	I like to look through mathematics books. أحب أن تفحص كتب مادة الرياضيات.	1	2	3	4	5
30.	Even when I am certain that the seller made a mistake in applying a discount, I cannot question him, since I will not be able to perform arithmetic computations when someone is watching me. على الرغم من اعتقادي بأن البائع أخطأ في عملية الخصم مني إلا أنني لا أستطيع الاعتراض عليه؛ لعدم استطاعتى إجراء عمليات حسابية مع وجود شخص آخر يراقبني.	1	2	3	4	5

APPENDIX 4

Ethics Approval Letter

Curtin University

Office of Research and Development

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Web research.curtin.edu.au

23-Nov-2016

Name: Jill Aldridge
Department/School: Science and Mathematics Education Centre (SMEC)
Email: J.Aldridge@curtin.edu.au

Dear Jill Aldridge

RE: Completion report acknowledgment
Approval number: RDSE-70-15

Thank you for submitting a completion report to the Human Research Ethics Office for the project **Investigating gender differences in engagement in university level mathematics in the U.A.E: Learning environment perception, motivation and mathematics anxiety.**

The completion report was processed by the Human Research Ethics Office on 23-Nov-2016.

The Human Research Ethics Office acknowledges completion of this project and its record will be closed accordingly.

Please ensure that all data are stored in accordance with WAUSDA and Curtin University Policy.

Should you have any queries regarding consideration of your project, please contact the Ethics Support Officer for your faculty or the Ethics Office at hrec@curtin.edu.au or on 9266 2784.

Yours sincerely

Dr Catherine Gangell
Manager, Research Integrity

APPENDIX 5

Participant Information Statement

PARTICIPANT INFORMATION STATEMENT (QUESTIONNAIRES)

HREC Project Number:	RDSF-70-15
Project Title:	Investigating gender differences in engagement in university level mathematics in the U.A.E: Learning environment perception, motivation and mathematics anxiety.
Principal Investigator:	Dr Jill Aldridge
Student researcher:	John Clark
Version Number:	1
Version Date:	16th October 2015

What is the Project About?

It is known that there may be differences in how male and female students engage in learning mathematics. They may respond differently to the same classroom environment. They may feel different levels of motivation and mathematics anxiety. How males and females respond to these factors may impact their levels of achievement. Little is known about gender differences in learning mathematics at the university-level in the U.A.E. Understanding possible differences assists us in providing all students with an educational experience that is more likely to be satisfying and fulfil their potential. It is hoped that all students in their first year of studying mathematics at the Petroleum Institute will be involved in this study.

Who is doing the Research

The project is being conducted by John Clark. The results of this research project will be used to obtain a Doctor of Philosophy at Curtin University and is funded by the University. There will be no costs to you and you will not be paid for participating in this project.

Why am I being asked to take part and what will I have to do?

You are being asked to participate in this study as you are a member of the group of students in their first year of studying mathematics at university-level, so your views are important to us if our information is to be complete. Your participation will involve the completion of two sets of questionnaires. This will require two 15-20 sessions during mathematics lessons. Session 1 will require you to complete the What Is Happening In this Classroom questionnaire, which asks you questions about your learning environment. Session 2 will require you to complete two shorter questionnaires; The Student Adaptive Learning Engagement in Mathematics and the Revised-Mathematics Anxiety Survey, which ask questions about motivation and mathematics anxiety, respectively.

Are there any benefits' to being in the research project?

This study may not provide any direct benefit to you, but it is possible that the results may assist in developing future educational programmes that better cater to student needs.

Are there any risks, side-effects, discomforts or inconveniences from being in the research project?

Apart from giving up your time, we do not expect that there will be any risks or inconveniences associated with taking part in this study.

Who will have access to my information?

The information collected in this research will be identifiable. This means that any information we collect that can identify you will stay on the information we collect and it will be treated as confidential and used only in the project unless otherwise stated. We can let others know this information only if you say so or if the law says we need to. All information will be stored securely at the Petroleum Institute and Curtin University. The following people will have access to the information we collect in this research: the research team and the Curtin University Ethics Committee.
Electronic data will be password-protected and hard copy data will be in locked storage.
The information we collect in this study will be kept under secure conditions at Curtin University for 7 years after the research has ended and then it will be destroyed.
You have the right to access, and request correction of, your information in accordance with relevant privacy laws. The results of this research may be presented at conferences or published in professional journals. You will not be identified in any results that are published or presented.

Will you tell me the results of the research?

We are not able to send you any results from this research as we do not collect any personal information to be able to contact you. However, results may be made available on a website for interested students to access.

Do I have to take part in the research project?

Taking part in a research project is voluntary. It is your choice to take part or not. You do not have to agree if you do not want to. If you decide to take part and then change your mind, that is okay, you can withdraw from the project. You do not have to give us a reason; just tell us that you want to stop. Please let us know you want to stop so we can make sure you are aware of any thing that needs to be done so you can withdraw safely. If you chose not to take part or start and then stop the study, it will not affect your relationship with the University, or faculty. If you chose to leave the study we will use any information collected unless you tell us not to.

What happens next and who can I contact about the research?

If you decide to take part in this research we will ask you to sign the consent form. By signing it is telling us that you understand what you have read and what has been discussed. Signing the consent indicates that you agree to be in the research project and have your health information used as described. Please take your time and ask any questions you have before you decide what to do. You will be given a copy of this information and the consent form to keep.
At the start of the questionnaire there is a checkbox to indicate you have understood the information provided here in the information sheet.

If you require further information, or answers to questions then please feel free to contact:
Researcher: Mr John Clark (Email: jclark@pi.ac.ae Office Telephone: 02 9675156).
Supervisor: Dr Jill Aldridge (Email: J.Aldridge@curtin.edu.au Office Telephone +61(8) 92663592).

Curtin University Human Research Ethics Committee (HREC) has approved this study (HREC number RDSE-70-15). Should you wish to discuss the study with someone not directly involved, in particular, any matters concerning the conduct of the study or your rights as a participant, or you wish to make a confidential complaint, you may contact the Ethics Officer on +61(8) 9266 9223 or the Manager, Research Integrity on +61(8) 9266 7093 or email hrec@curtin.edu.au.

APPENDIX 6

Consent Form

Curtin University

CONSENT FORM (QUESTIONNAIRES)

HREC Project Number:	RDSE-70-15
Project Title:	*Investigating gender differences in engagement in university level mathematics in the U.A.E: Learning environment perception, motivation and mathematics anxiety.*
Principal Investigator:	*Dr Jill Aldridge*
Student researcher:	*Mr. John Clark*
Version Number:	*1*
Version Date:	*16/10/2015*

- I have read the information statement version 1 listed above and I understand its contents.
- I believe I understand the purpose, extent and possible risks of my involvement in this project.
- I voluntarily consent to take part in this research project.
- I have had an opportunity to ask questions and I am satisfied with the answers I have received.
- I understand that this project has been approved by Curtin University Human Research Ethics Committee and will be carried out in line with the National Statement on Ethical Conduct in Human Research (2007) – updated March 2014.
- I understand I will receive a copy of this Information Statement and Consent Form.

Participant Name	
I.D Number	
Participant Signature	
Date	

Declaration by researcher: I have supplied an Information Letter and Consent Form to the participant who has signed above, and believe that they understand the purpose, extent and possible risks of their involvement in this project.

Researcher Name	Mr John Clark
Researcher Signature	
Date	

APPENDIX 7

Mean, standard deviation, skewness and kurtosis of instrument scales

Mean, standard deviation, skewness and kurtosis of instrument scales

	Item	Mean	SD	Skewness	Kurtosis
Student Cohesiveness	SC1	3.87	.99	-.49	-.57
	SC2	4.16	.90	-1.07	1.02
	SC3	4.34	.78	-1.27	2.00
	SC4	3.80	1.06	-.73	.04
	SC5	4.16	.91	-1.15	1.20
	SC6	4.06	.96	-.86	.17
	SC7	4.01	.87	-.60	.09
	SC8	3.92	1.02	-.77	.13
Teacher Support	TS9	3.27	1.23	-.25	-.84
	TS10	3.82	1.16	-.76	-.29
	TS11	3.48	1.30	-.52	-.77
	TS12	4.23	.97	-1.45	1.98
	TS13	3.79	1.19	-.81	-.26
	TS14	3.28	1.36	-.30	-1.08
	TS15	3.17	1.38	-.22	-1.19
	TS16	4.07	1.08	-1.15	.73
Involvement	IV17	3.44	1.06	-.39	.47
	IV18	3.44	1.12	-.29	-.743
	IV19	3.10	1.16	-.02	-.76
	IV20	3.10	1.20	-.10	-.85
	IV21	3.43	1.18	-.43	-.62
	IV22	3.37	1.15	-.26	-.78
Investigation	IN25	3.12	1.19	-.10	-.81
	IN26	3.04	1.16	-.11	-.76
	IN27	3.06	1.17	-.17	-.74
	IN28	3.14	1.15	-.19	-.68
	IN29	3.39	1.15	-.34	-.59
	IN30	3.36	1.15	-.41	-.52
	IN31	3.36	1.14	-.30	-.58
	IN32	3.54	1.02	-.36	-.39
Task Orientation	TO33	4.08	.84	-.66	-.02
	TO34	4.19	.80	-.90	.83
	TO35	4.10	.90	-.91	.60
	TO36	4.29	.84	-1.10	.82
	TO37	4.30	.80	-1.16	1.63
	TO38	4.29	.84	-1.27	1.95
	TO39	4.54	.72	-1.82	4.13
	TO40	4.31	.76	-.94	.79
Cooperation	CO41	4.07	.92	-.94	.80
	CO42	3.69	1.16	-.65	-.40
	CO43	3.87	1.21	-.97	.07
	CO44	3.31	1.40	-.37	-1.12
	CO45	3.81	1.16	-.82	-.03
	CO46	3.65	1.12	-.59	-.38
	CO47	3.60	1.17	-.57	-.48
	CO48	3.54	1.17	-.50	-.54
Equity	EQ49	4.19	1.08	-1.36	1.12
	EQ50	4.21	1.08	-1.41	1.25
	EQ51	4.19	1.01	-1.21	.89
	EQ52	4.46	.80	-1.64	2.95
	EQ53	4.33	.97	-1.55	1.95
	EQ54	4.31	.92	-1.38	1.63
	EQ55	4.14	1.06	-1.25	.98
	EQ56	4.30	.93	-1.33	1.28

	Item	Mean	SD	Skewness	Kurtosis
Learning Goal Orientation	LGO1	4.62	.59	-1.43	1.68
	LGO2	4.47	.64	-.86	-.05
	LGO3	4.59	.60	-1.31	1.29
	LGO4	4.75	.45	-1.46	.89
	LGO5	4.57	.62	-1.26	1.01
	LGO6	4.73	.49	-1.67	2.64
	LGO7	4.79	.46	-2.20	5.16
	LGO8	4.68	.53	-1.43	1.09
Task Value	TV9	3.29	.90	-.38	.30
	TV10	3.64	.88	-.43	.08
	TV11	4.11	.79	-.85	1.04
	TV12	4.12	.77	-.77	.86
	TV13	3.46	.99	-.25	-.21
	TV14	4.25	.76	-.93	1.05
	TV15	3.36	1.03	-.29	-.33
	TV16	4.22	.83	-1.19	1.97
Self-Efficacy	SE17	4.10	.67	-.54	.74
	SE18	4.07	.74	-.42	-.20
	SE19	4.26	.69	-.83	1.22
	SE20	4.38	.65	-.61	-.39
	SE21	4.17	.83	-1.01	1.34
	SE22	4.35	.64	-.90	1.98
	SE23	4.30	.73	-1.22	3.01
	SE24	4.07	.78	-.66	.51
Self-Regulation	SR25	3.82	.75	-.70	.74
	SR26	3.85	.83	-.52	.08
	SR27	3.69	.89	-.65	.43
	SR28	4.28	.74	-1.22	2.70
	SR29	4.12	.82	-.62	-.26
	SR31	4.22	.76	-1.05	1.96
	SR32	4.31	.67	-.70	.35
Mathematics Anxiety	MANX2	3.06	1.24	-.07	-.93
	MANX3	2.31	1.22	.66	-.51
	MANX5	2.36	1.23	.57	-.64
	MANX6	2.62	1.28	.31	-.94
	MANX7	1.93	1.16	1.20	.52
	MANX8	2.45	1.26	.50	-.74
	MANX10	2.90	1.38	.09	-1.16
	MANX11	2.35	1.17	.56	-.53
	MANX12	1.76	1.04	1.46	1.46
	MANX13	2.53	1.24	.44	-.72
	MANX15	2.49	1.29	.54	-.75
	MANX16	2.16	1.27	.84	-.40
	MANX18	2.83	1.30	.21	-.98
	MANX20	2.27	1.19	.69	-.44
	MANX21	1.88	1.06	1.16	.67
	MANX22	2.17	1.18	.71	-.48
	MANX23	1.85	1.08	1.21	.73
	MANX25	1.79	.99	1.25	1.04
	MANX26	2.03	1.10	.86	-.13
	MANX27	2.10	1.03	.78	.13
	MANX28	2.85	1.30	.14	-1.02
	MANX30	1.95	1.19	1.09	.16
Achievement	ACHT1	71.22	16.78	-.95	.88

APPENDIX 8

Composite reliability and average variance extracted for measurement instruments

Composite reliability and average variance extracted for measurement instruments

Factor	Item	Factor Loadings	Composite Reliability (CR)	Average Variance Extracted (AVE)	Cronbach's Alpha (α)
Student Cohesiveness	SC1	.69	.89	.52	.86
	SC2	.69			
	SC3	.64			
	SC4	.73			
	SC5	.75			
	SC6	.67			
	SC7	.78			
	SC8	.78			
Teacher Support	TS9	.74	.92	.58	.92
	TS10	.78			
	TS11	.83			
	TS12	.77			
	TS13	.75			
	TS14	.71			
	TS15	.70			
	TS16	.78			
Involvement	IV17	.74	.88	.56	.89
	IV18	.74			
	IV19	.77			
	IV20	.85			
	IV21	.69			
	IV22	.67			
Investigation	IN25	.69	.91	.57	.92
	IN26	.69			
	IN27	.83			
	IN28	.76			
	IN29	.88			
	IN30	.81			
	IN31	.78			
	IN32	.58			
Task Orientation	TO33	.63	.89	.50	.86
	TO34	.76			
	TO35	.65			
	TO36	.65			
	TO37	.76			
	TO38	.71			
	TO39	.73			
	TO40	.77			
Cooperation	CO41	.58	.90	.52	.90
	CO42	.56			
	CO43	.62			
	CO44	.68			
	CO45	.75			
	CO46	.82			
	CO47	.85			
	CO48	.86			
Equity	EQ49	.80	.94	.67	.94
	EQ50	.81			
	EQ51	.81			
	EQ52	.85			
	EQ53	.86			
	EQ54	.83			
	EQ55	.82			
	EQ56	.75			

Factor	Item	Factor Loadings	Composite Reliability (CR)	Average Variance Extracted (AVE)	Cronbach's Alpha (α)
Learning Goal Orientation	LGO1	.71	.89	.51	.85
	LGO2	.62			
	LGO3	.70			
	LGO4	.75			
	LGO5	.67			
	LGO6	.75			
	LGO7	.85			
	LGO8	.61			
Task Value	TV9	.75	.89	.49	.85
	TV10	.68			
	TV11	.82			
	TV12	.76			
	TV13	.73			
	TV14	.62			
	TV15	.67			
	TV16	.56			
Self-Efficacy	SE17	.74	.90	.54	.88
	SE18	.70			
	SE19	.74			
	SE20	.67			
	SE21	.75			
	SE22	.73			
	SE23	.77			
	SE24	.77			
Self-Regulation	SR25	.74	.86	.47	.82
	SR26	.76			
	SR27	.75			
	SR28	.62			
	SR29	.64			
	SR31	.60			
	SR32	.69			
Mathematics Anxiety	MANX2	.60	.95	.44	.93
	MANX3	.69			
	MANX5	.71			
	MANX6	.61			
	MANX7	.64			
	MANX8	.67			
	MANX10	.62			
	MANX11	.67			
	MANX12	.55			
	MANX13	.69			
	MANX15	.78			
	MANX16	.82			
	MANX18	.69			
	MANX20	.76			
	MANX21	.66			
	MANX22	.64			
	MANX23	.69			
	MANX25	.67			
	MANX26	.56			
	MANX27	.67			
	MANX28	.65			
	MANX30	.51			
Achievement	ACHT1	1.00	1.00	1.00	1.00