School of Education

Investigating Pre-Service Teachers' Mathematics Anxiety, Teaching Anxiety, Self-efficacy, Beliefs about Mathematics and Perceptions of the Learning Environment

Melissa McMinn

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

November 2018

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 March 2014. The proposed research study received human research ethics approval from the Curtin University Human Research Ethics Committee (EC00262), Approval Number # HRE2017-0013

Number #17824019

Signature: 

Date: November 2018

ABSTRACT

Past research provides strong evidence to suggest that pre-service teachers have high levels of mathematics anxiety and typically hold naïve views of mathematics. Other research findings suggest that the anxiety and beliefs about mathematics that teachers hold impact on self-efficacy and in turn, their teaching behaviour. Despite these important findings, there is, to the researchers' knowledge, no research that has been carried out in the United Arab Emirates (UAE) that explores the relationship between teacher anxiety and beliefs about mathematics, and teaching self-efficacy. Further, there has been no research on the impact of the tertiary-level mathematics learning environment on pre-service teachers' anxiety. The study reported in this thesis fills this overdue gap in the literature.

The study involved preservice teachers from two institutions and was carried out in Abu Dhabi, UAE. This emirate was, at the time of the study, undergoing large-scale educational reform in which pre-service teachers were required to teach mathematics to their future primary students in a markedly different way to the traditional methods through which they were taught themselves. Given the dearth of research in this region that was related to the variables in the present study, the first imperative was the development or modification and validation of suitable instruments to assess pre-service teachers': mathematics anxiety; mathematics teaching anxiety; self-efficacy for teaching mathematics; beliefs about mathematics; and, perceptions of the learning environments (Research Objective 1). The selection and development of these instruments involved an extensive review of literature to identify whole or part instruments that were suitable, and had been shown to be reliable and valid in past studies, and to identify key factors of students of the aforementioned phenomena, based on sound theoretical and research underpinnings. Five instruments were developed. A pilot study involving one class of Year 2 students (*n*=14) was used to examine the face validity of the instruments. Once the surveys were considered to be suitable, data were collected from 184 pre-service teachers across two higher educational institutes. Of this data set 157 were complete and usable for all surveys, Analyses of this data provided strong evidence to support the reliability and validity of the surveys in terms of factor structure, internal consistency reliability, and discriminant validity.

The second research objective sought to describe the anxiety, teaching efficacy, beliefs and perceptions of the learning environment as self-reported by the participants. To address this objective, the means, standard deviation, skewness and kurtosis were calculated. The results indicate that the pre-service teachers were ‘a little’ to ‘somewhat anxious’ about learning, doing and being evaluated in mathematics, were apprehensive about their methodological knowledge for teaching mathematics, and had slightly more traditional beliefs about doing mathematics, and slightly more sophisticated beliefs about the usefulness of mathematics. Despite this, pre-service teachers self-reported moderately positive self-efficacy for teaching mathematics, indicating they still have some belief in their ability to teach the subject effectively. The results also indicated that Emirati pre-service teachers' perceptions of their tertiary level mathematics learning environments was more positive than not.

The third research objective sought to examine whether relationships exist between pre-service teachers self-efficacy towards teaching the new mathematics and their mathematics anxiety, mathematics teaching anxiety, and beliefs about mathematics. To do this, simple correlation and multiple regression analysis were used. Statistically significant ($p<0.01$) relationships between all self-efficacy scales and some mathematics teaching anxiety and beliefs about mathematics scales were found. However, the only statistically significant relationship between any of the self-efficacy scales and mathematics anxiety was between the Self-confidence and Anxiety caused by Methodological Knowledge scales ($p<0.05$).

To examine the differences in variables between the four year groups of pre-service teachers (Research Objective 4), multivariate analysis of variance (MANOVA) was carried out using the data provided from the first four surveys: Anxiety for Mathematics, Teaching Anxiety for Mathematics, Modified Self-Efficacy for Teaching Mathematics Instrument, and the Beliefs about Mathematics survey, with year level as the independent variable. The only significant difference was in self-confidence, with second year students self-reporting more self-confidence for teaching mathematics than first year students.

The fifth research objective sought to examine whether relationships exist between pre-service teachers' perceptions of their mathematics learning environments and the

other variables of the study. To do this, simple correlation and multiple regression analysis were used. Pre-service teachers perceptions of their mathematics learning environment was found to have statistically significant ($p<0.05$) relationships with each of the other variables of the study, indicating that this should be an important focus for teacher educators.

As no such study has been previously undertaken in the UAE or wider region, nor during a period of educational reform, this study bridged research gaps. The results offer potentially important insights into students' attitudes, feelings and beliefs about learning, doing, being evaluated in, and ultimately teaching mathematics, that can inform policy makers, curriculum developers and teaching faculty at higher education institutes, as well as other stakeholders including the Abu Dhabi Education Council and the UAE Ministry of Education.

ACKNOWLEDGEMENTS

This thesis has been a major part of my life recently. While it sometimes felt like a weight around my shoulders, I have enjoyed the process and the opportunity to delve so deeply into a topic that I enjoy and am passionate about.

I have been fortunate to have several people in my professional and personal life, particularly some incredible and inspirational women, whose support has made this journey all the more pleasant. I would like to take this opportunity to extend my appreciation to them all (whether identified below or not).

I am, of course, grateful for the support and guidance of my supervisor, Associate Professor Jill Aldridge. Although we were only able to meet face-to-face a few times, you have become a very important and influential person in my life over the last couple years! Thanks for your patience in regards to my many emails and queries, and for your honesty, knowledgeable feedback, and direction. I also wish to thank my co-supervisor, Associate Professor David Henderson - your positivity and enthusiasm were contagious, and meant a lot to me.

I would like to acknowledge the contribution of an Australian Government Research Training Program Scholarship in supporting this research.

To Martina and Hanadi, for teaching me so much and putting me on the research path – I will always be grateful for your time and friendship, and I hope I continue to learn from you for a long time to come.

To my family, especially Mum (Annie), thanks for your support and belief that I could actually do this!

And finally, to the two most amazing kids in the world – I am sorry this work has meant your Mum was behind a closed door demanding peace and quiet so often. Jesse, my Buddy, your independence and initiative have not gone unnoticed, you have taken on the ‘parent’ jobs I didn’t have time for. Thanks for regularly checking in on my word count, and pushing me to do more. To Boogie, your unending and unconditional love and support (and desire for me to finish!), have kept me going. What would I do without you both? I have enjoyed making post-homework plans with you – let’s live them all!

CONTENTS

Chapter 1 Introduction 13

1.1 Background 15

1.2 Theoretical Framework 22

1.3 Purpose of the Study 23

1.4 Research Objectives 25

1.5 Significance 28

1.6 Thesis Overview 29

Chapter 2 Literature Review 31

2.1 Introduction 31

2.2 Mathematics Anxiety 31

2.3 Mathematics Teaching Anxiety 39

2.4 Teaching Self-efficacy 43

2.5 Beliefs about Mathematics 50

2.6 Learning Environments 57

2.7 Chapter Summary 64

Chapter 3 Research Methods 66

3.1 Introduction 66

3.2 Research Objectives 66

3.3 Research Design 67

3.4 Sample 68

3.5 Instruments Used 71

3.6 Pilot Study 84

3.7 Data Analyses 86

3.8 Ethical Considerations 90

3.9 Chapter Summary 92

Chapter 4 Data Analysis and Results 96

4.1 Introduction ... 96

4.2 Validity and Reliability of the Instruments ... 96

4.3 Descriptive analysis: Self-reports of anxiety, self-efficacy, beliefs and learning environment perceptions ... 112

4.4 Relationships between pre-service teachers' reports of self-efficacy, anxiety, and beliefs about mathematics ... 120

4.5 Differences for Year Groups: Anxiety, Beliefs about Mathematics and Self-efficacy ... 125

4.6 Relationship between perceptions of the learning environment and anxiety, beliefs about mathematics and self-efficacy ... 127

4.7 Chapter Summary ... 132

Chapter 5 Discussion, Conclusions, and Recommendations ... 135

5.1 Introduction ... 135

5.2 Summary and Discussion of Results ... 136

5.3 Educational Implications ... 162

5.4 Limitations ... 171

5.5 Summary of Recommendations ... 172

5.6 Significance of the Study ... 175

5.7 Concluding Remarks ... 179

References ... 181

Appendix 1 Participant Information Statement ... 216

Appendix 2 Anxiety for Mathematics Survey (AMS) ... 220

Appendix 3 Teaching Anxiety for Mathematics Survey (TAMS) ... 222

Appendix 4 Modified Self-Efficacy for Teaching Mathematics Instrument (M-SETMI) ... 224

Appendix 5 Beliefs About Mathematics Survey (BAMS) ... 226

Appendix 6 What Is Happening In this Class? (WIHIC) ... 227

Appendix 7 Learning Environment Surveys ... 230

Appendix 8 Ethics Approval 232

Appendix 9 Research Approval from the higher education institutes 232

Appendix 10 Differences in Year Level 234

TABLES

Table 3.1 Origin of AMS Items ... 74
Table 3.2 Description and Sample Item for Each Anxiety for Mathematics Survey (AMS) Scale ... 75
Table 3.3 Description and Sample Item for Each scale of the Teaching Anxiety in Mathematics Scale (TAMS) ... 77
Table 3.4 Description and Sample Item for Each Modified Self-efficacy for Teaching Mathematics Instrument (M-SETMI) scale ... 78
Table 3.5 Origin of BAMS Items ... 81
Table 3.6 Description and Sample Item for Each Beliefs about Mathematics Survey (BAMS) scale ... 81
Table 3.7 Description and Sample Item for Each What is Happening in this Class? (WIHIC) scale ... 82
Table 4.1 Factor Loadings, Percentage of Variance, and Eigenvalues for the Mathematics Anxiety Survey (AMS) ... 99
Table 4.2 Internal Consistency Reliability (Cronbach Alpha Coefficient) for the Anxiety for Mathematics Survey (AMS) ... 100
Table 4.3 Component Correlation Matrix for the Anxiety for Mathematics Survey (AMS) ... 100
Table 4.4 Factor Loadings, Percentage of Variance, and Eigenvalues for the Teaching Anxiety for Mathematics Survey (TAMS) ... 102
Table 4.5 Internal Consistency Reliability (Cronbach Alpha Coefficient) for the Teaching Anxiety for Mathematics Survey (TAMS) ... 102
Table 4.6 Component Correlation Matrix for scales of the Teaching Anxiety for Mathematics Survey (TAMS) ... 103
Table 4.7 Factor Loadings, Percentage of Variance, and Eigenvalues for the Modified Self-Efficacy for Teaching Mathematics Instrument (M-SETMI) ... 105
Table 4.8 Internal Consistency Reliability (Cronbach Alpha Coefficient) for the Modified Self-efficacy for Teaching Mathematics Instrument (M-SETMI) ... 105
Table 4.9 Component Correlation Matrix for scales of the Modified Self-efficacy for Teaching Mathematics Instrument (M-SETMI) ... 106

Table 4.10 Factor Loadings, Percentage of Variance, and Eigenvalues for the Beliefs About Mathematics Survey (BAMS) 107
Table 4.11 Internal Consistency Reliability (Cronbach Alpha Coefficient) for the Beliefs about Mathematics Survey (BAMS) 108
Table 4.12 Component Correlation Matrix for scales of the Beliefs About Mathematics Survey (BAMS) 108
Table 4.13 Factor Loadings, Percentage of Variance, and Eigenvalues for the What Is Happening In this Class? Survey (WIHIC) 110
Table 4.14 Internal Consistency Reliability (Cronbach Alpha Coefficient) for the What Is Happening In this Class? Survey (WIHIC)........................... 111
Table 4.15 Component Correlation Matrix for Scales of the What Is Happening In this Class? Survey (WIHIC) 112
Table 4.16 Descriptive Statistics for the Anxiety for Mathematics Survey (AMS), including the Skewness, Kurtosis, Mean, and Standard Deviation 113
Table 4.17 Descriptive Statistics for the Teaching Anxiety for Mathematics Survey (TAMS), including the Skewness, Kurtosis, Mean, and Standard Deviation.. 115
Table 4.18 Descriptive Statistics for the Modified Self-Efficacy for Teaching Mathematics Instrument (M-SETMI), including the Skewness, Kurtosis, Mean, and Standard Deviation.. 117
Table 4.19 Descriptive Statistics for the Beliefs about Mathematics Survey (BAMS), including the Skewness, Kurtosis, Mean, and Standard Deviation 118
Table 4.20 Descriptive Statistics for the What Is Happening In this Class? Survey (WIHIC), including the Skewness, Kurtosis, Mean, and Standard Deviation.. 120
Table 4.21 Simple Correlation and Multiple Regression Analyses for Associations between Pre-service Teachers' Self-efficacy towards Teaching Mathematics and their Mathematics Anxiety 122
Table 4.22 Simple Correlation and Multiple Regression Analyses for Associations between Pre-service Teachers' Self-efficacy towards Teaching Mathematics and their Anxiety towards Teaching Mathematics........ 123
Table 4.23 Simple Correlation and Multiple Regression Analyses for Associations between Pre-service Teachers' Self-efficacy towards Teaching Mathematics and their Beliefs about Mathematics............................. 124

Table 4.24 Average Item Mean, Average Item Standard Deviation and MANOVA Results for Differences between Years 1 to 4 in Teaching Self-efficacy using the Individual Student as the Unit of Analysis 126
Table 4.25 Effect Size and Tukey's HSD Multiple Comparison for Statistical Significance of Difference Between each Pair of Years for Teaching Self-efficacy 126
Table 4.26 Simple Correlation and Multiple Regression Analyses for Associations between Perceptions of the Learning Environment and Mathematics Anxiety 128
Table 4.27 Simple Correlation and Multiple Regression Analyses for Associations between the Learning Environment and Teaching Anxiety 129
Table 4.28 Simple Correlation and Multiple Regression Analyses for Associations between Perceptions of the Learning Environment and Teaching Efficacy 131
Table 4.29 Simple Correlation and Multiple Regression Analyses for Associations between the Learning Environment and Pre-service Teachers' Beliefs About Mathematics 132

FIGURES

Figure 4.1 Box and Whiskers Plot for Scales of the Anxiety for Mathematics scale 114
Figure 4.2 Box and Whiskers Plot for Scales of the Teaching Anxiety for Mathematics scale 116
Figure 4.3 Box and Whiskers Plot for Scales of the Modified Self-Efficacy for Teaching Mathematics scale 117
Figure 4.4 Box and Whiskers Plot for Scales of the Beliefs about Mathematics scale 119
Figure 4.5 Box and Whiskers Plot for Scales of the What is Happening in this Class? (WIHIC) 120

Chapter 1

INTRODUCTION

Emirati pre-service teachers in Abu Dhabi are being asked to teach mathematics to their future primary students in a markedly different ways to the one in which they were taught themselves. Within a few courses, over a four-year Bachelor degree programme, teacher educators are tasked with preparing confident, efficacious teacher graduates capable of teaching not only mathematics, but English and science as well.

Pre-service teachers have been found to have high levels of mathematics anxiety (Sloan, 2010), higher than all other undergraduate university students (Hembree, 1990), and female primary pre-service teachers seem to fare the worst in comparison with other pre-service teacher groups (Brady & Bowd, 2005). Mathematics anxiety in pre-service teachers has been linked to mathematics teaching anxiety (Peker & Ertekin, 2011), teaching efficacy (Peker, 2016), and beliefs about mathematics (Haciomeroglu, 2013), and all of these phenomena have been related to teacher behaviour and student achievement (Haciomeroglu, 2014; Hadley & Dorward, 2011; Hembree, 1990; Muijs & Reynolds, 2015). It has also been found that female teachers with mathematics anxiety can pass this anxiety on to female students.

Mathematics teaching anxiety differs from mathematics anxiety because it is based on one's anxiety about their ability to *teach* mathematics, as opposed to learning, doing or being evaluated in mathematics, While mathematics teaching anxiety has been linked to mathematics anxiety, this relationship is not always clear (Sloan, 2010). Past research suggests that mathematics teaching anxiety can increase during teacher education, (see for example, Ertekin, 2010) particularly when pre-service teachers are required to find concrete examples for mathematics concepts or organise constructivist-type learning activities (Peker, 2009b; Yazici, Peker, Ertekin, & Dilmac, 2011).

Pre-service teachers have also been found hold naïve views of mathematics (Ball, 1990; Briley, 2012; Carpenter, Lindquist, Matthews, & Silver, 1983; Paolucci, 2015; Szydlik, Szydlik, & Benson, 2003). That is, they believe mathematics involves a collection of isolated facts, formulas and rules (Jackson, 2008; Szydlik et al., 2003). Beliefs about mathematics have shown to have a great effect on pre-service teachers' learning to teach mathematics, and on their capacity to become effective teachers (Haciomeroglu, 2013).

Interestingly, teaching self-efficacy for mathematics, a belief in one's capabilities to successfully effect mathematics teaching tasks, and the intangible features developed through instructional practices that create the tone of the learning environment, have both shown to relate to mathematics anxiety and mathematical beliefs (see for example, Buckley, Reid, Goos, Lipp, & Thomson, 2016; Cornell, 1999; Fraser, 2012; Haciomeroglu, 2013; Peker, 2016). Given these relationships, and that mathematics anxiety and beliefs about mathematics can influence the way teachers practice, teaching self-efficacy and the learning environment should also be key considerations for teacher educators.

The catalyst for this study, was the researcher's experience with pre-service students regularly requesting to be assigned to lower grade-level classes during practicum placements. The consistent reasoning was the fear of the mathematics at the higher grade levels, or the perceived inability to be able to teach it. "I hate maths!', 'I can't do maths', 'I am not a maths person', and 'I am scared of the maths in grades four and five!' are all regular sentiments espoused by the Emirati pre-service students the researcher works with. To examine this phenomenon, this study investigated and described Emirati pre-service teachers' mathematics anxiety, mathematics teaching anxiety, self-efficacy for teaching mathematics, beliefs about mathematics, and perceptions of the learning environments of two higher education institutes in Abu Dhabi, United Arab Emirates. This study also examined how self-efficacy for teaching mathematics and perceptions of the learning environments were related to the other variables (see Section 1.4 for research objectives).

This chapter provides an introduction to the study. First, a brief overview of the history of education in Abu Dhabi and the specific context for the study is provided (Section 1.1). The subsequent sections provide information related to the conceptual and theoretical framework for the study (Section 1.2), the purpose of the study (Section

1.3), the research objectives (Section 1.4), and the significance of the study (Section 1.41.6). Finally, an overview of the thesis is outlined (Section 1.6).

1.1 Background

To understand the milieu in which this study is situated, a brief history of the United Arab Emirates, Abu Dhabi in particular (Section 1.1.1), and the education in the region to date (Section 1.1.2) are presented below.

1.1.1 Abu Dhabi, United Arab Emirates

The United Arab Emirates (UAE) is a federation of seven emirates (states) on the Arabian Peninsula, nestled between the Kingdom of Saudi Arabia to the west and south, and the Sultanate of Oman to the east. The area, previously known as the Trucial States, had been under British protection for a century and a half when the treaty relationship ended on December 1, 1971.

The UAE was founded on December 2, 1971, when six of the seven, formally separate, emirates united under the presidency of Sheikh Zayed bin Sultan Al Nahyan, ruler of Abu Dhabi. The seventh emirate, Ras Al Khaimah, joined the UAE a few months later. Abu Dhabi was provisionally made the capital of the UAE, and this was formalised in the early 1990s (Encyclopaedia Britannica, 2018). The United Arab Emirates is a member of the Gulf Cooperation Council (GCC), comprising of all Arab states of the Arabian Gulf, with the exception of Iraq.

Abu Dhabi, meaning 'Land of the Gazelle' in Arabic (Visit Abu Dhabi, 2018), is the largest of the seven emirates with approximately three-quarters of the UAE's total land area (Encyclopædia Britannica, 2018). As such, Abu Dhabi holds over 90% of the country's oil reserves, and is responsible for almost two-thirds of the UAE's total economic output (United Arab Emirates National Media Council, 2013). The Emirate of Abu Dhabi comprises of three regions: Abu Dhabi, Al Ain and Al Dhafra. About an hour and a half drive east of Abu Dhabi city, Al Ain city is the focal point of the Al Ain region, is one of the world's oldest permanently inhabited settlements, and a UNESCO World Heritage Site. Al Ain is the fourth biggest city in the UAE after Abu

Dhabi, Dubai and Sharjah. Al Dhafra, or the Western Region, as it is often referred, makes up over two thirds of the Abu Dhabi emirate and comprises a number of smaller towns including Madinat Zayed, Al Ruwais, and Liwa, which is the gateway to Rub Al Khali (The Empty Quarter) of Saudi Arabia, the world's largest uninterrupted sand mass.

Between the Al Ain and Al Dhafra regions, the Abu Dhabi region surrounds Abu Dhabi city. The city is built upon the largest of a number of islands along the coast, joined by a series of bridges to each other and to the mainland. The two higher education institutes involved in this study are both situated in Abu Dhabi city, while the vast majority of the students attending them reside on the Abu Dhabi mainland.

The population of the emirate is estimated at 2.784 million people, the second highest emirate by population after Dubai, with just under 20 percent being UAE nationals (a population of 536,741 people, World Population Review, 2017). UAE nationals make up 10 percent of the total estimated 9.54 million population nationwide (World Population Review, 2017).

1.1.2 Education Reform

Education in the UAE, and particularly in Abu Dhabi, is discussed in the following sections. A brief history of education in the region is presented in Section 1.1.2.1, and the Abu Dhabi Education Council’s formation and role in the emirate is discussed in Section 1.1.2.2. Finally, teacher education in Abu Dhabi, and the specific context for this study are considered in Section 1.1.2.3.

1.1.2.1 History of Education in the UAE

Before 1971, schooling in the UAE was not mandatory and only generally available for male students from the elite sector of society (Dickson, Kadbey, & McMinn, 2015; Ridge, 2009). This early schooling was predominately through the *katateeb* – mosque schools, which focused on Islamic religious texts, the Prophet's Hadith (sayings), and the basics of reading and writing (AlNaqbi, 2009). Katateeb was usually found in coastal areas or places with well-established commerce (Alnabah, 1996). In the 1950s and 1960s, schools were being established in the UAE with funding from neighbouring countries, initially Kuwait, and subsequently Egypt, India, Iran, Saudi Arabia, and Qatar (Bahgat, 1999; Brooks, 2012; Davidson, 2008; Suliman, 2000), typically using their own teachers, curricula and texts (Ridge, Kippels, & ElAsad, 2015).

After the UAE was established in 1971, educational improvement was – and continued to be at the time of writing this thesis - consistently recognised as a key priority to enhance the country's growth and development (United Arab Emirates National Qualifications Authority, 2013). As such, the Ministry of Education and Youth was one of the first government bodies to be created (Ahmed, 2011). The newly founded Ministry of Education (MOE) worked to bring together the diverse mix of schools and oversaw 47 schools that had previously been managed by Kuwait and other nations (Ridge, 2009; Suliman, 2000). At that time, basic public education was made mandatory for all children (Ridge, 2014), and free for all Emiratis (Alhebsi, Pettaway, & Waller, 2015). Primary enrolment reached high figures in a relatively short time frame. At this time, schools were established, and educational advisors and teachers were imported from Egypt's more established education system. These educators brought with them a curriculum that was perceived to offer a more "localized" education than Western models (Dickson, Kadbey & McMinn, 2015; Findlow, 2001, as cited in Ridge, Kippels & ElAsad 2017). This system was largely based on a traditional, transmission approach emphasising memorisation through rote learning of relevant sections of a textbook (Von Oppell & Aldridge, 2015, p. 37). It is widely acknowledged that the Egyptian model had the greatest influence on the country's emerging formal education system (Findlow, 2001, as cited in Ridge et al, 2017), and the enduring presence of Egyptian teachers and their teaching styles are still evident to date (Ridge et al, 2015). In 1995, the effectiveness of public schooling in the UAE was described as disturbingly low (Shaw, Badri, & Hukul, 1995) with only a relatively small percentage of students who enter the system completing their studies.

By the 2000s, education in Abu Dhabi was still described as "teacher dominated, heavily transmitted teaching styles" (Shaw et al., 1995, p. 12), and leaders were appealing for additional overhaul of a system which was thought to have become staid by then (Macpherson, Kachelhoffer, & El Nemr, 2007). In 2005, the government of Abu Dhabi laid the groundwork for an ambitious programme of educational reform:

the Education Strategic Plan, inspired by the Abu Dhabi government's Vision 2030 (Badri & Khaili, 2014). The Abu Dhabi Education Council (ADEC) was formed and assumed all responsibility from the Ministry of Education of all education in Abu Dhabi; pre-primary to grade 12 (P-12), higher education, and technical and professional education.

1.1.2.2 Education Reform and the Abu Dhabi School Model

In 2006, the Abu Dhabi Education Council began to implement its significant reform programme to improve the quality of education in government-run P-12 schools, which primarily serve Emirati students (McMinn, Kadbey, & Dickson, 2015). A new outcomes-based curriculum was developed using the Australian New South Wales curriculum as a foundation, which was implemented progressively into public schools with the support of Education Advisors from advisory consultancy companies, hired predominantly from native English speaking countries, such as, Australia, New Zealand, England, South Africa and Canada. Abu Dhabi's public school teachers of students from Grade 4 onwards were required to hold a degree in their subject area, but they were not required to hold a teaching degree, and the new outcomes-based curriculum was significantly different to the previous textbook-based curriculum. The Education Advisors role was to support teachers in implementing the new curriculum, and to provide professional development training in student-centred, hands-on, inquiry approach instruction. Whilst there were varying degrees of success in these projects, it was felt by some that a lack of a coherent strategy, inconsistency among companies, and a lack of consultation by some advisory companies, hindered progress (see for example, Ashencaen Crabtree, 2010; Thorne, 2011). By the 2009-2010 academic year, most consultancy companies had ended their contracts and, although in-service advising still took place, it was in a much less frequent and concentrated form with advisors mostly coming from Abu Dhabi Education Council itself (Dickson, Kadbey, & McMinn, 2016).

In 2010, the 'New School Model' was launched in Grades 1 to 3 in all public schools. As part of this stage in the reform, Mathematics, Science, and English, were to be taught by a common teacher in an integrated manner through the medium of English by English Medium Teachers (EMTs), employed largely from Western countries. This recruitment policy was based on the theory that these teachers would bring with them 'best practice' experience, having being educated, trained and having worked in countries with long established education systems, and implement this in the schools of Abu Dhabi (Dickson et al., 2015). The goal of the New School Model, at the time of the study reported in this thesis, was to develop "confident and life-long learners" by implementing effective approaches that focused on the student as the centre of the teaching and learning process (ADEC 2013, p. 12). Each year since 2010, the New School Model was rolled out into the subsequent grade level in all Abu Dhabi public schools, with a common teacher for Mathematics, Science, and English up to and including Grade 5. The New School Model has been through various modifications since its inception, and is currently called the Abu Dhabi School Model (Dickson, McMinn, & Kadbey, 2017).

At the time of this study, public schools were heavily monitored and were required to adhere to the Abu Dhabi School Model (Dickson et al., 2015). As the public schools served the local Emirati community (and, in some cases where enrolment numbers allow, the children of expatriate Arab government employees), Abu Dhabi also had many private schools. The number of private schools has increased rapidly over the last two decades, due in part to the dependence on foreign labour (McKinnon, Barza, & Moussa-Inaty, 2013). National students have the option of attending these fee-paying schools and currently make up about 25 percent of the private school student population (Abu Dhabi Education Council, n.d.). Private schools were also required to abide by the Abu Dhabi Education Council's governing rules and guidelines and are subject to regular evaluation by ADEC. However, they were able to operate using any approved curriculum they choose, including those from Britain, Canada, Australia, India, Pakistan and the United States of America.

1.1.2.3 Teacher Education in Abu Dhabi

As part of the education reform in Abu Dhabi, ADEC also assumed responsibility for higher education. The Abu Dhabi 2030 Vision aimed to have 90 percent Emiratis in the education sector by 2030 (The Abu Dhabi Government, 2008). As such, four public higher educational institutes, these being, Zayed University, UAE University, Higher Colleges of Technology and Emirates College for Advanced Education, were approved to offer Bachelor of Education (B.Ed.) programmes (Sharif, Hossan, & McMinn, 2014) at no cost to Emirati students (McMinn, Dickson, & Kadbey, 2015). The main responsibility of these higher educational institutes was to prepare future Emirati teachers to teach Mathematics, Science and English in ADEC's New School Model public schools (grades 1 to 5) through the medium of English. With the new outcomes-based curriculum, which required critical thinking instead of rote learning (Davidson, 2010), teacher education programmes in Abu Dhabi were required to adapt in order to address the challenges introduced by the new curricula, and to prepare teacher graduates with the skills necessary for such a change.

All of the approved higher educational institutes offered four-year B.Ed. programmes, but differed in the specialization, both in age-range of students and subject area. Two of the institutes offered programmes for early childhood education, with one of them also offering Mathematics and English tracks for grades 6 to 8. Three institutes offered programmes for primary school education (grades 1 to 5), however one of these programmes offered subject specialist tracks (either English or a combined Mathematics and Science track), while the other two offered generalist programmes (Mathematics, English and Science education).

In addition to a Bachelor of Education degree, prospective teachers for Abu Dhabi's public schools were required to hold an International English Language Testing System (IELTS) certificate for Academic English with a score of 6.5 or higher. This qualification was obtained from external centres, however the higher education institutes all had IELTS check-points built into their B.Ed. programmes. Usually this was in the form of a minimum IELTS score for entry into a programme, and a requirement that the 6.5 score be obtained before graduation. In the case of one programme, an IELTS score of 6.0 was required to enter the final year.

The study reported in this thesis involved pre-service teachers from two of these higher education institutes in Abu Dhabi. One of the higher education institutes was a teachers' college established in 2007, specifically to help to address the major educational reforms taking place in the emirate's public school system. The other was an existing education programme in an established institute, previously focussed on English language teaching, which was modified to meet the new needs. Both institutes offered Bachelor of Education programmes to local Emirati students that had been approved by the Abu Dhabi government. The programmes at both institutes were offered fees-free, exclusively for Emirati students. For one institute, this was offered for females only, while in the other, both male and females were eligible, however male enrolment numbers were very low. These institutes were chosen for this study as they had the only generalist teaching programmes (English language, mathematics and science), designed specifically for Abu Dhabi's public primary schools.

Methodology courses at both institutions aimed to prepare the pre-service teachers for the Abu Dhabi School Model, introduced as part of Abu Dhabi's educational reform. At the time the study took place, the first higher education institute had dedicated classrooms and specialist teachers for the mathematics courses within the Bachelor of Education programme. This programme consisted of three mathematics content courses, taken over the first three semesters of the programme, designed to improve the pre-service teachers' mathematics skills and concepts. Following on were three methodology courses, taken over the subsequent three semesters of the programme, aimed at teaching mathematics at the primary school level. The second higher education institute did not have dedicated classrooms, and any of the Education faculty could be assigned to teach the mathematics courses that constituted part of the B.Ed programme. This programme included one mathematics content course, and one methodology course, taken concurrently in the fifth semester of the programme. Students at the second higher education institute were also required to take a mathematics course as part of the general studies requirement, taught by a member of the general studies faculty. Students at both institutions were required to complete teaching practice placements (practicum) in local primary schools. Students usually had the chance to experience both public and private schools during their training. Practicum occurred once every year for the students in the first higher education institute, while students in the second higher education institute were placed in schools every semester. This meant that the students in the second higher education institute, who had less exposure to mathematics courses, had more opportunities to experience mathematics education 'in action' (and vice versa). The duration of placements increased throughout both programmes from 10 to 15 days, to an internship in the final semester of eight to 12 weeks.

The researcher was, at the time of the study, a faculty member at the second higher education institute and had taught a variety of courses to many of the students, including mathematics content and methodology courses to two cohorts at the time of data collection.

1.2 Theoretical Framework

All research, including this study, is underpinned by one or more paradigms; a cluster of assumptions about knowledge, truth, and reality, and beliefs about how research should be conducted, and the results interpreted (Bryman, 2012; Kuhn, 1996; Willis, Jost, & Nilakanta, 2007). The current study was underpinned by a constructivist, post-positivistic paradigm - which supposes that there is reality to be ‘captured’ and that this reality can never be wholly knowable, but can merely be approximated (Krauss, 2005; D. L. Smith & Lovat, 2003). This approach rejects absolute truths, and views reality as constructed, transactional, and value-laden (Terre Blanche, Durrheim, & Painter, 2006). Although we may be able to measure some of the physical and physiological accompaniments, phenomena such as anxiety, self-efficacy, beliefs and perceptions, cannot be directly observed (Trochim, 2006), making this study less suitable for an interpretivist paradigm.

Consistent with the post-positivist view, this study does not assume certainty and universally generalizable results, but it does strive for context-dependent generalizations. This study attempts to ensure the participant sample is representative for the context (Cooper, 1997), and assumes that those involved in a study (including the researcher) are idiosyncratic, unpredictable, and subject to biases (Charney, 1996), Post-positivism also necessitates that the researcher take an impersonal stance to minimize "the chances of influencing participants to adapt to his or her predispositions... [and] to reduce the effect of biases by limiting and systematizing interactions” (Charney, 1996, p. 585). As such surveys were utilized for the collection of data for this study, so participants could independently and anonymously self-report on the variables without guidance from the researcher.

This study draws on existing theoretical work in self-efficacy and learning environments. More recent work on teaching self-efficacy, and specifically, mathematics teaching self-efficacy, has derived from Albert Bandura's (1977) seminal work on Social Cognitive Theory, which first introduced the concept of self-efficacy. Learning environment research started even earlier, with its roots in early 20th century social psychology. Early theorists established that human behaviour is specific to the environment in which it occurs, and that the learning environment may be perceived differently by those within it, than outside observers.. These theories are discussed in detail in Chapter 2.

Past research has frequently found that many pre-service teachers are mathematics anxious (Novak & Tassell, 2017; Sloan, 2010) and hold naïve beliefs about mathematics (Briley, 2012; Paolucci, 2015). Research has also shown that mathematics anxiety and beliefs about mathematics can influence self-efficacy for teaching mathematics (Haciomeroglu, 2013; Peker, 2016), and that the learning environment also relates to mathematics anxiety and beliefs about mathematics (Beswick, 2012; Buckley et al., 2016). While mathematics anxiety and mathematics beliefs have been linked to mathematics teaching anxiety (Peker & Ertekin, 2011; Uusimaki & Nason, 2004), the relationship between mathematics teaching anxiety and both teaching efficacy and perceptions of the learning environment have yet to be examined. Based on past research and the researcher's experience with working with the sample population, this study hypothesises that Emirati pre-service teachers, who were being trained in teach mathematics in a decidedly different way than they were taught themselves, would be anxious about mathematics and the prospect of teaching it, and hold naïve beliefs about the subject. This study also hypothesised that perceptions of the learning environment would be related negatively to mathematics anxiety, mathematics teaching anxiety and beliefs about mathematics, and that these variables impact teaching efficacy, and therefore the potential of pre-service teachers to be effective teachers.

1.3 Purpose of the Study

The purpose of the study reported in this thesis was to identify the level of mathematics anxiety experienced by pre-service teachers, their beliefs about mathematics, and how efficacious they feel when it comes to teaching mathematics within the context of the Abu Dhabi School Model, in terms of both content and pedagogy. Emirati teachers' are not an abnormality in regards to being expected to teach in a pedagogically different way than their own teachers taught (McMinn et al., 2015). However, if the desired instructional approaches (e.g. hands-on, inquiry, and student-centredness), are not modelled effectively to pre-service teachers during their professional training, it is likely to affect their confidence in using such approaches in their own teaching (Isiksal-Bostan, 2016; Woodcock, 2011a). Temiz and Topcu (2013, p. 1439), contend it is necessary to provide pre-service teachers "…with constant opportunities to practice with respect to constructivism".

Even when desired methods are modelled during teacher training, there can be many barriers to effective mathematics teaching, namely mathematics anxiety, anxiety for teaching mathematics, teaching efficacy and beliefs about mathematics. The effectiveness of educational reform rests on well-prepared teachers (Weiss, Banilower, McMahon, & Smith, 2001). Therefore developing confident, efficacious teaches with sophisticated beliefs about mathematics is of utmost importance.

Research has repeatedly found that teachers with mathematics anxiety, lower self-efficacy for teaching mathematics, and/or more traditional beliefs about the subject are likely to use more traditional, surface-level teaching, focusing on rules, procedures and correct answers (see for example, Aslan, Oğul, & Taş, 2016; Bekdemir, 2010; Enochs, Smith, & Huinker, 2000; Gresham, 2008, 2018; Puchner & Taylor, 2006). Teachers with higher anxiety and/or lower teaching efficacy for mathematics are also more likely to spend less time teaching the subject (Peker & Ertekin, 2011; Riggs & Enochs, 1990). Conversely, higher self-efficacy for teaching has been linked to a greater willingness to implement new instructional strategies and innovations (Gresham, 2008; Nurlu, 2015; Swars, Daane, & Giesen, 2006), such as those endorsed by the Abu Dhabi School Model.

Teaching self-efficacy has also been linked to retention in the profession. That is, teachers with higher self-efficacy displaying a greater commitment to teaching, even in the challenging beginning years (Coladarci, 1992; Hemmings, 2015; Knobloch & Whittington, 2002). With the goal to have 90 percent Emiratis in the education sector by 2030 (The Abu Dhabi Government, 2008), developing positive self-efficacy for teaching needs to be a key objective of teacher educators.

Several studies have identified the teacher as the most crucial element in a mathematics learning environment (Aldridge, Fraser, & Huang, 1999; Bekdemir, 2010; Tobias, 1980). Other perceived elements of the learning environment have been linked to anxiety (Frenzel et al, 2007; Goetz et al., 2006) and specifically to mathematics anxiety (B. A. Taylor & Fraser, 2013; Trujillo & Hadfield, 1999), Similarly, connections between perceptions of the learning environment and mathematics self-efficacy have also been found (Afari, Aldridge, Fraser, & Khine, 2013; Fraser, 2012), and the quality of relationships within the learning environment can play a significant role in changing the beliefs of pre-service teachers (Beswick & Dole, 2001). Encouragingly, research has shown that teacher education programmes can lower mathematics anxiety (Haciomeroglu, 2014; Peker, 2009b), mathematics teaching anxiety (Gürbüz & Yildirim, 2016; Hadley & Dorward, 2011), increase teaching efficacy for mathematics (Bandura, 1997), and improve beliefs about mathematics (Briley, 2012; Hughes, 2016; Paolucci, 2015), so long as these issues are identified and explicitly addressed, and effective teaching methodologies are utilised within a learning environment students perceived to be positive. This study was intended to provide an objective assessment of the mathematics anxiety, mathematics teaching anxiety, teaching efficacy, beliefs, and perceptions of the learning environment of Emirati pre-service teachers.

1.4 Research Objectives

The overarching aim of this study was to investigate pre-service teachers' mathematics anxiety, mathematics teaching anxiety, self-efficacy for teaching mathematics, beliefs about mathematics and their perceptions of their mathematics learning environments within the context of the Abu Dhabi education reform. To support this aim, five specific research objectives were delineated.

Given that the present study utilised five questionnaires it was necessary to ensure their suitability for use in this context, and to provide confidence in the resulting data that inform the subsequent research objectives. In all cases, the surveys used in this study were either modified or developed for use in the study reported in this thesis. In the case of one survey, which had been widely used in countries around the world, it has had limited use in the UAE, and had not been utilised with pre-service teachers in this context. Therefore, the first research objective was:

To modify and validate scales to assess:

a. pre-service teachers’ anxiety towards mathematics in general;
b. pre-service teachers’ anxiety towards teaching mathematics;
c. pre-service teachers’ self-efficacy towards teaching the ‘new mathematics’
d. pre-service teachers’ beliefs about the nature of mathematics;
e. pre-service teachers’ perceptions of their mathematics learning environments.

Mathematics anxiety, mathematics teaching anxiety, self-efficacy and beliefs about have all been found to effect the ways in which teachers teach in the classroom, the amount of time spent on mathematics, the commitment to new reform pedagogy, and retention in the profession (Gresham, 2018; Hemmings, 2015; Nurlu, 2015; Peker & Ertekin, 2011). It has also often been found that pre-service teachers have high levels of mathematics anxiety (Novak & Tassell, 2017; Sloan, 2010), and that the learning environment can affect mathematics anxiety (B. A. Taylor & Fraser, 2013), as well as mathematics self-efficacy (Afari, Aldridge, & Fraser, 2012; Fraser, 2012), and beliefs about mathematics (Beswick & Dole, 2001). Therefore, this study sought to describe Emirati pre-service teachers’; mathematics anxiety, anxiety and self-efficacy for teaching mathematics, beliefs about mathematics, and perceptions of the learning environment. Therefore, the second research objective was:

To describe Emirati pre-service teachers':

a. mathematics anxiety;
b. mathematics teaching anxiety;
c. self-efficacy for teaching mathematics;
d. beliefs about mathematics; and
e. perceptions of the learning environment

Research related to pre-service teachers’ mathematics teaching self-efficacy (reviewed in Chapter 2) has shown mixed results regarding the relationships of the variables of this study, and that they can have significant impact on students’ achievement (see for example, Beilock & Maloney, 2015; Beswick, 2012; Hadley & Dorward, 2011;

Klassen & Tze, 2014). To date, such research has not been undertaken in the UAE with Emirati pre-service teachers. Therefore the third research objective was:

> To examine whether relationships exist between pre-service teachers self-efficacy towards teaching the new mathematics and their:
>
> a. anxiety towards mathematics in general;
> b. anxiety towards teaching mathematics; and
> c. beliefs about the nature of mathematics.

Existing research has also shown that these variables can be increased or reduced during teacher education (see for example, Buckley et al., 2016; Gürbüz & Yildirim, 2016; Isiksal-Bostan, 2016; Swars, Hart, Smith, Smith, & Tolar, 2007). To investigate how Emirati pre-service teachers are faring over the four-year Bachelor of Education programme, the fourth research objective was:

> To investigate whether pre-service teachers in different year levels differ in terms of:
>
> a. anxiety towards mathematics in general;
> b. anxiety towards teaching mathematics;
> c. beliefs about the nature of mathematics; and
> d. self-efficacy for teaching mathematics.

Due to previous findings that teacher education can impact a pre-service teacher's mathematics anxiety, mathematics teaching anxiety, teaching efficacy and beliefs about mathematics (see for example, Buckley et al., 2016; Gürbüz & Yildirim, 2016; Isiksal-Bostan, 2016; Swars et al., 2007), and given the connections found in previous studies between the learning environment and mathematics anxiety (B. A. Taylor & Fraser, 2013), the fifth research objective was:

> To examine whether the learning environment perceived by pre-service teachers is related to their:
>
> a. anxiety towards mathematics in general;
> b. anxiety towards teaching mathematics;
> c. beliefs about the nature of mathematics; and

d. self-efficacy for teaching mathematics.

1.5 Significance

The findings of this study offer theoretical, methodological, and site-specific contributions to teacher education. This section provides an overview of the significance of this study, which will be expanded upon in Section 5.6 of Chapter 5.

Given past research related to mathematics anxiety and teaching self-efficacy of pre-service teachers (see for example, Briley, 2012; Isiksal, 2010; J. P. Smith, 1996; Tschannen-Moran & Woolfolk-Hoy, 2007; Wilson, 2013) and the context of the significant educational reform project in Abu Dhabi, it seems feasible that Emirati pre-service teachers may consider the teaching of the ‘new’ mathematics a challenge. However, the review of literature (see Chapter 2), indicated that, to date, no research related to mathematics anxiety, mathematics teaching anxiety, teaching self-efficacy and beliefs about mathematics, and very limited research relating to leaning environments, has been conducted in the UAE, nor in any of the neighbouring Gulf Cooperation Council (GCC) countries. Further, such research has not been carried out within the context of large-scale educational reform. Therefore, the findings of this study will not only play a role in filling this research gap and adding to the limited literature, but will also be important to a number of stakeholders. Science, technology, engineering and mathematics education (STEM) is a prominent feature of the 2030 UAE Strategic Vision. As such, mathematics teachers have a vital role to play in the realisation of this vision. Therefore, the findings of this study will be of significance to the UAE Ministry of Education, the Abu Dhabi Education Council and the Knowledge and Human Development Authority, and also in the link to national developmental needs in the UAE.

The two institutions involved are likely to find significance in the results of this study. The pre-service teacher participants involved in this investigation were in school themselves prior to the reform, and as such, were taught by subject specialist teachers in a traditional fashion. Therefore, the results will provide important information in relation to how they are faring. The findings may also suggest strategies to alleviate mathematics anxiety and teaching anxiety, and enhance teaching self-efficacy during teaching education in order to optimize their future classroom teaching.

The findings of this research are also likely to be of significance to policy makers, curriculum developers and teaching faculty at teachers' colleges in the region. With new national Teacher Licensure Standards, benchmarked against international best-practice criteria, about to be officially announced in the UAE, and with the Abu Dhabi 2030 Vision aim to have 90 percent Emiratis in the education sector by 2030 (The Abu Dhabi Government, 2008), it is essential that local teacher education programmes build capacity by producing fully prepared pre-service teachers to teach the 'new mathematics' effectively and with confidence.

1.6 Thesis Overview

This thesis is organised into five chapters. This chapter (Chapter 1) has presented background information of the educational milieu of the United Arab Emirates, specifically, the emirate of Abu Dhabi. This chapter has provided information relating to the specific context for the study, has defined the research objectives and outlined the significance of the study.

Chapter 2 provides a review of literature relevant to the research reported in this thesis, including mathematics anxiety, mathematics teaching anxiety, self-efficacy for teaching mathematics, beliefs about mathematics, and how perceptions of classroom environments may impact learning. This review focuses on the variables in relation to pre-service teachers and teacher education, examines possible causes and consequences of these variables, and the interrelationships between the variables.

Chapter 3 describes the research methods used in the present study. The development and selection of the five instruments employed are described. Chapter 3 also provides details of the sample selections for the study, and data collection procedures for both the pilot study and for the main study. A summary of the ethical considerations made throughout the study concludes this chapter.

Chapter 4 present the results of the study, organised around the five research objectives. First the results of data analyses regarding the reliability and validity of the five instruments questionnaires used in this study are reported. The self-reported mathematics anxiety, the anxiety and self-efficacy for teaching mathematics, beliefs about mathematics and perceptions of the learning environment are reported. The relationships between teaching self-efficacy and perceptions of the learning environment, respectively, and the other variables are analysed, and the differences in the variables by year level are presented.

Finally, Chapter 5 summarises the results and discusses the implications of the findings, interpreting them in light of the context of the study (Chapter 1) and the literature reviewed in Chapter 2. The limitations of the study are acknowledged, and the significance discussed. Based on the findings, recommendations for teacher education in Abu Dhabi are presented, with suggestions made for possible future research directions.

Chapter 2

LITERATURE REVIEW

2.1 Introduction

As described in the previous chapter, the aims of the study were three-fold. First, the study described the mathematics anxiety, mathematics teaching anxiety, teaching efficacy, beliefs about mathematics, and the perceptions of mathematics learning environments' of Emirati pre-service teachers at two higher educational institutes in Abu Dhabi. Second, the impact of self-efficacy for teaching mathematics and the learning environment on pre-service teachers' mathematics anxiety, mathematics teaching anxiety and beliefs about the nature of mathematics were investigated. Third, the study examined whether these variables differed depending on a students' length of time within the Bachelor of Education programmes of two higher educational institutes. To accomplish these objectives of the study, it was necessary to develop and validate instruments for the measurement of each of the study's variables. This chapter reviews literature relevant to the variables of this study, these being: mathematics anxiety (Section 2.2); mathematics teaching anxiety (Section 2.3); mathematics teaching efficacy (Section 2.4); beliefs about the nature of mathematics (Section 2.5); and learning environments (Section 2.6). Section 2.7 provides a summary of the chapter and considers the contribution of the study to the existing literature in the field of pre-service teachers' mathematics education.

2.2 Mathematics Anxiety

Interest in mathematics anxiety started with the observations of mathematics teachers in the early 1950s (Baloğlu & Zelhart, 2007). In 1954, Gough coined the term 'mathemaphobia', a term she declared unnecessary to define due to its self-explanatory nature. Gough claimed that it was 'mathemaphobia' that was the root cause of many failures in mathematics classes, and that it is as prevalent as the common cold – the symptoms of which are often unnoticed until in its chronic stages.

A study by Dreger and Aiken (1957, p. 344) suggested the existence of "a syndrome of emotional reactions to arithmetic and mathematics". They labelled the syndrome 'number anxiety'. In their study of 704 students in a basic university mathematics class, they found that number anxiety appeared to be a factor separate from general anxiety, that is, an anxiety specific to dealing with numbers. In 1972, this research finding was supported by Richardson and Suinn whose research demonstrated that mathematics anxiety exists among many people who do not normally suffer from any other tensions, and more recently by Goetz and Hall (2013) who claimed mathematics anxiety is a wide-spread, detrimental emotion in the classroom.

Since that time, researchers, have attempted to define mathematics anxiety (see for example, F. C. Richardson & Suinn, 1972; Tobias, 1980) and develop ways to diagnose and measure it; impelled by the view that the construct compromises both achievement and participation in mathematics (see for example, Alexander & Martray, 1989; Fennema & Sherman, 1976; Gresham, 2018; Hembree, 1990; Herts & Beilock, 2017; Novak & Tassell, 2017; Peker, 2006; Plake & Parker, 1982; Ramirez, Chang, Maloney, Levine, & Beilock, 2016; F. C. Richardson & Suinn, 1972; Sandman, 1980). However, in order to define mathematics anxiety, a key variable in the current study, one must first understand anxiety. Therefore, this section begins with a brief discussion of the different definitions and types of anxiety (Section 2.2.1), from which a definition of mathematics anxiety was identified for the purpose of this study (Section 2.2.2). The section goes on to review research that has examined mathematics anxiety in relation to pre-service teachers specifically (Section 2.2.3). A summary of the section is then provided in Section 2.2.4.

2.2.1 Definition of Anxiety

Defining anxiety was a first step towards defining mathematics anxiety for the current study. Anxiety is one of the most intensely researched constructs in the psychology field and, as such, various definitions have been espoused. Typically, general anxiety is defined as unpleasant emotional reactions such as uncertainty, stress and helplessness to real or imagined situations that are perceived as threatening or potentially dangerous. Byrd (1982, p. 5) explains that "[A]nxiety is an extremely complex phenomenon with manifestations in various areas including the affective, behavioural and physiological. It is subjective and experiential, something people feel", and can interfere with cognitive functioning.

Anxiety can be organised into two discrete types: trait anxiety and state anxiety. Trait anxiety is defined as relatively constant individual differences in the inclination towards anxiety (Baloğlu, 1999), or the relatively consistent tendency to view situations as threatening and react to them as such (Leso, 1992). State anxiety is a transitory emotional condition (Baloğlu, 1999), that relates directly to a stressful situation during a finite period of time (Leso, 1992). (See Section 2.2.2 regarding state and trait anxiety in relation to mathematics anxiety.)

Anxiety and fear are terms that are often used interchangeably (see for example, Ashcraft, 2002; Chang & Beilock, 2016; Ma, 1999; Okur & Bahar, 2010; Ramirez et al., 2016), however the two concepts can be distinguished by the type of threat and the reaction to that threat. With fear, the threat is known and the reaction is physical - flight or fight - whereas with anxiety the threat is unknown and the psychological effects of uncertainty and helplessness follow (Byrd, 1982).

2.2.2 Definition of Mathematics Anxiety

Mathematics anxiety meets all of the diagnostic criteria for a genuine phobia (Faust, 1992). Drawing on Gough's (1954) term 'mathemaphobia', Lazarus (1974) coined the term 'mathophobia', to describe an irrational, obstructive fear of mathematics, . More recently, Gresham (2008) describes mathematics anxiety as a debilitating state of mind which can lead to mathematics phobia. However, Byrd (1982) warned that, while there is still disagreement, phobia, fear and anxiety are generally deemed to be distinct constructs. Similarly, the terms anxiety and attitudes have been used both synonymously and separately. Byrd (1982) makes the distinction, claiming that attitudes are primarily cognitive in nature whilst anxiety is primarily emotional in nature.

Despite the work that has gone into defining anxiety, mathematics anxiety has been described as difficult to define (see for example Baloğlu, 1999; Hembree, 1990; Rounds & Hendel, 1980; Wood, 1988) and many definitions that have been put forth have been critiqued for being too narrow (see for example, Byrd, 1982; Wood, 1988). Possibly the most quoted definition is that of Richardson and Suinn (1972, p. 551): "Mathematics anxiety involves feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations". This definition is more concerned with the effect of mathematics anxiety on mathematical performance, while other definitions focus on the emotional effect on the individual. For example, "feelings of anxiety, dread, nervousness and associated bodily symptoms related to doing mathematics" (Fennema & Sherman, 1976, p. 326), or "an emotion that blocks a person's reasoning ability when confronted with a mathematical situation" (Spicer, 2004, p. 1). Byrd (1982) points out that definitions of mathematics anxiety may be limited in terms of the mathematics they refer to, often relating to arithmetic and/or problem solving only.

In numerous attempts to define anxiety, highly emotive terms have been used to illustrate a 'sophisticated and multi-dimensional phenomenon' (Bekdemir, 2010), including; helplessness (Hunt, 1985), tension (F. C. Richardson & Suinn, 1972), apprehension (Ramirez et al., 2016), fear and angriness (Fennema & Sherman, 1976), panic (Hunt, 1985; Miller & Mitchell, 1994), and paralysed (Morris, 1981). Several of these authors have asserted that these symptoms were physically visible (see for example, Bekdemir, 2010; Fennema & Sherman, 1976). Perhaps with that in mind, Tobias (1980) likened mathematics anxiety to an unsurmountable feeling of sudden death.

A further complication to the development of a clear definition of mathematics anxiety is that the apprehension felt in situations as diverse as avoiding the small amount of mathematics required to check an invoice, and wrestling with a complex problem on a pre-graduate mathematics examination, are often equally claimed to be a result of mathematics anxiety (Ashcraft & Moore, 2009; Wood, 1988). These, in fact, may be the result of significantly different issues:

> It becomes a subtle but important question to decide whether mathematics anxiety describes, or is a function of, some peculiar feature of the discipline of mathematics itself that produces a specific kind of anxiety that interferes with people's ability to perform

> mathematical tasks, or rather, whether doing mathematics produces anxiety of a more general nature. (Wood, 1988, pp. 8-9).

If the former view is accepted, the focus should be those aspects that are intrinsic to mathematics that cause it to evoke anxiety. However, if it is the latter, then the attention should be on the societal, educational or environmental factors that cause a perception that mathematics is anxiety-producing (Wood, 1988; see Section 2.2.4 for discussion on causes of mathematics anxiety).

If general anxiety can be classified as either state or trait (see Section 2.2.1), so too can mathematics anxiety. However, the literature is divided as to which type of anxiety, state or trait, mathematics anxiety belongs.

Mathematics anxiety has been claimed to be a form of state anxiety as it is a "perceived threat to self-esteem brought about in situations involving mathematics" (Atkinson, 1988, p. 30). State mathematics anxiety has a direct impact on performance (Buckley et al., 2016), as the cognitive burden caused by state mathematics anxiety can disrupt performance on mathematics tasks (Ashcraft & Kirk, 2001; Devine, Fawcett, Szűcs, & Dowker, 2012). Baloğlu (1999), Brady and Bowd (2005), and Byrd (1982) agree, stating that mathematics anxiety occurs in mathematically related environments.

Betz's (1978) study into the mathematics anxiety of college students, found moderately strong relationships between mathematics anxiety and trait anxiety, and Jenßen, Dunekacke, Eid, and Blömeke (2015) study of pre-service preschool teachers, assessed mathematics anxiety to be a trait. Moreover, mathematics anxiety has been found to be stable and consistent over time and therefore can be generalized across various situations (Beilock & Maloney, 2015; Liebert & Liebert, 1998), and this is supported by Klieme et al., (2008, p. 5) who found that mathematics anxiety "cannot be attributed to situational factors but rather to stable personality characteristics", suggesting that mathematics anxiety is a form of trait anxiety.

Some researchers have found mathematics anxiety to be both trait and state, depending on the individual's academic self-concept (Roos et al., 2015). Buckley et al. (2016) argued that mathematics anxiety can be both state and trait with each having different outcomes; state mathematics anxiety can negatively affect performance on mathematics tasks, while trait mathematics anxiety functions like an attitude, causing sufferers to avoid mathematics-related courses, careers, and opportunities. This would suggest that individuals may suffer from either state or trait mathematics anxiety and that the differentiating factor would be the response individuals had to the mathematics anxiety: freezing up in the moment or irrationally dreading an upcoming mathematics event; or a long term avoidance of mathematics.

Mathematics anxiety is often described in terms of its debilitating effects, physically visible symptoms, and as both state and trait anxiety. For the purposes of this study, mathematics anxiety is defined as any negative behavioural, attitudinal or emotional reaction that impedes performance in any situation where the individual is learning, doing, or being evaluated in, mathematics. Note that anxiety, as it relates to teaching mathematics, is covered in Section 2.3

2.2.3 Mathematics Anxiety and Pre-service Teachers

Many studies have reported high incidences of mathematics anxiety among pre-service teachers (Harper & Daane, 1998; Hembree, 1990; Kelly & Tomhave, 1985; Novak & Tassell, 2017; Sloan, 2010). In a meta-analysis of 151 studies, Hembree (1990) found that pre-service teachers maintain the highest levels of mathematics anxiety when compared to other undergraduate university students. The mathematics anxiety of future teachers is of concern as several studies have linked mathematics anxiety to previous school experiences, and have suggested that schools and teachers play a significant role as environmental antecedents for mathematics anxiety (Beilock & Maloney, 2015; Buckley et al., 2016; Harper & Daane, 1998; Sloan, 2010; Stoehr, 2017; Whyte & Anthony, 2012). In fact, Uusimaki and Nason (2004) reported that their pre-service teacher participants attributed most of their mathematics anxiety to prior school experiences, with 72% of the reasons particularly ascribed to primary school teachers.

Research has suggested that teachers with mathematics anxiety are likely to use more traditional, surface level teaching, and can even perpetuate mathematics anxiety in their students (Beilock, Gunderson, Ramirez, Levine, & Smith, 2010; Gresham, 2018).

Teachers with mathematics anxiety are likely to teach mathematics using whole class, lecture-style lessons, rote memorisations of algorithms, with fewer problem-solving techniques and games, possibly disregarding students' learning preferences (Bekdemir, 2010; Bursal & Paznokas, 2006; Bush, 1989; Gresham, 2018; Hadfield & McNeil, 1994; Trujillo & Hadfield, 1999). Furthermore, when mathematics anxious individuals become teachers, they can bring with them a dislike of teaching mathematics (Gresham, 2018; Ma & Xu, 2004). Hadley and Dorward (2011) investigated mathematics anxiety as a determining factor in the year level primary teachers choose to work in, and found that teachers with lower anxiety about mathematics were more commonly teaching in the upper primary level. This corresponds with the author's experience when eliciting pre-service teachers' choices (and reasons for those choices) for lower grade levels for practicum placements. It has also been found that mathematics-anxious teachers spend less time on planning for mathematics and dedicate less teaching time to the subject (Bush, 1989; Peker & Ertekin, 2011; Swetman, Munday, & Windham, 1993); in some cases, 50 percent less time teaching mathematics than non-anxious teachers (Schmidt & Buchmann, 1983). This causes reservations about the effectiveness of such teachers (Hadfield & McNeil, 1994; Kelly & Tomhave, 1985). Academic success in mathematics classes of teachers with mathematics anxiety is therefore likely to suffer.

It has been suggested that teachers pass on their avoidance of the subject and their mathematics anxiety can be passed from the teacher onto their students (Bulmahn & Young, 1982; Bush, 1989; Çatlioğlu, Birgin, Coştu, & Gürbüz, 2009; Gresham, 2018; Herts & Beilock, 2017; Vinson, 2001; Wood, 1988), potentially creating another generation of mathematics-anxious people. Beilock et al. (2010) assessed the mathematics anxiety of 17 female first and second grade teachers, and the achievement of their students at the beginning and end of the school year, and found that (female) teachers with high mathematics anxiety appear to have a large influence on girls' gender-related beliefs about who is good at mathematics, which in turn negatively affected the girls' mathematics achievement. They argued that, if these teachers were just worse at teaching mathematics, a relationship between teacher anxiety and the mathematics achievement of both boys and girls could be expected, but this was not the case. This is a disturbing finding at such an early stage in girls' educational careers, particularly given that for girls, mathematics anxiety has the tendency to endure over time once formed (Ma & Xu, 2004). These findings were similar to those found by Suman, Caglayan, and Kartal (2015) who found that students' mathematical fear resulted to a large extent from the attitudes and behaviours of their teachers.

Fortunately, research has also shown that mathematics anxiety in teachers may have a positive side. Widmer and Chavez (1982) found mathematics anxious primary teachers were keen to break the cycle and to reduce mathematics anxiety in their own students. Similarly, A. B. Brown, Westenskow, and Moyer-Packenham (2012) found several pre-service teachers were using their negative prior experiences with mathematics as the motivation for teaching mathematics better to their future students. Given these findings, it is important to identify the mathematics anxiety of pre-service teachers, such as the participants of the current study, with an aim to remedy the situation during teacher education, or channel the anxiety into more positive outcomes.

2.2.4 Summary of Mathematics Anxiety

This section has provided information about mathematics anxiety and its link with pre-service teachers. For over six decades, researchers have been interested in mathematics anxiety. The literature remains divided over whether mathematics anxiety is state or trait anxiety; an individual's reaction to the anxiety may help to diagnose the type they experience.

Teachers who are mathematics anxious tend to teach in a more traditional manner and may communicate their anxiety to their students. Unfortunately, high levels of mathematics anxiety have been found in pre-service primary teachers. As teachers themselves have been identified as one of the causes of mathematics anxiety, it is important to identify this phenomena in pre-service teachers in order to take action before the cycle continues.

While mathematics anxiety research now has a substantial history and continues to be an ever-growing area of study, to date there is very limited research in the UAE or wider Gulf region. Mathematics anxiety is a key variable in the current study. This study built on past research by examining the prevalence of mathematics anxiety among Abu Dhabi's future teachers. The current study also extended past previous studies by relating the mathematics anxiety within the Emirati pre-service teacher population, with both teaching self-efficacy and the learning environment.

The next section introduces, defines and explains mathematics teaching anxiety, and reviews how it may be associated with mathematics anxiety.

2.3 Mathematics Teaching Anxiety

Much past research has reported a strong relationship between mathematics teaching anxiety and the way in which teachers teach (A. B. Brown et al., 2012; Bursal & Paznokas, 2006; Peker & Ertekin, 2011). However the link between mathematics anxiety, which has shown to be prevalent in pre-service teachers world-wide (Harper & Daane, 1998; Hembree, 1990; Kelly & Tomhave, 1985; Sloan, 2010), and mathematics teaching anxiety is less clear. Mathematics teaching anxiety can have a great influence on pre-service teachers' potential effectiveness when teaching mathematics (A. B. Brown et al., 2012; Bursal & Paznokas, 2006; Peker & Ertekin, 2011), and past research has found that higher mathematics teaching anxiety was associated with lower student mathematics achievement (Hadley & Dorward, 2011). Mathematics teaching anxiety has been found to be damaging to the teachers' health (Bernstein, 1983; Peker, 2009b); physical or psychological reactions can include headaches, hypertension, ulcers (Bernstein, 1983), stomach cramps, heart-rate acceleration, being upset, and feelings of distress or apprehension (Ameen, Guffey, & Jackson, 2002), and trembling (Gardner & Leak, 1994).

In this section, literature related to mathematics teaching anxiety is reviewed. The section starts by examining definitions for teaching anxiety and, subsequently a definition for mathematics teaching anxiety for the purpose of this study, is established (Section 2.3.1). The section then reviews literature related to the relationship between mathematics anxiety and mathematics teaching anxiety (Section 2.3.2). The section is then summarised in Section 2.3.3.

2.3.1 Definitions

Teaching anxiety can be characterised as causing physiological arousal, subjective distress, and behavioural disruption (Bernstein, 1983).Initially, it was proposed by Bernstein (1983) that large numbers of teachers suffered from anxiety caused by public speaking, and subsequently conceptualized teaching anxiety as a specific case of speech anxiety encountered by teachers in the classroom. Since then, researchers have suggested that teaching anxiety goes beyond just speech anxiety (see for example, Gardner & Leak, 1994; Thomas, 2006). However, teachers have much longer-lasting relationships with their 'audiences' (students) than a public speaker and, therefore, become more involved with their audience (Thomas, 2006). Thus, teaching anxiety involves uneasiness concerning interactions with the audience, such as difficult questions, interruptions or distractions, or student evaluations (Gardner & Leak, 1994). Therefore, Gardner and Leak (1994) conceptualized teaching anxiety as the anxiety experienced by teachers during the preparation and implementation of classroom activities.

Building on this understanding of teaching anxiety, Peker (2006) described mathematics teaching anxiety as the apprehension or tension which teachers feel when teaching mathematical concepts, and skills, or during problem-solving. It has been found that pre-service teachers, in particular, often feel nervous and unable to concentrate in class due to their high level of mathematics teaching anxiety (Peker, 2006) Mathematics teaching anxiety may reflect real or perceived knowledge deficits in mathematics concepts and/or in mathematics teaching skills (Peker, 2009b; Romeo, 1987), and symptoms may include "extreme nervousness, the inability to concentrate, negative self-talk, being easily upset by noises, being unable to hear the students, and sweaty palms—to name a few" (Peker, 2009a, p. 336). Similar to mathematics anxiety, mathematics teaching anxiety may be caused by memories of past experiences of mathematics failure or bad mathematics learning experiences in the past (Ertekin, Dilmac, Yazici, & Peker, 2010; Peker & Ulu, 2018). In contrast, A. B. Brown et al. (2012) asserted that while mathematics anxiety is a result of past experiences, mathematics teaching experiences and, therefore, perhaps pre-service teachers' mathematics teaching anxiety, are in the future. Lynch (1994) likewise found that as their mathematics methods course neared completion, pre-service teachers were more anxious about having to teach mathematics than they were about learning mathematics.

For the study reported in this thesis, mathematics teaching anxiety was defined as any negative behavioural, attitudinal or emotional reaction that impedes performance in any situation where the individual is teaching mathematics.

2.3.2 Relationships between Mathematics Teaching Anxiety and Mathematics Anxiety

This section reviews literature related to the relationship between anxiety for teaching mathematics and mathematics anxiety. Mathematics teaching anxiety, a key variable in the current study, differs from mathematics anxiety because it is based on an individual's anxiety about their ability to *teach* mathematics, as opposed to learning, doing or being evaluated in mathematics. According to A. B. Brown, Westenskow, and Moyer-Packenham (2011, p. 2), "Mathematics anxiety is more internally focused and reflects how the individual views their own ability to interact with the mathematics; on the other hand, mathematics teaching anxiety is more externally focused and reflects how the individual views their ability to engage children in an interaction with the mathematics".

While it may seem likely that pre-service teachers with mathematics anxiety would also have mathematics teaching anxiety, research on the connection between the two phenomena has found mixed results. Uusimaki and Nason (2004) reported that pre-service teachers' negative beliefs and anxiety about mathematics have a powerful impact on teaching practice. Similarly, (Peker & Ertekin, 2011) found a significant positive relationship between pre-service teachers' mathematics anxiety and their mathematics teaching anxiety. However, Hadley and Dorward (2011) found no relationship with anxiety for teaching mathematics when primary teachers had higher anxiety about mathematics. Their study, involving in-service primary teachers, found that teachers who were not anxious about mathematics would likely not be anxious about teaching mathematics. However they also found that as mathematics anxiety increases, some teachers show an increase in mathematics teaching anxiety, while others are able to maintain low anxiety about teaching mathematics. They suggest that this could be due to the self-reported low teaching anxiety teachers being able to teach at a grade level where they feel comfortable. In another study, A. B. Brown et al. (2011) found that pre-service teachers that reported high levels of mathematics anxiety, did not report mathematics teaching anxiety. The same researchers suggest that a person may be very confident about their mathematics knowledge and therefore not suffer from mathematics anxiety, but may still experience mathematics teaching anxiety due to a lack of confidence in their abilities to communicate mathematical concepts to students.

Much research to date regards mathematics anxiety as a pre-existing condition (caused by negative experiences or weak mathematical backgrounds, for example) that pre-service teachers bring with them to higher education (A. B. Brown et al., 2011). However, this stance overlooks the possibility that mathematics anxiety may develop as a result of mathematics teaching anxiety. Levine (cited in Ertekin et al., 2010) found that in the same way as with mathematics anxiety, mathematics teaching anxiety can interfere with learning new course material (during a mathematics methods course at teachers' college), and therefore pre-service teachers who experience mathematics teaching anxiety may be less able to learn and create material for the teaching of the subject. It is therefore essential to identify mathematics teaching anxiety in pre-service teachers during teacher education. This study built upon this existing research to identify the teaching anxiety for mathematics of Emirati pre-service teachers, a previously unstudied population.

2.3.3 Summary of Mathematics Teaching Anxiety

This section examined the definitions of teaching anxiety and mathematics teaching anxiety, and then described the relationship between mathematics teaching anxiety and mathematics anxiety. Mathematics teaching anxiety is the anxiety felt by teachers when tasked with teaching mathematics specifically, and may reflect real or perceived shortfalls in mathematics knowledge or teaching skills. It has been found to be a frequent fear of pre-service teachers (Peker, 2009b). Its link to the more commonly studied mathematics anxiety remains unclear, with various studies producing mixed results regarding correlations. The nature of teaching, which involves public speaking, answering questions 'on the spot', and conducting student evaluations, teaching has been identified as an anxious craft (Bernstein, 1983; Thomas, 2006). While it is difficult to ascribe specific causes for mathematics teaching anxiety, the lack of teaching content or skills, past negative experiences with mathematics, and the way teachers are being asked to teach mathematics (which may be different to how they were taught) are often suggested. The literature reviewed indicated that mathematics teaching anxiety has been related to physical or psychological reactions in teachers. It can also affect how a teacher teaches mathematics, which may negatively impact their effectiveness as mathematics teachers, and has been linked to lower student achievement.

The research reported in this thesis builds on and extends these past studies. To date, no research of this kind has been conducted in the UAE or wider Gulf context, therefore, this study fills an overdue gap by examining how mathematics teaching anxiety affects this population of pre-service teachers who are expected to teach mathematics in very different ways to which they were taught, and to which extents, so interventions during teacher education can be recommended. This study extends the existing literature by examining the mathematics teaching anxiety of Emirati pre-service teachers, and investigating how this anxiety relates to teaching self-efficacy and the mathematics learning environment.

The next section will explore literature on teaching efficacy for mathematics and how teaching efficacy may be influenced by mathematics anxiety.

2.4 Teaching Self-efficacy

Another key variable in this study was teaching self-efficacy. Self-efficacy beliefs are considered to be one of the most significant factors in the affective domain of mathematics teaching (Peker, 2016). Significant positive links between teaching self-efficacy and student achievement have been reported repeatedly over the last 20 years (Ashton & Webb, 1986; Huinker & Madison, 1997; Klassen & Tze, 2014; Muijs & Reynolds, 2015; Mulholland & Wallace, 2001; Swars et al., 2007; Tschannen-Moran, Woolfolk-Hoy, & Hoy, 1998; Woolfolk & Hoy, 1990), making the importance of teaching self-efficacy clear. The relationship with student achievement is likely to be due to the teacher behaviours and strategies that have also been frequently associated with teaching self-efficacy (see for example, Gresham, 2008; Nurlu, 2015; Puchner & Taylor, 2006; Woodcock, 2011b). Teachers have been found to spend more time teaching in subject areas in which their sense of efficacy is higher (Riggs & Enochs, 1990), and mathematics anxiety in students can be prevented by highly efficacious teachers (Tschannen-Moran et al., 1998). Teaching self-efficacy has also been linked to retention in the profession, that is, teachers with a higher sense of efficacy displaying a greater commitment to teaching, even in the challenging beginning years (Coladarci, 1992; Knobloch & Whittington, 2002). As a key variable in the current study, this section reviews literature related to the meaning of self-efficacy (Section 2.4.1), and how this relates to teaching self-efficacy (Section 2.4.2), and mathematics teaching self-efficacy (Section 2.4.3. The section concludes with a summary (Section 2.4.4)

2.4.1 Self-Efficacy

Albert Bandura's (1977) seminal work on Social Cognitive Theory introduced the concept of self-efficacy and, according to McGee (2012), remains the most widely accepted framework for self-efficacy. Bandura asserts that self-efficacy refers to how well a person believes they can "…organize and execute the courses of action required to produce given attainments" (1997, p. 3). Self-efficacy beliefs influence the effort that people put into tasks, the choices they make and the degree of anxiety they experience (Bandura, 1977, 1986). Bandura (1993) suggested that people with high self-efficacy approach difficult tasks as opportunities for mastery and that any failures are within their power to surmount. Self-efficacious people are more likely to attempt tasks and will persist longer with them even when faced with obstacles. Conversely, people with low self-efficacy take failure at difficult tasks personally, even leading to stress and depression, and will avoid activities they see as exceeding their capabilities. "Those who persist in subjectively threatening activities that are in fact relatively safe will gain corrective experiences that reinforce their sense of efficacy, thereby eventually eliminating their defensive behaviour. Those who cease their coping efforts prematurely will retain their self-debilitating expectations and fears for a long time" (Bandura, 1977, p. 194). Self-efficacy is considered to be an unstable trait, a situation-specific construct based on a particular context (Bandura, 1977, 1986).

Bandura’s (1977) Social Cognitive Theory involves two main constructs: efficacy expectations and outcome expectations. An efficacy expectation is the belief that one can successfully perform the behaviour required to produce the desired outcomes, whereas an outcome expectancy is a person's estimate that a given behaviour will lead to certain outcomes (Bandura, 1977). Efficacy and outcome expectations differ in that an individual may believe that certain actions will yield certain outcomes, but such belief will not impact their behaviour if they have serious doubts about their abilities to perform such actions. Similarly, an individual may give up trying even when confident in their capabilities if they expect their behaviour will have no effect on an unresponsive environment, or expect to be consistently punished (Bandura, 1977).

Current use of the term self-efficacy comes from the original construct of efficacy (Bandura, 2006). Assessments of self-efficacy are task-specific and vary in strength and magnitude (Bandura, 1977; Pajares, 1997). Self-efficacy is not solely responsible for the outcome of an event, but the outcomes that a person may expect are dependent on the individual’s assessment of how much they believe they can accomplish (Bandura, 1986).

As important as self-efficacy may be in many cognitive processes and subsequent behaviours, it is not a measure of ability for each individual (Bandura, 1977), but a sense of confidence in how well one might expect to perform a task given a particular set of conditions. People may over or underestimate their actual abilities, which will influence how they use their skills, the activities they choose, and the level of effort they employ. In order to accomplish any given task, one must possess knowledge, skills *and* self-efficacy (Bandura, 1986); that is, an individual must be capable of completing the task and also believe that they can complete it. “Insidious self-doubts can easily overrule the best of skills" (Bandura, 1997, p. 35). It seems that in most instances, somewhat overestimating one's actual abilities has the most positive influence on performance (Tschannen-Moran et al., 1998), although others claim that overestimating one’s abilities is related to flawed decision-making (Johnson & Fowler, 2011; Roos et al., 2015), which could in turn negatively affect students’ academic performance.

Confidence is often used synonymously with self-efficacy in the literature, with several authors defining self-efficacy as the confidence in one's own ability to perform a particular task (Hackett & Betz, 1989; A. W. Hoy & Spero, 2005; Isiksal-Bostan, 2016). Although a clear distinction is made between self-efficacy and self-esteem: "Perceived efficacy is a judgment of capability; self-esteem is a judgment of self-worth. They are entirely different phenomena" (Bandura, 2006, p. 309). Whereas this section reviewed self-efficacy, the next section reviews the notion of teaching self-efficacy.

2.4.2 Teaching Self-efficacy

Drawing on Bandura's theoretical framework, described in the previous section, teaching self-efficacy has been defined as a belief in one's capability to successfully accomplish tasks related to teaching (Hemmings, 2015), and past research indicates that it influences teachers' performance (Duffin, French, & Patrick, 2012; Woolfolk, Rosoff, & Hoy, 1990), and therefore also influences student outcomes such as motivation and achievement (Allinder, 1994; Duffin et al., 2012; Woolfolk & Hoy, 1990). It is, in fact, one of the few teacher characteristics consistently related to student achievement (Woolfolk et al., 1990). Furthermore, "It could be argued that teacher self-efficacy might be an instrumental factor in the success or failure of a school teacher and whether or not a school teacher remains in the teaching profession" (Hemmings, 2015).

If Bandura's (1977) two main constructs (personal self-efficacy and outcome expectancy) are applied to teaching, personal self-efficacy for teaching is the belief that one can teach effectively, and outcome expectancy for teaching is the belief that one's students will learn from that teaching. The independence of these beliefs suggests that they may influence teachers' instructional decision-making and behaviour in varying ways (Soodak & Podell, 1996). A teacher's personal teaching self-efficacy may influence the amount of effort they exert when working with students, whereas a teacher's outcome expectancy for teaching may influence the degree to which instruction is subsequently modified (Soodak & Podell, 1996). For example, teachers high in personal self-efficacy for teaching but low in outcome expectancy for teaching may refer difficult-to-teach students to others (e.g. special needs educators) because, although these teachers feel confident in their abilities, they do not believe their actions will be effective with this population (Soodak & Podell, 1996).

A third factor, commonly known as general teaching efficacy, has also been identified by researchers in this field (see for example, Gibson & Dembo, 1984; W. K. Hoy & Woolfolk, 1990; Soodak & Podell, 1996). General teaching efficacy refers to the belief that teachers, as a collective, can overcome the effects of outside influences. These influences include student motivation, ability level, family influence (Ashton, 1984; L. J. Smith, 2010), heredity, television violence (Soodak & Podell, 1996), and school conditions (Gibson & Dembo, 1984). Teachers with high teaching self-efficacy take responsibility for student learning, while teachers with a lower teaching self-efficacy are more likely to believe that outside influences are more powerful factors than teacher influence in student progress (Ashton & Webb, 1986; Coleman, 2001). Research suggests that teachers with high efficacy are more likely to engage in behaviours associated with effective instruction (Gibson & Dembo, 1984; Muijs & Reynolds, 2015).

Teaching self-efficacy has been conceptualised as an umbrella construct incorporating the more specific domains of instructional strategies self-efficacy, classroom management self-efficacy, and student engagement self-efficacy (Ashton & Webb, 1986; Tschannen-Moran & Woolfolk-Hoy, 2001). Teaching self-efficacy is considered to be context and subject-matter specific (Ashton & Webb, 1986; Tschannen-Moran et al., 1998). A teacher may hold high teaching self-efficacy beliefs when teaching a particular subject to a particular group of students at a particular grade level, but may be less efficacious in a different setting.

In the next sections, literature related to mathematics teaching self-efficacy specifically, and the links between mathematics teaching efficacy and mathematics anxiety are reviewed.

2.4.3 Mathematics Teaching Self-efficacy

Following on from the previous section, mathematics teaching efficacy, is a belief in one's capabilities to successfully effect mathematics teaching tasks. As teaching self-efficacy is conceived to be subject-matter specific, and mathematics is a field in which many teachers hold self-doubts about their competence (Charalambous, Philippou, & Kyriakides, 2008), it is important to study teaching self-efficacy within the context of the subject matter. Again, if we apply Bandura's (1977) two-factor construct, personal mathematics efficacy is the teachers' beliefs in their ability to effectively teach mathematics, and outcome expectancy for mathematics teaching is the teachers' beliefs that student learning can be affected by effective teaching (Isiksal-Bostan, 2016). It is possible that teachers may have varying levels of teaching self-efficacy within the umbrella of the mathematics subject (McGee, 2012). For example, teachers may hold high self-efficacy beliefs about teaching 2D shape characteristics, but lower self-efficacy beliefs about teaching problem solving.

Past research suggest that pre-service teachers come to the profession with relatively fixed self-efficacy beliefs and these beliefs are often linked with feelings of fear regarding mathematics, and anxiety about the prospects of teaching the subject (Newton, Leonard, Evans, & Eastburn, 2012; J. P. Smith, 1996; Ural, 2015). Although Bandura (1997) suggests teaching self-efficacy may be most malleable early on in a teacher education program, Tschannen-Moran and Woolfolk-Hoy (2007) claim that once the teaching self-efficacy beliefs of pre-service teachers are established, they appear to be somewhat resistant to change. However, interestingly, several studies have found that teaching self-efficacy increased during teacher preparation, but dropped during the first year of teaching (Hemmings, 2015; Woolfolk-Hoy, 2000; Woolfolk-Hoy & Spero, 2005). It is notable, given that anxiety is another key variable in this study, that past research has reported strong negative correlations between teaching self-efficacy for mathematics and mathematics anxiety (Akin & Kurbanoglu, 2011; Bursal & Paznokas, 2006; Gresham, 2008; Isiksal, 2010; Peker, 2016; L. J. Smith, 2010; Swars et al., 2006; Ural, 2015). That is, the higher the mathematics anxiety, the lower the mathematics teaching efficacy, and vice versa. Interestingly, previous research has also indicated that pre-service teachers who have suffered with mathematics anxiety when learning mathematics and how to teach it, may still believe that they are capable of teaching it (Gresham, 2008; McGlynn-Stewart, 2010; Stoehr, 2017; Swars et al., 2006; Trujillo & Hadfield, 1999). In Stoehr's three case studies, the participants' strategies for managing their mathematics anxiety "…served as a means for them to continue to pursue their goal of becoming a competent and successful elementary teacher" (2017, p. 81). Similarly, Trujillo and Hadfield (1999) found that the mathematics-anxious pre-service teachers they interviewed were optimistic about setting aside their fears in order to be effective mathematics teachers. Swars et al. (2006) found that pre-service teachers with high mathematics anxiety built upon their own past experience and felt a sense of empathy with students who struggle with mathematics, which they believed would help them be effective mathematics teachers.

While several studies have examined the relationship between mathematics anxiety and self-efficacy for teaching mathematics (see for example, Akin & Kurbanoglu, 2011; Bursal & Paznokas, 2006; Gresham, 2008; Isiksal, 2010; Peker, 2016; L. J. Smith, 2010; Swars et al., 2006; Ural, 2015), no research could be found that considered the relationship between mathematics teaching anxiety and efficacy for teaching mathematics. This study addressed this research gap and extended the existing literature by examining the relationship between teaching self-efficacy and mathematics anxiety, mathematics teaching anxiety, and beliefs about mathematics.

2.4.4 Summary of Teaching Self-efficacy

This section has reviewed the concept of self-efficacy, which arose out of Social Cognitive Theory (Bandura, 1977), and refers to how well a person believes they can succeed at a particular task. People with higher self-efficacy are more likely to attempt tasks and will persevere longer even if the task is challenging. People with lower self-efficacy may avoid tasks and will take any failures personally. Self-efficacy is not a measure of actual ability, but more a sense of confidence for performance for which there is not a global measure (Bandura, 2006). The four sources of self-efficacy are enactive mastery experiences, vicarious experiences, verbal or social persuasion, and physiological and affective states (Bandura, 1986, 1997). Self-efficacy for teaching-related tasks is commonly known as teaching or teaching self-efficacy, and has been found to affect teachers' performance, and therefore student motivation and achievement. In fact, it has been asserted that teaching self-efficacy may be a significant factor in the success of a teacher (Hemmings, 2015). Teachers with higher self-efficacy have been shown to demonstrate more positive teacher behaviours, have a strong academic focus, utilise student-centred methodologies in their classrooms and stay in the profession longer.

Specifically, mathematics teaching self-efficacy, is a belief in one's abilities to successfully realise mathematics teaching tasks. Teachers are likely to spend less time teaching subjects in which they feel less self- efficacious. Teaching self-efficacy has been repeatedly linked with mathematics anxiety, that is, the higher the mathematics anxiety, the lower the mathematics teaching efficacy, and vice versa. However, some studies have found that mathematics anxious pre-service teachers may still have self-efficacy for teaching primary mathematics. Teaching self-efficacy has been found to be relatively constant, however it may be most malleable during the early stages of development, for example during teacher training. Given this imperative, the present study built upon these past studies to identify the levels of self-efficacy for teaching mathematics among Emirati pre-service teachers during a time of educational reform in Abu Dhabi. Given that teachers with low efficacy are likely to utilise teaching methods that undermine the reform project, and ultimately affect student achievement, the findings of this study can provide a springboard for improving self-efficacy beliefs during teacher education.

The next section considers literature relating to the beliefs about the nature of mathematics, and in particular, those belonging to pre-service teachers.

2.5 Beliefs about Mathematics

Another variable in this study was teachers' beliefs about mathematics. These beliefs have been shown to influence behaviours (see for example, Hughes, 2016), and similar to mathematics anxiety, mathematical beliefs can have a "profound effect on pre-service teachers' learning to teach mathematics as well as their potential to become effective teachers" (Haciomeroglu, 2013, p. 7). Mathematical beliefs can range between 'naïve' (knowledge is certain, simple, and handed down by authority), and 'sophisticated' (knowledge is tentative, complex, and derived from reason) (Schommer, 1994). Research has found that teachers who have more naïve beliefs regarding mathematics tend to teach in more traditional ways focusing on rules, procedures and correct answers (Aslan et al., 2016; A. G. Thompson, 1984). Whereas teachers who have a problem solving view of mathematics tend to employ activities that allow students to construct mathematical ideas for themselves (Szydlik et al., 2003). Even when teachers hold constructivist views about pedagogy, traditional views of mathematics are likely to result in traditional instructional practices (Purnomo, Suryadi, & Darwis, 2016; Raymond, 1997).

The current study aimed to identify what Emirati pre-service teachers believe about mathematics, and how these beliefs may relate to teaching self-efficacy and the learning environment. This section reviews literature related, first, to beliefs about the nature of mathematics in general (Section 2.5.1) and then, specifically, the beliefs of pre-service teachers regarding the subject (Section 2.5.1.2). The section goes on to review research that has examined the relationships between mathematical beliefs, and mathematics anxiety and teaching efficacy for mathematics (Section 2.5.2). The section is then summarised in Section 2.5.3.

2.5.1 Beliefs about the Nature of Mathematics

Up until the 1960s, a pre-service teacher's knowledge of his/her subject was commonly used as a predictor for his/her future success at teaching – simply put, the teachers that knew their subject matter very well made the best teachers (Bursal & Paznokas, 2006). However, in the second half of the last century the interest in pre-service teachers' beliefs and the impact this may have on their teaching became more prevalent (Bursal & Paznokas, 2006) and pre-service teachers' beliefs are now deemed to be one of the most important concepts in teacher education (Kagan, 1992; Pajares, 1992). If behaviours are based on beliefs, then it is important that the mathematical beliefs of pre-service teachers, and the implications of those beliefs, be identified. In this section, the definitions for beliefs, and then definitions of mathematics beliefs are examined (Section 2.5.1.1). This is followed by a brief review of literature pertaining to the mathematical beliefs of pre-service teachers (Section 2.5.1.2).

2.5.1.1 Defining Mathematics Beliefs

This section begins by defining beliefs in general and then goes on to define mathematics beliefs in particular. “As a global construct, belief does not lend itself easily to empirical investigation” (Pajares, 1992, p. 308), and lacks a universally agreed upon definition (Beswick, 2006; Uysal & Dede, 2016). Even within mathematics education the term belief has been used with a variety of meanings, such as concepts, meanings, propositions, rules, preferences or mental images (A. G. Thompson, 1992). Nonetheless, many attempts have been made over the last four decades to define the elusive notion, as beliefs have been a popular topic of research in recent decades (Uysal & Dede, 2016). Ajzen and Fishbein (1980) defined belief as anything that a person considers to be true, and are part of the foundation upon which behaviours are built; and similarly, over 30 years later Roscoe (2011, p. 49) defined belief as “any psychologically held proposition about the world that is thought to be true”. However, there is still disagreement as to whether beliefs reside in the affective or cognitive domain. Researchers have noted confusion and overlap between beliefs and attitudes, emotions (Leder & Grootenboer, 2005; Uysal & Dede, 2016), feelings and values (Leder & Grootenboer, 2005).

Proponents of the affective nature of beliefs suggest that beliefs have stronger affective elements than knowledge, are justified by personal and often private means, and typically operate independently of the cognition accompanying knowledge (Nespor, 1987). Beliefs are held with an awareness that others may hold differing beliefs (Abelson, 1979), and this discriminates beliefs from knowledge, as knowledge is aligned with truth and certainty (A. G. Thompson, 1992). A. G. Thompson (1992) put forth that beliefs can be strongly or weakly held, further differentiating beliefs from knowledge as this quality is not a characteristic of knowledge (which is either present or absent in an individual, i.e. you can’t strongly know a fact). Ernest (1989) claimed that while beliefs are a knowledge of sorts, knowledge is the cognitive outcome of thought; beliefs are the affective outcome of thought, however he conceded that beliefs also have a small but significant cognitive component.

Mcleod (1992) differentiated beliefs from attitudes and emotions by placing them on a continuum, with beliefs to be at the most stable, least intense end of the continuum, emotions at the opposite end, and attitudes somewhere in between. Mcleod (1992) also theorised beliefs to have the highest levels of cognitive involvement and the least level of affective involvement. Welder, Hodges, and Jong (2011) also agree that beliefs are more cognitive, less intense than attitudes, and that they are harder to change. Further, Roscoe considered beliefs to be “firmly rooted in the study of cognition” (2011, p. 13), as cognition describes human behaviour as a function of human mental processes. That environmental factors may be particularly important in the development of beliefs, also suggests beliefs, at least, have a cognitive component (Ertekin, 2010). Österholm (2009), after a critical perspective regarding the concept of beliefs, claims that the difference between knowledge and beliefs is not so absolute and that, when defining beliefs, one must decide which perspective is the most suitable and then be consistent within this one perspective.

Beliefs have been observed to be domain specific (Ertekin, Dilmac, & Yazici, 2009) and one field in which beliefs are a focus is mathematics teaching (Ertekin, 2010). Further to the debate of the definition of beliefs, there is also debate over the definition of mathematical beliefs, or beliefs about the nature of mathematics, even among mathematicians (Dossey, 1992). For teachers, beliefs about the nature of mathematics and beliefs about teaching and learning are often intertwined, as seen in several definitions in the literature. Mathematical beliefs are thought to be the personal philosophies, assumptions and judgements about the nature of mathematics, as well as about teaching and learning mathematics (Ernest, 1989; Kagan, 1992; Raymond, 1997; A. G. Thompson, 1992). A. G. Thompson (1992) states that many educated people view mathematics in terms of operations, theorems and infallible procedures which result in exact answers. Teachers’ conceptions of the nature of mathematics form the basis of their mathematics beliefs, although these may not be consciously held views (Ernest, 1989).

For the purpose of this study, mathematics beliefs are defined as personal ideas and assumptions about the nature of mathematics, including what it is, who can do it, how useful it is, and how it can be taught and learned.

2.5.1.2 Mathematics Beliefs of Pre-service Teachers

Past research has consistently found that many pre-service teachers hold a naïve view of mathematics (Ball, 1990; Briley, 2012; Carpenter et al., 1983; Paolucci, 2015; Szydlik et al., 2003). Further, these studies have found that many students enter teacher education programmes believing that teachers are experts who provide black-and-white, right-or-wrong-answers (Perry, 1970, as cited in Cady & Rearden, 2007). Pre-service teachers often view mathematics as a random collection of facts and rule-bound procedures (Ball, 1990). Similarly, Szydlik et al. (2003) found that pre-service teachers believe mathematics to be an authoritarian discipline that involves applying memorized formulas to textbook exercises. Jackson (2008) analysed pre-service teachers' beliefs about mathematics and found the most frequent belief to be mathematics is a 'right or wrong' subject. The same participants largely agreed that one must be a logical thinker in order to do mathematics. Such studies have led researchers to conclude that pre-service teachers have not been encouraged to be creative or innovative with mathematics, nor developed independent mathematical thinking (Buxton, 1981; Jackson, 2008; Oxford, 1995). Furthermore, pre-service teachers have been found to believe that their role, as students, is to memorise the right answers and produce them upon request (Muis, 2004). These findings indicate that pre-service teachers could expect to learn step-by-step approaches for teaching mathematics during their pre-service training (Cady & Rearden, 2007). Clearly, this has the potential to be a barrier to student-centred, inquiry-based learning.

Many researchers have found that pre-service teachers support pre-conceptions about the teaching and learning of mathematics from their earlier experiences as students (Bekdemir, 2010; Bramald, Hardman, & Leat, 1995; Cady & Rearden, 2007; Calderhead & Robson, 1991; Raymond, 1997; V. Richardson, 2003; A. G. Thompson, 1992; Uusimaki & Nason, 2004). These past experiences may have included inadequate mathematics instruction, ineffective teaching practices (Hembree, 1990), and unsympathetic teachers (Cornell, 1999). In fact, one study showed that 72% of the reasons for negative school experiences with mathematics were attributed to teachers, particularly primary school teachers (Uusimaki & Nason, 2004). According to Pajares (1992), the emotion associated with these experiences is a key element in the formation of beliefs. These experiences are also more likely to reflect traditional roles of teachers as dispensers of knowledge and students as receivers of knowledge (Cady & Rearden, 2007).

This study builds on past research to examine the beliefs of Emirati pre-service teachers. Given that the model that Emirati pre-service teachers have of mathematics teaching from their own schooling experiences, was primarily a direction to a textbook page this study sought to examine their mathematical beliefs.

2.5.2 Relationships between Beliefs and Mathematics Anxiety and Self-efficacy

The results of past research provide strong evidence to suggest that a negative relationship exists between mathematics anxiety and mathematical beliefs (Atkinson, 1988; Başpinar & Peker, 2016; Byrd, 1982; Haciomeroglu, 2013; Peker & Ulu, 2018; Swars et al., 2006; Swars, Smith, Smith, & Hart, 2009; Uusimaki & Nason, 2004). However the casual directionality remains unclear: some deeming mathematics anxiety to be influenced by beliefs (Kogelman, 1978; Peker & Ulu, 2018; Suman et al., 2015; Tobias, 1980); while, more recently, others considering that mathematics anxiety plays a role in developing (negative) mathematical beliefs (Haciomeroglu, 2013; Uusimaki & Nason, 2004).

A specific relationship has been found between mathematics anxiety and beliefs about the usefulness of mathematics (see for example, Byrd, 1982; Miller & Mitchell, 1994; Sloan, Daane, & Giesen, 2002). According to Atkinson (1988), this can be interpreted in two ways. Firstly, an individual who considers mathematics to be useful, may experience anxiety stemming from their lack of confidence in an important subject; or a person with high mathematics anxiety may perceive mathematics as not useful as a psychological defence mechanism. Or secondly, an individual may truly believe mathematics to be not useful. In this case, anxiety may manifest as failure at mathematics activities results in a blow to self-esteem, whereas success at an ‘unimportant’ subject is meaningless (Atkinson, 1988).

Pre-service teachers’ beliefs about mathematics have similarly been linked to mathematics teaching efficacy, with several studies finding that pre-service teachers with greater efficacy in their abilities to be effective teachers had more sophisticated mathematical beliefs (Briley, 2012; Haciomeroglu, 2013; Swars et al., 2007). Briley’s (2012, p. 8) study specifically showed that “personal mathematics teaching efficacy was found to have a statistically significant positive relationship to the belief about the nature of mathematics, to the belief about doing, validating, and learning mathematics, and to the belief about the usefulness of mathematics” for the pre-service teacher participants. Briley’s study demonstrated that mathematical beliefs were a significant predictor of, and had a significant effect on, mathematics teaching efficacy. Similarly, McGee and Wang (2014, p. 391) claim “a teachers’ belief system is often marked by his or her self-efficacy for specific tasks”. Such findings imply that mathematical beliefs play a central role in the mathematics teaching efficacy of pre-service teachers.

2.5.3 Summary of the Beliefs about Mathematics

The review provided above indicates that pre-service teachers’ beliefs about teaching and particular subjects, including mathematics, are an important construct in teacher education. Beliefs, while difficult to define, generally refer to anything an individual considers to be true, and on which behaviours are based. There continues debate regarding whether beliefs lie in the cognitive or affective domain, or whether they cross both at differing intensities or levels of sophistication. Beliefs regarding mathematics teaching have become a focus in literature over the last 25 years, and are thought be one’s personal philosophies, assumptions and judgements about the nature of mathematics, as well as about teaching and learning mathematics. Pre-service teachers’ beliefs about mathematics have been positively correlated with their mathematics teaching efficacy, and negatively correlated with mathematics anxiety. Researchers have consistently found that many pre-service teachers hold naïve views of mathematics, which is likely to negatively affect their instructional practices when teaching the subject; teachers who have more traditional beliefs regarding mathematics tend to teach in more traditional ways. Such beliefs were likely to have been developed while pre-service teachers were in school themselves, and tend to be resistant to change. This review of literature indicates that, to date, no research of this kind has been conducted with Emirati pre-service teachers. Given the importance of mathematical beliefs on future teaching, and the influence this could have on the reform efforts underway, this key factor was included in this study. As such, the study builds on past research carried out in other parts of the world, by identifying the mathematical beliefs of pre-service teachers in Abu Dhabi, and fills a gap in the literature by, first, involving pre-service teachers in the UAE and, second, examining whether the beliefs of pre-service teachers are related to teaching self-efficacy and the learning environment.

The next section reviews literature related to the field of learning environments, and how the learning environment in mathematics classes may affect the mathematics, anxiety, self-efficacy and beliefs of pre-service teachers.

2.6 Learning Environments

The learning environment of any classroom includes the physical space for learning, but also refers to the intangible features that give the space its feel or tone (Fraser, 2001), that is, “the social, physical, psychological and pedagogical context in which learning occurs” (Fraser, 2007, 2012). This environment can be constructed through the relationships developed within the classroom and through the instructional practices (Aldridge, Fraser, & Ntuli, 2009). The quality of life in classrooms, including students' perceptions of, and reactions to their school experiences are important (Fraser, 2001). As such, over the past several decades, research into classroom environments has constantly increased and been applied in a variety of useful ways. This section begins with a brief history of learning environment research (Section 2.6.1). Next, research related to the relationships between the learning environment and various outcomes in general is reviewed, and with mathematics in particular (Section 2.6.2). Finally, a review of how learning environments and mathematics anxiety are connected is provided (Section 2.6.3). The section is then summarised in Section 2.6.4.

2.6.1 History of Learning Environment Research

Contemporary research into learning environments developed from earlier work in social psychology. In the 1920s, Hartshorne and May suggested that human behaviour is specific to the environment in which it occurs – an idea central to learning environments research (MacLeod & Fraser, 2010). In 1936, Kurt Lewin, a German-American psychologist, published seminal work identifying that behaviour is a function of the person and his environment, for which he developed the heuristic formula, B = f(P, E), in which 'P' represents people, and 'E', environment. Lewin believed that learners live and move in their own 'life-space', a construct of their psychological world as it exists for them, which teachers should seek to understand (Gould, 1955). Even in early studies of human environments, it was recognised that the perception of an environment is highly individualised; persons from different perspectives are likely to interpret the same environment in different ways (Fraser, McRobbie, & Fisher, 1996).

Building on Lewin's work, the American psychologist, Henry Murray (1938), developed a theory of human personality based on a person's needs, for example a need for membership to a social group or a need for achievement, and the person's relationship with, or the 'press' of, the physical and social environment. Murray is also noted for introducing the terms 'alpha press' and 'beta press', to describe an environment as evaluated by an outside observer and one described by an inhabitant of the environment, respectively (Fraser, 2012). The needs-press model later became the basis for George Stern's theoretical model (1970). Stern claimed that the unique atmosphere of an educational institution depends on the interaction of such a system, including its rules and regulations and classroom culture, with the people who learn there, and therefore this context must be taken into consideration when studying the behaviour within it. Clearly, the work of these theorists illustrated that any study of behaviour cannot be separated from the environment in which the behaviour occurs.

The development of research instruments in which to better understand learning environments began over 40 years ago. Two independent fields of research were to provide the groundwork for the development of numerous subsequent instruments. First, Herbert Walberg sought to evaluate the learning environment as part of his work on the Harvard Physics Project (Walberg & Anderson, 1968). Two major contributions to the field stemmed from that work. Firstly, Walberg developed the Learning Environment Inventory (LEI), a survey for use in secondary physics classes, since widely used and, secondly, the study demonstrated that students could make sound assessments of their classrooms, and that these insights should be used in learning environment research (Dorman, 2002). At around the same time, Rudolf Moos and Edison Trickett (Trickett & Moos, 1973) developed social climate scales, initially for use in psychiatric hospitals and correctional institutions, but which led to the development of the Classroom Environment Scale (CES) (Fraser, 2012), designed specifically for use in education (see Appendix 7 for a description of these and other learning environment instruments). Moos identified three dimensions of human environments: relationships with the environment, personal development, and system maintenance and system change, which is still the general framework for conceptualising environments used today.

2.6.2 Relationship to Outcomes

In the early 1980s, Fraser and Fisher (1982) highlighted that student perceptions of classroom environments were an important variable responsible for difference in students' outcomes. Since then, the results of many studies have presented persuasive evidence that the quality of the learning environment is a significant factor in student achievement, as well as a range of emotional and social outcomes (Anderman, 2002; Fraser, 2007, 2012; McRobbie & Fraser, 1993; Wolf & Fraser, 2008; Wubbels & Levy, 1993). In fact, investigating associations between students' cognitive and affective outcomes and their perceptions of the learning environment has become the predominant practice in classroom environment research (Fraser, 2012; Goh & Fraser, 1998; McRobbie & Fraser, 1993; Teh & Fraser, 1995).

In addition to other subjects, studies examining the learning environments of mathematics classes have proliferated. Such studies have involved a wide variety of learning situations all over the world, including primary maths classes in Singapore (Goh, Young, & Fraser, 1995); primary mathematics and science classrooms in Qatar (Knight, Parker, Zimmerman, & Ikhlief, 2014); grade five to 10 mathematics students in Bavaria (Frenzel, Pekrun, & Goetz, 2007); secondary mathematics and science students and teachers in Australia and The Netherlands (Wubbels & Levy, 1993); primary pre-service teachers in mathematics methods courses at three universities in the eastern USA (Jong & Hodges, 2015); tertiary-level mathematics classes in the United Arab Emirates (Afari et al., 2012), and tertiary-level science classes in Myanmar (Khine, Fraser, Afari, Oo, & Kyaw, 2018). Other than the tertiary-level mathematics study referred to here (Afari et al, 2012), no other mathematics learning environment studies in higher education institutes have been identified, again, indicating the significance of the current study.

Student achievement has been found in numerous past studies to be influenced by students' perceptions of the classroom environment (Frenzel et al., 2007). For example, a secondary analysis of data from 7000 U.S. middle school students found that the classroom environment was responsible for statistically significant amounts of variance in student achievement scores (Fraser & Kahle, 2007). Haertel, Walberg and Haertel's (1981) meta-analysis of studies involving 17,805 students in four countries highlighted consistent higher achievement in classrooms perceived to have greater cohesiveness, satisfaction, and goal direction, and less disorganization and friction. Chionh and Fraser (2009) also found that more student cohesiveness in classrooms was associated with improved student achievement, and Afari et al, (2012) found that academic efficacy was higher in classes that were perceived as personally relevant.

Relationships with teachers have been found to affect student achievement. According to Fraser (2001, p. 4), "There is no doubt that the teacher is a central figure in the classroom environment. How the teacher behaves in the classroom determines whether students feel comfortable, happy, threatened or motivated". In a study in primary mathematics classes in Singapore, higher cognitive outcomes were related with better teacher leadership, understanding and empathic teachers, and more helpful, friendly classroom environments (Goh & Fraser, 1998). Similarly, Lang, Wong, and Fraser (2005) found that both cognitive and affective gains were made when secondary chemistry students perceived teachers to provide a pleasant, well-structured and task-orientated environment, and the lowest gains were made when students perceived teachers to be aggressive or uncertain. Wubbels (1993) found that students' perceptions of interpersonal teacher behaviour accounted for 70 percent of the variability in student achievement, and the differences in outcomes of teachers presenting different types of behaviours were far greater than differences in outcomes when other teacher differences were considered (e.g., age, teaching experience, curricula deployed).

When the learning environment is considered in relation to affective outcomes, it is often students' attitudes that are measured. Studies have consistently found strong associations between positive classroom learning environments and positive attitudes

(Fraser, 1998, 2012; Martin-Dunlop & Fraser, 2008; McRobbie & Fraser, 1993). Similar findings have been found at the primary (Goh et al., 1995; Peer & Fraser, 2015), secondary (Chionh & Fraser, 2009; Deieso & Fraser, 2018), and tertiary levels (Martin-Dunlop & Fraser, 2008). Similarly with students' achievement, teachers' interpersonal behaviour is associated with students' attitudes, with a high correlation found with teacher support (Chionh & Fraser, 2009; Goh & Fraser, 1998; Lang et al., 2005; Martin-Dunlop & Fraser, 2008; Peer & Fraser, 2015; Wubbels & Levy, 1993). More positive student attitudes have also been linked with more cohesive classes with less friction (Goh et al., 1995), greater task orientation and equity (Chionh & Fraser, 2009), and greater student responsibility and freedom (Lang et al., 2005; Wubbels & Levy, 1993). Martin-Dunlop and Fraser (2008) found that correlations between student attitudes and the learning environment were positive for all learning environment scales in their study with pre-service teachers undertaking a science course, "thus confirming the link between a favourable learning environment and positive student attitudes found in considerable prior research" (p.183).

An important characteristic of any learning environment are the subjective feelings, emotions and attitudes students bring with them into the classroom concerning a particular subject area. As B. A. Taylor and Fraser (2013, pp. 299-300) assert, "While feelings of joy and enjoyment are certainly helpful and welcomed in the classroom, feelings of fear and dread seem to be a part of some classrooms where some subjects, especially mathematics are taught". Of relevance to this study are the research findings that have highlighted the relationship of the mathematics classroom environment to students' achievement (Gilbert et al., 2014; Jong, Pedulla, Reagan, Salomon-Fernandez, & Cochran-Smith, 2010), more positive student attitudes towards mathematics (Goh et al., 1995), mathematics efficacy (Gilbert et al., 2014) and students' enjoyment and interest in mathematics (Dorman, 2002). Specifically, outcomes in mathematics classrooms have been positively correlated with student cohesion (Chionh & Fraser, 2009; Dorman, 2002), teacher expectations (Gilbert et al., 2014); teacher support, task orientation and equity (Chionh & Fraser, 2009) and perceived quality of instruction (Frenzel et al., 2007), student involvement and task orientation (Ogbuehi & Fraser, 2007; Opolot-Okurut, 2010); and negatively correlated with friction within the classroom (Dorman, 2002; Goh et al., 1995).

Several studies have identified the teacher as the most crucial element in a mathematics learning environment (Aldridge et al., 1999; Bekdemir, 2010; Tobias, 1980). Teacher support and expectations have also been linked with students' self-esteem (Chionh & Fraser, 2009), self-efficacy (Fraser, 2012), motivation (Gilbert et al., 2014), confidence (Byrd, 1982), and enjoyment (Afari et al., 2013). Perceived elements of the learning environment have also been associated with anxiety in learning. In particular, perceived punitive teacher behaviour (Frenzel et al., 2007; Helmke, 1983), achievement pressure (Goetz, Pekrun, Hall, & Haag, 2006; Helmke, 1983), and competition within the class (Frenzel et al., 2007) have been positively related to anxiety. However, when students perceived the quality of instruction to be high, anxiety was slightly reduced (Frenzel et al., 2007).

2.6.3 Mathematics Anxiety and the Learning Environment

As discussed in Section 2.1.5, environmental forces are one of three over-arching forces considered to be antecedents to mathematics anxiety. Among other aspects, the influence of teachers (Buckley et al., 2016; Whyte & Anthony, 2012), and the classroom environment (Dossey, 1992; Trujillo & Hadfield, 1999) have been shown to contribute to, or reduce, mathematics anxiety. Research specifically looking at mathematics anxiety in 745 secondary students and the learning environment, found that students were less anxious about the mathematics classroom and mathematics learning when there was more peer interaction and acceptance, and more motivation and time on task (B. A. Taylor & Fraser, 2013). Byrd (1982) found that teacher personality and an uncomfortable classroom atmosphere contributed to making a mathematics learning situation anxiety-provoking. As Byrd (1982, pp. 176-177) stated, "… an individual with a lot of self-doubt and a high need for approval may experience anxiety in the presence of an aloof teacher because approval needs are not met and self-esteem is threatened".

While it appears that the learning environment, including the students' relationship with the teacher, can have a significant effect on mathematics anxiety, there is also evidence that the same can impact self-efficacy in mathematics (see Section 2.3.1.3) and beliefs about mathematics (see Section 2.4.6). Students' mathematics self-efficacy and their perceptions of the learning environment have been found to be positively related (Afari et al., 2013; Fraser, 2012), particularly in relation to teacher expectations (Gilbert et al., 2014). Inadequate mathematics instruction, ineffective teaching practices (Hembree, 1990), and unsympathetic teachers (Cornell, 1999) have all been associated with the way in which the nature of mathematics is perceived. Beswick and Dole (2001) inferred from their study with pre-service teachers during mathematics education classes that emotions play a significant role in changing the beliefs of pre-service teachers and that the quality of relationships that lecturers develop with their students may have the biggest impact.

2.6.4 Summary of Learning Environments

As far back as the 1920s, it was recognised that the environment influences the behaviour within it. The perception of human environments is understood to be highly individualised and, therefore, the context must be taken into consideration when studying behaviour within it. In the late 1960s, the development of instruments to measure perceptions of the classroom environment began and these have since been used in a myriad of studies, although very rarely in the UAE. Such instruments enabled researchers to show that students could make valid judgements about their classrooms and that these judgements could be used as a basis for improvement of the environment. The learning environment of a classroom includes the physical, social, psychological and pedagogical environment and may be created through classroom relationships and instructional practices. Many studies have shown that the classroom environment has been positively associated with student learning and emotional and social outcomes. More specifically, a relationship has been found between the mathematics classroom environment and students' achievement, attitudes towards mathematics, self-efficacy for mathematics, beliefs about mathematics, and enjoyment of the subject. Importantly, aspects of the classroom environment have been shown to contribute to or reduce mathematics anxiety. This means that mathematics anxiety may be reduced by creating a more positive classroom environment, while self-efficacy, achievement and enjoyment are increased, and more sophisticated beliefs developed. Clearly, when research shows the prevalence of mathematics anxiety among pre-service teachers is high (Harper & Daane, 1998; Hembree, 1990; Kelly & Tomhave, 1985; Sloan, 2010), learning environment research that connects a positive perception of the environment to reduced mathematics anxiety and increased efficacy, is important to be included in any study examining mathematics efficacy and anxiety. This study built on past research by examining whether the learning environment influences pre-service teachers' beliefs about mathematics. Given that, to the best of the researchers' knowledge, no studies have been carried out in the UAE to examine pre-services teachers' perceptions of their learning environments and whether this was related to their mathematics anxiety, teaching self-efficacy and beliefs, this study fills an overdue gap.

2.7 Chapter Summary

This chapter has reviewed literature related to pre-services teachers' mathematics anxiety, mathematics teaching anxiety, mathematics teaching self-efficacy, beliefs about the nature of mathematics and perceptions of mathematics learning environments. The purposes of this chapter was to situate this study within the context of existing research, to justify the study's unique research objectives (see Chapter 1), and to inform the research design for this study (see Chapter 3) and interpretation of the findings (see Chapter 5).

The review of literature revealed that research linked to pre-service teachers' mathematics anxiety, mathematics teaching anxiety, mathematics teaching self-efficacy, beliefs about the nature of mathematics, and their perceptions of their learning environment has not been carried out in the UAE, nor in any of the surrounding Gulf Cooperation Council (GCC) countries. Further, such research has not been conducted within the context of large-scale educational reform. This study aimed to contribute to this gap in the literature by describing Emirati pre-service teachers' mathematics anxiety, mathematics teaching anxiety, mathematics teaching self-efficacy, beliefs about the nature of mathematics, and their perceptions of their learning environment (Research Objective 2), and examining relationships of the variables to teaching efficacy and perceptions of the learning environment (Research Objectives 3 and 5 respectively). This study also investigated whether pre-service teachers in different year levels differed in terms of the variables (Research Objective 4). An additional contribution was made through the development and validation of instruments to measure the variables of this study (Research Objective 1)

The next chapter, Chapter 3, describes the research design for this study, as informed by the literature review in the current chapter.

Chapter 3

RESEARCH METHODS

3.1 Introduction

Whereas the last chapter reviewed literature pertinent to the present study, this chapter describes the methods used. The chapter begins with a summary of the research objectives that were introduced in chapter 1 (Section 3.2). Next, an overview of the research design (Section 3.3), and details regarding the participants involved in the study (Section 3.4) are shared. The instruments chosen and developed for use in this study are then described (Section 3.5). The pilot study, conducted prior to the main administration, is explained (see Section 3.6); as well as the data analyses conducted in order to investigate each research objective (see Section 3.7). The ethical considerations made throughout the study and how these were addressed, are then reported (Section 3.8). Finally, Section 3.9 provides a summary of the chapter.

3.2 Research Objectives

The overarching aim of this study was to examine whether Emirati pre-service teachers' self-efficacy, in regards to teaching mathematics, and their perception of their college mathematics learning environments, were related to their mathematics anxiety, mathematics teaching anxiety, and their beliefs about the nature of mathematics. Consequently, the specific research objectives for the study (as introduced in Chapter 1) were:

1. To modify and validate scales to assess:
    a. pre-service teachers' anxiety towards mathematics in general;
    b. pre-service teachers' anxiety towards teaching mathematics;
    c. pre-service teachers' self-efficacy towards teaching the 'new mathematics'
    d. pre-service teachers' beliefs about the nature of mathematics;
    e. pre-service teachers' perceptions of their mathematics learning environments.

2. To describe Emirati pre-service teachers':
    a. mathematics anxiety;
    b. mathematics teaching anxiety;
    c. self-efficacy for teaching mathematics;
    d. beliefs about mathematics; and
    e. perceptions of the learning environment
3. To examine whether relationships exist between pre-service teachers self-efficacy towards teaching the new mathematics and their:
    a. anxiety towards mathematics in general;
    b. anxiety towards teaching mathematics; and
    c. beliefs about the nature of mathematics.
4. To investigate whether pre-service teachers enrolled in different year levels differ in terms of their:
    a. anxiety towards mathematics in general;
    b. anxiety towards teaching mathematics;
    c. beliefs about the nature of mathematics; and
    d. self-efficacy for teaching mathematics.
5. To examine whether the learning environment perceived by pre-service teachers is related to their:
    a. anxiety towards mathematics in general;
    b. anxiety towards teaching mathematics;
    c. beliefs about the nature of mathematics; and
    d. self-efficacy for teaching mathematics.

The next Section (Section 3.3) describes how the study was designed in order to address these research objectives.

3.3 Research Design

This study utilised quantitative data to investigate and describe the current trends in relation to Emirati pre-service teachers' self-efficacy for teaching the 'new' mathematics under the education reform process in Abu Dhabi. A cross-sectional survey design was used in order to collect data about the attitudes, feelings and beliefs of pre-service teachers were sought in relation to learning, doing, and ultimately teaching, mathematics to primary school children amidst a major reform (as outlined in Chapter 1). A cross-sectional design was considered to be an appropriate design to examine the variation in the attitudes, feelings and beliefs of pre-service teachers, and also in terms of explaining the relationship between variables. Given that this study sought to explain the relationships between a range of variables (see Section 3.2 for the research objectives), it was an example of explanatory correlational research (Creswell, 2012; Price & Jhangiani, 2013). As such, this research collected data at a point in time, obtaining data for each variable from each participant and, using correlational analysis to examine the relationships between the variables.

Given that the research sought to examine the attitudes, feelings and beliefs of pre-service teachers to address the various research objects, it was appropriate to collect data at the individual level (see Section 3.3). The surveys administered in this study (refer to Section 3.5 for a description of surveys) used multiple-indicator measures throughout, identified as scales. The advantages of such an approach helped to avoid any potential problems occurring from reliance on a single indicator that could be misunderstood by participants, and permitted access to a wider range of aspects of the concepts studied, allowing finer distinctions to be made (Bryman, 2012). All of the concepts that were examined in the current study (teaching self-efficacy, mathematics anxiety, mathematics teaching anxiety, beliefs about the nature of mathematics, and perceptions of the learning environment) were considered to be multidimensional or comprised of different dimensions (based on relevant theory and research, see Chapter 2).

This section has provided a broad overview of the design of the study. Given this, the next Section (Section 3.4) describes the sample for the study and outlines background information pertinent to the participants.

3.4 Sample

This section describes the sample and its selection used for the present study, with respect to: the selection of institutions (Section 3.4.1); and the selection of students (Section 3.4.2).

3.4.1 Selection of Institutes

Two higher education institutes in Abu Dhabi, United Arab Emirates, were purposefully selected as they represent the majority of Education graduates in Abu Dhabi, and are the only graduates trained specifically to teach English, mathematics and science, through the medium of English, for Abu Dhabi's public primary schools. One Higher Education Institute was established in direct response to the reform project in the emirate and is a dedicated teachers' college. The other higher education institute is the Abu Dhabi campus for one of the largest higher education institutes in the United Arab Emirates (see Chapter 1). Education is one of several programmes offered by this institute, and is offered in a number of campuses nationwide. Although these institutes differ in structure and approach, both offer programmes tailored to meet the needs of the educational reform, and students graduate with a Bachelor of Education, therefore both were included with the intention of having a representative sample and making the results more generalizable. The researcher was a faculty member at one of the higher educational institutes and a former faculty member of the other, allowing access to their students, thus also making the sample one of convenience (Bryman, 2012; Creswell, 2012).

It is important to note that, at the time that this study was undertaken, the mathematics course requirements differed between the two institutions. At one higher educational institute, students completed a mathematics content course in each of the first three semesters, and then completed mathematics methodology courses in each of the subsequent three semesters. In the seventh semester, at this institution, mathematics was drawn together with science and English in an integrated methods course. As this institute had a student intake only once per academic year, and the data were collected during the second semester of the year, all students at this institute, had at least one full semester of experience with a mathematics class at the institute.

In contrast, at the other institute, students were required to take one mathematics content course, within the first 2 years of the programme, which was conducted by the General Studies Department at the institute. Students at this institute did not take any mathematics courses under the umbrella of the Education Department until the third year of their studies, at which time they took a mathematics content and a mathematics methodology course simultaneously – the only mathematics courses that was provided in this programme. This institute had an intake of students each semester, meaning that approximately half of the participants at this institute had not taken the Education Department mathematics courses when the study was carried out, and some had not yet completed the required General Studies mathematics course. In these cases, students were directed to consider their foundations mathematics courses (a preparatory programme), conducted at the same institute before joining the education programme, when responding to surveys (see Section 3.5.5).

Effectively, the difference between the two institutions meant that Year 4 students enrolled at the first institute had twice as many mathematics classroom experiences to draw from than the other institute students, when completing the surveys. The differences between two institutes were substantial (and, therefore, not controlled). Also, pre-service teachers in these institutions completed teaching placements in schools once or twice a year, allowing them opportunities to observe and often practice the 'new' mathematics first hand.

3.4.2 Selection of Students

The two institutes provided a total target sample of approximately 550 Emirati pre-service teachers, predominantly female. This sample included approximately 200 first year students, 170 second year students, and 100 and 80 third and fourth year students, respectively.

Prior to the main administration of the surveys, one class was selected to participate in a pilot study (see Section 3.6 for details on the pilot study). These students were chosen predominantly due to convenience; as they had a timetabled class with the researcher who was able to plan the class around the survey. These students were also approaching the half way point in their four-year degree, and had completed four teaching placements in local schools, therefore it was assumed they were developing a fuller picture of what it meant to be a teacher in Abu Dhabi's primary schools, and what is required to teach mathematics. The sample consisted of 14 students, of which nine completed all five surveys. All of these students were female, but constitute a varied sample in terms of ability (based on grade point average).

For the main survey, all students attending the two institutes were approached and invited to partake in the study. Data were collected from 184 participants from within the total population. Of these, the data collected from at least 157 were complete and useable across all of the questionnaire; approximately 21% were in their first year of the programme, 44% were in their second year and 28% and 7% in their third and fourth years respectively. Over two-thirds (68%) of the participants were between 18 and 22 years of age, 23% were aged between 23 and 27 years bracket and 9% were aged 28 years or older. Only eight of the 157 participants were male, which is representative of the total pool (total male students, n = 16, or 4%, at higher education institute 1, the only bachelor of education programme in the UAE to admit male students). Of the 184 total participants, 84 (46%) were enrolled at one of the higher education institutes and 100 participants (54%) were enrolled at the other.

The surveys were administered through a mix of face-to-face and online administration. Wherever possible, the researcher visited classes personally, at times arranged with their lecturers, to introduce the online survey, which was responded to by participants during class time. Students who did not consent or were absent during their class visit were not included in the sample. This method of administration helped to ensure consistency in the collection of data and allowed a short introduction to the research as well as clarification, if required, during the completion of the online survey. To increase the sample size, the researcher visited another group of students to ask for participation and to describe the research. However, for these students (n=9) the survey was completed during their free time. Where students were unavailable to be visited personally, they received the link to the survey via email.

3.5 Instruments Used

This section details the instruments used to collect data for the study from the participants described in the previous section. Five surveys were used to collect the data in this study, to assess: the anxiety that Emirati pre-service teachers have in regards to mathematics; their anxiety towards teaching mathematics; their self-efficacy for teaching mathematics; their beliefs about mathematics; and their perceptions of their mathematics classroom environments during their teacher training. An extensive review of literature, described in Chapter 2, was conducted to ensure that pre-existing instruments were suitable, and had been shown to be reliable and valid in past studies. Where a single instrument could not be found to meet the requirements of the present study, several existing instruments were examined, and scales and/or items were drawn together to form new surveys (as described below).

All five of the surveys utilised a five-point response scale, however the ratings used in the response scales differed between the surveys; the response formats for each survey are described below. Because of the variance in response formats, and to improve validity, the questions for each of the five surveys were kept in blocks, rather than being presented cyclically. This also allowed the use of meaningful headings that provided contextual cues for participants. The individual surveys were presented together and completed by each participant in a single sitting, therefore, before each section, participants were cued into the type of rating scale being used.

In the following subsections, the five surveys are described: the Anxiety for Mathematics Survey (AMS; Section 3.5.1); the Teaching Anxiety in Mathematics Scale (TAMS; Section 3.5.2); the modified Self-efficacy for Teaching Mathematics Instrument (M-SETMI; Section 3.5.3); the Beliefs about Mathematics Survey (BAMS; Section 3.5.4); and the What Is Happening in This Class? (WIHIC; Section 3.5.5) survey.

3.5.1 Anxiety for Mathematics Survey (AMS)

The Anxiety for Mathematics (AMS) survey was developed by the researcher to assess pre-service teachers' anxiety towards mathematics in general. The items and scales for the survey were drawn from four existing mathematics anxiety surveys, and a fifth was developed for the purpose of this study. This section describes the steps take to develop the survey. The organisation of the existing items into four scales is then described, and the development of a fifth scale as well as supplementary items for each of the scales, are presented.

Four existing instruments were identified as pertinent and used to develop the new Anxiety for Mathematics Survey, these being: Mathematics Anxiety Rating Scale; Abbreviated Mathematics Anxiety Rating Scale; Revised Mathematics Anxiety Rating

Scale; and the Revised Mathematics Anxiety Survey. The first of these surveys, the Mathematics Anxiety Rating Scale (F. C. Richardson & Suinn, 1972), has been extensively used (see for example, Bessant, 1995; Kelly & Tomhave, 1985; Plake & Parker, 1982; Rounds & Hendel, 1980), which has led to the development of the Abbreviated Mathematics Anxiety Rating Scale (A-MARS, Alexander & Martray, 1989) and the Revised Mathematics Anxiety Rating Scale (R-MARS, Suinn & Winston, 2003), as well as other shortened versions (Plake & Parker, 1982; Rounds & Hendel, 1980). In 2006, Bursal and Paznokas developed items from the Mathematics Anxiety Survey to create the Revised Mathematics Anxiety Survey (R-MANX), which was also considered for the current study. These surveys have been tried and tested for validity, reliability and internal consistency by the respective authors (see related articles for details of this validation). In the development of the new study, 12 items of the original MARS instrument were selected and a further eight items were rewritten for language and context. For example, an original item from the MARS (F. C. Richardson & Suinn, 1972) was modified from 'Determining the amount of change you should get back from a purchase involving several items' to 'Working out how much change you should get back after buying several items'. In addition to the 12 MARS items, three items from the R-MARS items were chosen and used without change. In addition, one item from the A-MARS and five items from the R-MANX, were adapted for use in the new survey. For example, an original item from the R-MANX was modified from 'I am afraid of presenting the problems to the teacher which I can solve' to 'I show the teacher my completed mathematics work'.

These 29 existing or modified items from the MARS, A-MARS, R-MARS and R-MANX were organised into four scales, namely: Anxiety caused by Mathematics Learning; Anxiety caused by Mathematics Evaluation; Anxiety caused by Numerical Tasks; and Anxiety caused by Mathematics in Real-life Situations. Table 3.1 displays the origin of existing items.

Table 3.1 Origin of AMS Items

Original Instrument	AMS items – To assess the extent to which … Anxiety is caused by Mathematics Learning	Anxiety is caused by Mathematics Evaluation	Anxiety is caused by Numerical Tasks	Anxiety is caused by Mathematics in Real-life Situations
Mathematics Anxiety Rating Scale	Listening to another student explain a mathematics formula. E.g. “To find the area of a triangle, you multiply the base by the height and divide by 2” Walking into a mathematics class Sitting in a mathematics class and waiting for the instructor to arrive Raising your hand in a mathematics class to ask a question Realizing that you have to take a certain number of mathematics classes to fulfil the requirements in your major Listening to a lecture in a mathematics class	Taking an examination (quiz) in a mathematics course Taking an examination (final) in a mathematics course Thinking about a mathematics test you have in one week Thinking about a mathematics test you have in one day Thinking about a mathematics test you have in one hour Waiting to get mathematics test results back in which you expect to do well Waiting to get mathematics test results back in which you expect to do badly Being given a "pop" quiz in a math class	Having someone watch you as you total up a column of figures Dividing a five digit number by a two digit number in private with pencil and paper Adding up 976 + 777 on paper Being given a set of addition problems to solve	Working out how much change you should get back after buying several items Working out how much spending money you have after paying bills
Revised Mathematics Anxiety Rating Scale			Being given a set of division problems to solve Being given a set of subtraction problems to solve Being given a set of multiplication problems to solve	
Abbreviated Mathematics Anxiety Rating Scale	Watching a teacher demonstrate an algebraic equation on the blackboard. E.g. $x^2 + (12 – 8) = 53$ (What is the value of x?)			
Revised Mathematics Anxiety Survey	When the teacher pulls our class names out of a hat to choose someone to answer a question in mathematics class When the teacher pulls my name out of a hat to choose someone to answer a question in mathematics class	Showing the teacher my completed mathematics work	Being asked to help a Grade 5 student with their mathematics homework Being asked to help a Grade 2 student with their mathematics homework	

Finally, a fifth scale, Anxiety caused by Non-mathematics Situations, was developed for the purpose of the present study to allow for the inclusion of items that reflect non-mathematics content through analogous situations, such as “Being given a ‘pop’ quiz in an Arabic class”, “Waiting to get a science test returned in which you expected to do poorly”. Such items aimed to identify a mathematics specific anxiety as opposed to general anxiety. While the researcher could not find any examples of mathematics anxiety instruments deploying such a scale, it has been used in science anxiety scales (Güzeller & Doğru, 2012; Mallow, 2006; Udo, Ramsey, & Mallow, 2004), and has recently been used in a science anxiety study with pre-service teachers in Abu Dhabi (Dickson et al., 2017).

To ensure that each scale had equal representation (10 items in each scale), an additional item was developed for each of three scales: Anxiety caused by Mathematics Learning, Anxiety caused by Mathematics Evaluation, and Anxiety caused by Numerical Tasks scales. A total of eight new items were developed for the Anxiety caused by Mathematics in Real-life Situations scale, and all 10 items were developed for the Anxiety caused by Non-mathematics Situations. Table 3.2 displays the scales and sample items.

Table 3.2 Description and Sample Item for Each Anxiety for Mathematics Survey (AMS) Scale

Scale	Purpose	Sample item
Anxiety caused by mathematics learning	To assess the extent to which anxiety is caused by learning mathematics	I feel anxious when walking into a mathematics class.
Anxiety caused by mathematics evaluation	To assess the extent to which anxiety is caused by being evaluated in mathematics	I feel anxious when I think about a mathematics test that I have in one hour.
Anxiety caused by numerical tasks	To assess the extent to which anxiety is caused by performing numerical tasks	I feel anxious when someone watches me add up a list of numbers.
Anxiety caused by mathematics in real-life situations	To assess the extent to which anxiety is caused by undertaking mathematics in real life situations	I feel anxious when I would feel anxious if I needed to - Work out how much something will cost me when there is a ‘25% off’ sale.
Anxiety caused by non-mathematics situations	To assess the extent to which anxiety is caused by analogous situations	I feel anxious when thinking about an upcoming Arabic test 5 minutes before.

Items of the newly developed survey were responded to using a five-point frequency response format which allowed participants to rate their anxiety (‘*how anxious you have felt in the last year’)*; not at all anxious, a little anxious, somewhat anxious, anxious, and very anxious. The final version of the AMS included five scales, with 10 items in each. A copy of the survey as used in this study can be found in Appendix 2.

3.5.2 Teaching Anxiety in Mathematics Survey (TAMS)

The second survey, the Teaching Anxiety in Mathematics (TAMS) survey, used an existing instrument as a starting point for its development. This section describes the selection of the instrument, the three scales utilised, the modification and development of items, and the response format used.

The Teaching Anxiety in Mathematics Scale (TAMS) drew on the work of Peker (2006) who developed the Mathematics Teaching Anxiety Scale (MATAS). The MATAS has been used several times with pre-service teachers over the past decade (see for example, Ertekin et al., 2010; Peker, 2009b, 2016; Ural, 2015), and was tested for reliability (reliability coefficient is 0.91, see related articles for further details). For the purpose of this research, three of the four scales developed for the MATAS (Content Knowledge, Teaching Mathematics, and Methodological Knowledge) were used as a guide for developing the new TAMS instrument, see Table 3.3 for scale names. Given that only one item for each MATAS scale has been published, it was necessary to develop new items for each scale. Further, the available item for each scale also required modification to ensure that they were contextually relevant. For example, one of the original items (Peker, 2006); ‘I got anxious when it comes to the point of teaching some mathematical topics’, was modified to; ‘I get anxious when I teach measurement and data topics’ for the Anxiety caused by Content Knowledge scale. Three other similar items in this scale were developed by the researcher to reflect each of the mathematics strands used in the ADEC New School Model Curriculum. In total, twenty-four items were developed by the researcher: nine items for the Anxiety caused by Content Knowledge scale; seven items for the Anxiety caused by Teaching Mathematics scales; and eight items for the Anxiety caused by Methodological Knowledge scale. This provided a total of 27 items across the three scales. Table 3.3 displays the scale name, purpose of each scale and a sample item for each scale.

Table 3.3 Description and Sample Item for Each scale of the Teaching Anxiety in Mathematics Scale (TAMS)

Scale	Purpose	Sample item
Anxiety caused by Content Knowledge	To assess the extent to which anxiety is caused by content knowledge	I feel nervous that I will make a mistake in front of my students.
Anxiety caused by Teaching Mathematics	To assess the extent to which anxiety is caused by attitude towards teaching mathematics	I look forward to teaching mathematics lessons.
Anxiety caused by Methodological Knowledge	To assess the extent to which anxiety is caused by methodological knowledge	I feel anxious when planning mathematics lessons.

The TAMS was responded to using a five-point Likert Scale to rate the degree of agreement with each item (strongly disagree, disagree, neither agree nor disagree, agree, strongly agree). A copy of the TAMS can be found in Appendix 3.

3.5.3 Modified Self-efficacy for Teaching Mathematics Instrument (M-SETMI)

The Self-efficacy for Teaching Mathematics Instrument (SETMI) was chosen as the most appropriate tool to assess mathematics teaching self-efficacy. It was originally developed by McGee (2012) and has since been further tested and refined by McGee and Wang (2014). In this section, the modification to the original scales and items, the development of new items, and the response format are explained.

The SETMI development was largely guided by the Teacher’s Sense of Efficacy Scale and uses the same theoretical framework: Bandura’s (1977) Social Cognitive Theory. While the TSES is still the most widely accepted measure of general teaching self-efficacy worldwide (Duffin et al., 2012; McGee, 2012; Poulou, 2007), the SETMI aimed to be content specific and grade level specific, i.e. self-efficacy for teaching mathematics at a primary school level. The SETMI consists of two scales; ‘Pedagogy in Mathematics’ and ‘Teaching Mathematics Content’.

It has been found that the SETMI is a valid and reliable measure of two aspects of self-efficacy: ‘Pedagogy in Mathematics’ and ‘Teaching Mathematics Content’. However, Tschannen-Moran and Woolfolk-Hoy (2007) found that the factor structure often is less distinct for pre-service teachers. Therefore, for the current study, the seven SETMI items for ‘Pedagogy in Mathematics’ were split into two new scales: ‘Efficacy for Teaching Mathematics’ and ‘Efficacy for Making a Difference’. This aligns with the two main constructs of Bandura’s (1977) Social Cognitive Theory: efficacy expectations and outcome expectations (see Section 2.4.1.1). Three new items were added by the researcher to bring the total of items in each of these scales to five. In addition, a fourth scale, ‘Self-Confidence’ consisting of eight new items, was added to assess how the participants feel about teaching mathematics (as opposed to what they believe they can do). See Table 3.4 for the scale names, purpose of each scale and a sample items.

Table 3.4 Description and Sample Item for Each Modified Self-efficacy for Teaching Mathematics Instrument (M-SETMI) scale

Scale	Purpose	Sample item
Efficacy for teaching mathematics	To assess the extent to which pre-service teachers believe they can teach mathematics (efficacy expectations)	I can provide effective scaffolding for students learning mathematics.
Efficacy for making a difference	To assess the extent to which pre-service teachers believe they can make a difference (outcome expectations)	I can help students to love mathematics.
Efficacy for teaching mathematics content	To assess the extent to which pre-service teachers believe they can teach mathematics content	I can teach students to change a fraction to a decimal.
Self-confidence	To assess the extent of pre-service teachers self confidence in teaching mathematics	I am confident that I can answer most mathematics questions asked by my students.

Items in the ‘Efficacy for Teaching Mathematics Content’ scale, were tailored to align with the terminology and content of ADEC’s Cycle One (primary) mathematics curriculum. For example, the term ‘decomposing’ was changed to ‘partitioning’. Given that converting between measurement units is not included in the Cycle 1 Mathematics curriculum, items related to this content were removed. Additional items, related to relevant content, were added to replace the removed items. This content was taken directly from the ADEC learning outcomes, and modified for simple language. A further two items were added using the same process to ensure an appropriate coverage of the four ADEC mathematics strands and of the five grade levels in the primary curriculum, making a total of 17 items in this scale.

The language used in the SETMI was modified for use in this study. First, to ensure that the wording of each statement could elicit a judgement of perceived ability (as recommended by Bandura, 1997), the wording 'I can' was used for the first three scales (Efficacy for teaching mathematics, Efficacy for making a difference, Efficacy for teaching mathematics content), replacing 'To what extent can you'.. Other wording from the original SETMI was also modified for ease of understanding. For example, "How well can you implement alternative teaching strategies for mathematics in your classroom?' was changed to 'I can implement different teaching strategies for mathematics in my classroom'. Further modifications were made to ensure that all items were positive to reduce confusion among participants. For example "I can implement different teaching strategies for mathematics in my classroom", "I can help students to love mathematics".

The response format for the modified Self-efficacy for Teaching Mathematics Instrument (M-SETMI) was changed from the original survey to fit with the "I can' statements used in individual items. Items were responded to using a five point Likert-response format to allow participants to rate their degree of agreement with an item: strongly disagree, disagree, neither agree nor disagree, agree, strongly agree. This differs from the original SETMI instrument, which was rated on a five-point scale that ranged from not at all to a great deal. The final version of the M-SETMI utilised for this study includes 35 items across four scales. A copy of the M-SETMI can be found in Appendix 4.

3.5.4 Beliefs about Mathematics Survey (BAMS)

The fourth survey used in the study was developed to assess pre-service teachers' beliefs about mathematics. This section describes the development of the Beliefs about Mathematics Survey (BAMS), which involved the adoption of items from four existing mathematics beliefs surveys. The section goes on to discuss the organisation of those items into three scales. Finally, the response format for the survey is presented.

Research has found that a traditional perspective of mathematics held by students is that mathematics is a collection of unrelated facts and formulae, that is an exact body of knowledge over which they have no control, and that doing mathematics involves memorising and following rules (Lampert, 1990; Schoenfeld, 2016). If one believes mathematical knowledge is an assortment of isolated facts, and therefore acquiring a new piece of information has little effect on the development of another, it is likely that teachers will not make explicit the connections that exist between concepts and skills. Beliefs have also been repeatedly found to be related to both mathematics anxiety and teaching self-efficacy (see for example, Haciomeroglu, 2013)

As a first step, the development of the BAMS involved a review of literature regarding beliefs about mathematics (see Chapter 2, Section 2.5 for more information). In this process, several instruments were reviewed, of which four were considered to be relevant to the measurement of the beliefs of the participants in the current study: Mathematics and Mathematical Educational Values Scale (Durmus & Bicak, 2006); Maths Beliefs Survey Instrument (Austin, Wadlington, & Bitner, 1992); Beliefs about Mathematics Survey (Aksu, Demir, & Sumer, 2002); Conceptions of Mathematics Inventory-Revised (Briley, Thompson, & Iran-Nejad, 2009). Six items each from the Mathematics and Mathematical Educational Values Scale (Durmus & Bicak, 2006) and the Maths Beliefs Survey Instrument (Austin et al., 1992) were utilised. Five items from the Beliefs about Mathematics Survey (Aksu et al., 2002); and three items from the Conceptions of Mathematics Inventory-Revised (Briley et al., 2009) were utilized. One additional item (‘Mathematics is a collection of facts and rules’) was added to the first scale (Beliefs about the Nature of Mathematics) by the researcher, based on relevant literature and previous experiences when teaching mathematics courses to pre-service teachers. Table 3.5 provides a summary of the purpose of each scale and the origin of the items included in the BAMS instrument.

Each of the items were modified for language and context and were organised into three scales: Beliefs about the Nature of Mathematics; Beliefs about the Usefulness of Mathematics; and Beliefs about Learning and Doing Mathematics (Aksu et al., 2002). The final version of the Beliefs about the Nature of Mathematics instrument was comprised of three scales and 21 items. Table 3.6 provides for each scale, a brief description and sample item.

Table 3.5 Origin of BAMS Items

	BAMS items		
Original Instrument	To assess the beliefs about the nature of mathematics	To assess the beliefs about the usefulness of mathematics	To assess the beliefs about doing mathematics
Mathematics and Mathematical Educational Values Scale	Mathematics can be understood only by people who are clever New subjects in mathematics cannot be learned without knowing previous subjects	Mathematics has a vital role on the development of civilizations Learning problem solving in mathematics prepares people to deal with problems in their daily lives	In mathematics teaching, activities should be designed in a way that students are actively involved People learn not only from their correct solutions but also learn from their mistakes
Maths Beliefs Survey Instrument	There is a best way to solve a mathematics problem Mathematics is not creative Mathematics requires logic, not intuition		Some people have a mathematics mind and some don't Mathematics requires a good memory Men are better than women at mathematics
Beliefs about Mathematics Survey	Mathematics is numbers	Mathematics is a universal language Knowing mathematics is important for all professions Maths makes everyday life easier	To be good at maths, you need a good memory
Conceptions of Mathematics Inventory-Revised	Mathematics consists of mostly unrelated topics	I use mathematics in many ways in my life	Knowing why an answer is correct in mathematics is as important as getting a correct answer

Table 3.6 Description and Sample Item for Each Beliefs about Mathematics Survey (BAMS) scale

Scale	Purpose	Sample item
Beliefs about the nature of mathematics	To assess the beliefs about the nature of mathematics	There is a best way to solve a mathematics problem.
Beliefs about the usefulness of mathematics	To assess the beliefs about the usefulness of mathematics	Mathematics is a universal language.
Beliefs about learning and doing mathematics	To assess the beliefs about learning and doing mathematics (and who they believe might be more successful at mathematics)	Some people have a mathematics mind and some don't.

The items of the Beliefs about Mathematics Survey (BAMS), were responded to using a Likert Scale on which respondents could rate their degree of agreement using the responses of strongly disagree, disagree, neither agree nor disagree, agree, strongly agree. A copy of the BAMS can be found in Appendix 5.

3.5.5 What is Happening in this Class? (WIHIC) Survey

The fifth instrument was a modified version of the What is Happening in this Class (WIHIC) survey was selected for use in this study to assess Emirati pre-service teachers' perceptions of their mathematics classroom environments. While there many learning environment surveys available (see Appendix 7), the WIHIC was deemed the most appropriate. The original WIHIC instrument was originally developed by Fraser et al. (1996) to bring parsimony to the learning environments field by combining modified versions of the most significant scales from well-established surveys with new dimensions of contemporary relevance (Aldridge et al., 1999). This 'best of all' arrangement was the main reason for selecting this tool. The original version of the WIHIC, containing 90 items across nine scales, was later refined by Aldridge et al. (Aldridge et al., 1999; Fraser et al., 1996), and the final version emerged, with seven scales and 56 items. In this section, the WIHIC and the modifications made for the study reported in this thesis, are described.

The WIHIC was, more recently, been modified for use in the United Arab Emirates by Afari et al. (2013), and it's successful use in context was another reason for inclusion in the current study. This version utilised five of the seven original WIHIC scales: Student Cohesiveness; Teacher Support; Involvement; Cooperation; and Equity. The original scales of Task Orientation and Investigation were removed as they were not considered relevant to the study conducted by Afari et al (2013). Afari et al (2013) added the Personal Relevance scale from the Constructivist Learning Environment Survey (CLES, P. C. Taylor, Fraser, & Fisher, 1997). As the mathematics taught in the classrooms of Emirati pre-service teachers should be linked directly to their future work as teachers in ADEC schools, this scale was also deemed appropriate for the current study. Therefore, a total of six scales, were included for this study. Table 3.7 provides a brief description and sample item for each of the six scales.

To ensure its suitability for the sample, the modified WIHIC was revised for language and context of the UAE setting. Six of the eight items for the Student Cohesiveness scale were reworded to fit with the stem, 'In my college mathematics classes…', which was added for participant clarification based on feedback from the pilot survey (see Section 3.6). The the intent was to have the pre-service teachers think of their collective experience in both mathematics content and mathematics pedagogical courses at their respective higher education institutes, as opposed to other classes. The Cooperation scale was changed to Collaboration (perceived to be a better term) for the current study, and items for the scale modified to match. The rest of the survey remained consistent with the Afari et al (2013) version, which involved six scales with eight items in each.

Table 3.7 Description and Sample Item for Each What is Happening in this Class? (WIHIC) scale

Scale	Purpose	Sample item
Student Cohesiveness	To assess the extent to which students are friendly and supportive of each other	I feel supported by students in this class.
Teacher Support	To assess the extent to which the teacher helps, befriends and is interested in students	The teacher takes an interest in my progress.
Involvement	To assess the extent to which students have attentive interest, participate in discussions and enjoy the class	I give my opinions during class discussions.
Collaborate	To assess the extent to which students collaborate with each other during activities	I work with other students on projects in this class.
Equity	To assess the extent to which the teacher treats students equally, including distributing praise, questions and opportunities to be included in discussions	I get the same amount of help from the teacher as other students do.
Personal Relevance	To assess the extent to which there is a link between what is taught and students' out of school experiences	I relate what I learn in this class to life outside college.

The items of the What is Happening in this Class (WIHIC) were responded to using a five-point frequency response scale of almost never, seldom, sometimes, often, almost always. All items of the WIHIC were positive, for example "I work well with other class members" and "I get the same opportunity to answer questions as other students". A copy of the WIHIC, as used in this study, can be found in Appendix 6.

This section has detailed the five surveys used in this study and their development or modification. The next section (Section 3.6) describes the pilot survey that took place prior to data collection.

3.6 Pilot Study

Given that four of the five surveys (described above) had not been used previously in the UAE, and the fifth had not been used with Emirati pre-service teachers, it was important to pilot them (as recommended by Bryman, 2012; Creswell, 2012). This section describes the pilot that was undertaken.

As described in Section 3.5, the scales and individual items included in each of the surveys were examined by the researcher to ensure that the wording and content was suitable for the UAE context. At this stage, modifications to the wording of individual items was made. Although all efforts were made to ensure wording was simple and clear, it was necessary to confirm that the targeted participants would be able to understand the language in the surveys and to be able to complete them independently. The pilot study was used to examine:

a. the participants' interpretation of the items and whether these were similar to the researcher's;
b. the ease of use, including the clarity of instructions and the functionality of the surveys as a whole (Bryman, 2012); and
c. the time taken to complete the surveys.

The pilot study involved the simultaneous administration of all five surveys to one class of second year students (the sample for which is described in Section 3.4.2). The participants were informed that their answers would be anonymous and would not be included in the study. The sample consisted of 14 students, of which nine completed all five surveys. First, the pilot study was used to examine the face validity of the surveys to ensure that the pre-service teachers had interpreted the items as they were intended (as recommended by Cohen, Manion, & Morrison, 2011; Trochim & Donnelly, 2008). Munby (1997) argues that the best way to confirm face validity requires seeking the opinions of a representative sub-sample about their comprehension of the items. Therefore, the participants were asked to 'find flaws and make comments' about the surveys as they responded to them. This was followed by an informal focus group, held immediately after they had responded to the surveys, during which they were asked to give feedback about the survey.

The interpretation of items was examined through spot-checks on random items during the focus group discussion. For example, the researcher asked the participants; 'what do you think (item) is asking you?', to ensure the correct understanding. Participants were also invited to identify any items they felt unsure about. Through this process, the term 'pop-quiz' was discussed as one participant felt somewhat unsure, although she had correctly guessed the meaning. The other participants felt sure their peers would know this term, and on their recommendation it was retained.

During the survey administration and the subsequent focus group discussion, students highlighted some areas for adjustment, including adding meaningful headings and stems to scales/items for clarification. For example, the item stem "In my college mathematics classes…", was added to all scales in the classroom environment survey (WIHIC) for participant clarification based on feedback, to cue participants to consider their college mathematics classes specifically when responding to the items. 'Over the past year,' was added to precede 'I have felt anxious when' in the AMS survey, to encourage participants to think about their recent experiences. This was due to some pilot study participants relating anecdotes of high school mathematics experiences during the focus group discussion. The participants also queried some of the terms used in the instruments, which resulted in minor changes for clarity, such as 'Someone watches me total up a column of figures' was modified to 'Someone watches me add up a list of numbers'.

The pilot study also aimed to determine the ease of use of the surveys. This included how easily the on-line form could be navigated and the workability of the three different response formats. Pilot participants reported no problems accessing the on-line questionnaire through the emailed link, nor navigating through the five surveys. During the administration, participants identified an error in the online survey, where the response 'Anxious' had been recorded twice, i.e. for response 4 and 5 on the Likert scale, instead of ‘Anxious’ and ‘Very Anxious’, which was consequently corrected. No other issues with the response formats were noted.

Finally, the pilot study was used to ascertain how much time the five surveys (plus demographic information) would take to complete in a single sitting. The response time to complete the online form (demographics and five survey instruments) was between 30 and 39 minutes. This included brief stoppages to clarify the issues identified above. Due to the stoppages, it was presumed the average response time for the surveys would be closer to 30 minutes.

This section discussed the pilot study that took place prior to the main administration. The next section (Section 3.7) details the data analyses that were used to address the research objectives.

3.7 Data Analyses

As described earlier, the data were collected from Emirati pre-service teachers (*n*=184) by means of five surveys. In the following sections (Sections 3.7.1-3.7.4), information about the data analyses for each of the research objectives (see Section 3.2) is provided.

3.7.1 Validity of the Surveys

Given that the five surveys used in the present study were modified for use or developed specifically for this study, it was important to provide evidence to support their reliability and validity when used with pre-service teachers in the UAE context. To do this, the data collected from the pre-service teachers from two higher educational institutes were used to examine the factor structure, scale internal consistency reliability, and the discriminant validity. For all analyses, only data from valid cases were included. Valid cases for each survey instrument decreased from the first survey that was presented, AMS (*n*=176), to the last survey, WIHIC (*n*=157), as participants asserted their right to opt out at any time (see Section 3.8.1 for participants' information and rights).

To examine the factor structure of the five surveys, principal axis factor analysis with oblique rotation was used. This analysis was performed separately for each instrument and sought to reduce the number of variables with which the researcher need to deal by establishing whether there is a trend for groups of variables to be interrelated (Bryman, 2012). Based on recommendations by Pituch and Stevens (2016), the criteria for retaining items was that they were required to have a factor loading of more than 0.40 on its *a priori* scale and less than 0.40 on any other scale. Eigenvalues were calculated to investigate the relative importance of each factor, and were required to have a value greater than 1, to satisfy Kaiser's (1960) recommendation.

The scale internal consistency reliability was examined to measure whether each item in a scale assessed a similar construct. The Cronbach alpha coefficient was computed for each scale. Alpha coefficients range from 0.00, indicating no reliability, to 1.00, indicating a perfect reliability (Cronbach, 1951). As per Cohen et al. (2011) advice, a cut-off value of 0.6 was used to indicate a suitable scale for the current study.

Finally, the correlation matrix, generated during oblique rotation, was used to examine discriminant validity as this offers a realistic representation of how factors are interrelated (T. A. Brown, 2015; Field, 2013). Discriminant validity assesses the interrelatedness of the different components in a survey. According to Field (2013), there should be moderately strong relationships between factors, however factor correlations above 0.80, indicate that the constructs overlap and, therefore, there is inadequate discriminant validity.

3.7.2 Descriptions of pre-service teachers' self-reports of anxiety, self-efficacy, beliefs, and learning environment perceptions

The second research objective sought to describe the anxiety, teaching efficacy, beliefs and perceptions of the learning environment as self-reported by the participants. To do this the skewness, kurtosis, means and standard deviation, were calculated for each of the scales for the five surveys, and box and whisker plots were developed.

First, descriptive analysis, based on the participants' responses to the five surveys was used to describe the each of the scales. The average item mean for each scale, calculated for each survey, were used to generate profiles to provide an understanding of the participants' views as a whole. The average item mean (as opposed to a scale score), was used to provide a score that was meaningful given that the number of items in the scales were different. Second, standard deviation was calculated to show the average amount of variation around the mean, and the skewness and kurtosis were examined to give insights into the shape of the data distribution, with a normal distribution having a skewness of 0, and a kurtosis of 3. Finally, box and whisker plots were also generated to show the spread and centres of the data set. The five-number summary generated was used to show the minimum, first quartile, median, third quartile, and maximum for each scale. For each box plot, the 'box' was used to represent the interquartile range. A vertical bar across the centre of the box represents the median, while the ends of the box specifies the first quartile (the 25% mark), and the third quartile (the 75% mark). The bottom of the chart (the end of the 'whisker'), shows the minimum (e.g. lowest anxiety) and the top shows the maximum number in the data set (e.g. the highest anxiety).

3.7.3 Relationships between self-efficacy, anxiety and mathematics beliefs

The third research objective sought to examine whether relationships exist between pre-service teachers' self-efficacy and their anxiety (mathematics anxiety and teaching mathematics anxiety), and beliefs about the nature of mathematics. The data collected using four of the five surveys was analysed using simple correlation and multiple regression analyses. Simple correlation analysis was conducted to provide information about bivariate association between the different variables.

To examine how much variance in the dependent variables the independent variable were able to explain, multiple regression analysis was used. For this research objective, the independent variables were pre-service teacher's mathematics anxiety, their anxiety for teaching mathematics and their beliefs about mathematics. Self-efficacy was used as the dependent variable. To provide information about the unique contribution of the pre-service teachers' anxiety and beliefs about the nature of mathematics to their self-efficacy, the beta values were examined.

3.7.4 *Differences in Year Groups for pre-service teachers' anxiety, beliefs about mathematics and self-efficacy*

The fourth research objective sought to examine whether differences exist between pre-service teachers in different year levels, in terms of their mathematics anxiety and teaching mathematics anxiety, self-efficacy, and beliefs about mathematics. To address this objective, multivariate analysis of variance (MANOVA) was carried out separately for the data provided from the first four surveys: Anxiety for Mathematics, Teaching Anxiety for Mathematics, Modified Self-Efficacy for Teaching Mathematics Instrument, and the Beliefs about Mathematics survey. For each survey, year level was used as the independent variable and the scales of the survey in question as the dependent variable. For all surveys, preliminary assumption testing was undertaken (as recommended by Tabachnick & Fidell, 2013) to ensure normality, linearity, univariate and multivariate outliners. In all cases, no serious violations were noted.

Once it was established that the significance level of the Wilk's Lambda was less than .05, the between subject effects and ANOVA results were interpreted. Given that there were more than two groups, post-hoc testing was carried out to examine whether there were statistically significant differences between specific groups. To do this, Bonferonni adjustment was used to guard against the possibility of an increased Type 1 error.

In addition to the MANOVA, effect sizes were calculated to provide an indication of the magnitude of the differences (as recommended by B. Thompson, 2001). Effect sizes expressed the difference between the pre-service teachers' mean scores in standard deviation units. They were calculated using the formula:

$$= \frac{M_1 - M_2}{\sqrt{\frac{\sigma_1^2 + \sigma_2^2}{2}}}$$

3.7.5 Relationship between learning environment perceptions and anxiety, beliefs, and self-efficacy

To examine whether pre-service teachers' perceptions of the learning environment was related to mathematics anxiety, mathematics teaching anxiety, teaching self-efficacy and beliefs about mathematics (Research Objective 5), simple correlation and multiple regression analyses were used. As with Research Objective 3, the simple correlation analysis provided information about bivariate association between the variables and each learning environment scale, while the multiple regression analysis sought to determine the strength of relationships and to reduce the risk of Type 1 errors. Using the WIHIC scales as the dependent variables, separate multiple regression analysis was performed with anxiety, self-efficacy and beliefs as the independent variables. To provide information about the unique and significant contribution of the pre-service teachers' anxiety, self-efficacy and beliefs about the nature of mathematics on their perceptions of the learning environment, the beta values (β) were interpreted.

This section has described how the data were analysed in relation to the research objectives. The next section (Section 3.8) provides information about the ethical considerations that were made throughout this study.

3.8 Ethical Considerations

To conduct ethical research, considerations were made regarding whether this study would cause any harm to, or deception of, participants; invade participants' privacy; or be conducted without informed consent (Diener & Crandall, 1978). The following sections describe the ethical practices that were considered throughout this study. Section 3.8.1 discusses permission and informed consent, and anonymity and confidentiality are discussed in Section 3.8.2. Consideration and issues related to the research design are reviewed in Sections 3.8.3.

3.8.1 Permission and Informed Consent

Ethics approval for this study was first obtained from Curtin University's Human Research Ethics Committee (see Appendix 8 for a copy of the Ethics Approval).

Approval to conduct the research at both higher education institutes was also granted (see Appendix 9 for a copy of the Research Approval from the institutions).

It is important to protect the privacy and confidentiality of participants, and researchers need to be sensitive to any potential harm that may be experienced by taking part in a study (Creswell, 2012). As such, before completing the surveys, students were informed about the purpose of the research and the parties involved (verbally and/or in writing, see Section 3.4.2). A Participant Information Statement (see Appendix 1 for a copy of the statement) was sent to all participants attached to the same email that contained the link to the on-line survey. This statement was written in plain language, so as to be easily understood by participants in order to give informed consent. The aim of this was to provide prospective participants with as much information about the research as possible, including background information, information about the researcher, why participants were being asked to take part, and any benefits of risks that may be associated. The statement also informed participants about who would have access to the information obtain from the survey and how results may be disseminated. Students were given the option to participate and were informed that, if they chose to participate, they could decide to discontinue at any time, without prejudice, and without the need for explanation. It was also made clear that participation (or non-participation) in the study was unrelated to any of their courses, and would have no effect on grades, academic standing or any other aspect of their college careers. As pre-service teachers completed the survey online, a consent form was not used. However, before entering the online survey, participants were required to indicate that that had received information regarding the research and voluntarily consented to participate. Given that all participants were over the age of eighteen, parental consent was not required.

3.8.2 Anonymity and confidentiality

The surveys were completed anonymously and, as such, the data collected did not include identifiers. This was of importance as the researcher was teaching a mathematics content course and a co-requisite mathematics methodology course to one cohort at one of the higher education institutes at the time of data collection, therefore students could be assured that no aspect of the research would be used in determining students' grades in these courses. The data were collected near the beginning of the semester, so students were asked to consider any previous experience with mathematics courses at the higher education institute.

The researcher had taught the same courses to another class previously, from whom data were collected, however students in this class were asked to consider all of their mathematics experiences at the institute and, as the researcher was no longer teaching them for any courses, they could be confident that their answers would not compromise their situation at the institute. Students were asked to identify which higher educational institute they were enrolled at, however the names of the institutes were not used in the survey, nor anywhere in the reporting of the study.

Access to the survey data at Qualtrics.com is password protected and raw data were shared only with the researcher's Ph.D. supervisor.

3.8.3 Consideration

Implementation of the survey was planned to ensure minimal disruption to participants. Approximately 30 minutes was required for the completion of the survey. For the majority of students at one of the higher education institute, this was completed during class time to increase the likelihood of responses, but in negotiation with, and in consideration of, teaching faculty. For one cohort at this institute and students from the other higher education institute, the link to the online survey was sent via email, and willing participants completed the survey in their own time.

This section has described the ethical practices that were considered throughout this study, including permission and informed consent, and anonymity and confidentiality. Consideration and issues related to the research design were also reviewed. The next section summarises the chapter.

3.9 Chapter Summary

This chapter has presented a detailed account of the methods that were used in the current study to investigate the five research objectives (summarised in Section 3.2). A cross-sectional research design (Section 3.3) was adopted for the study in order to collect data about the feelings, attitudes and beliefs surrounding mathematics of Emirati pre-service teachers, and to identify relationships between and among the variables. This research design was also utilised to investigate any variation in the attitudes, feelings and beliefs of pre-service teachers between students of different years in the Bachelor of Education programmes.

Data were collected from 184 Emirati pre-service teachers, of which the responses of 157 were complete and usable for all surveys, undertaking Bachelor of Education programmes at two higher education institutes in Abu Dhabi (Section 3.4.2). These institutes were selected as they graduate teachers specifically trained to teach English, mathematics and science, through the medium of English, for Abu Dhabi's public primary schools.

The construction of the surveys (described in Section 3.5) was based on locating and modifying the most appropriate existing tools available, or developing new surveys drawn from several existing tools. Five surveys, alongside basic demographic information were utilised to collect data in this study. After minor adjustments based on a pilot survey (Section 3.6), data were collected using an online platform, from pre-service teachers who were visited during class time by the researcher, or invited to participate via email (see Section 3.4.2). Sections 3.5.1 – 3.5.5 described each of the surveys used, how they were chosen and/or developed and the purpose of each.

First, the Anxiety for Mathematics Survey (AMS, Section 3.5.1) sought to identify levels of mathematics anxiety related to learning, doing and being evaluated in mathematics, whether this anxiety permeates into a person's everyday life. The contents of the survey was drawn from four existing instruments, in addition to researcher developed questions. A total of 50 items were organised into five scales: Anxiety caused by Mathematics Learning; Anxiety caused by Mathematics Evaluation; Anxiety caused by Numerical Tasks; Anxiety caused by Mathematics in Real-life Situations and Anxiety caused by Non-mathematics Situations.

Second, the Teaching Anxiety in Mathematics Scale (TAMS, Section 3.5.2) was developed to assess the aspects of teaching mathematics that pre-service teachers may feel anxious about. Although the survey utilised scale descriptions from the

Mathematics Teaching Anxiety Scale (MATAS, Peker, 2006), the majority of items were developed by the researcher in consideration the context for which it is designed. The three scales were: Anxiety caused by Content Knowledge; Anxiety caused by Teaching Mathematics; and Anxiety caused by Methodological Knowledge.

Third, the Self-efficacy for Teaching Mathematics Instrument (SETMI, McGee, 2012, Section 3.5.3) was chosen to assess Emirati pre-service teachers' self-efficacy for teaching the 'new' mathematics. The survey was modified by the researcher for language and content, one of the original scales was split into two scales to further define the constructs and an additional scale to assess self-confidence was added. Several new items were added by the researcher, making a total of 35 items designed to assess the levels of Emirati pre-service teachers' self-efficacy. The four scales were: Efficacy for Teaching Mathematics; Efficacy for Making a Difference; Self-confidence; and Efficacy for Teaching Mathematics Content.

Fourth, a survey was developed to assess the beliefs of Emirati pre-service teachers' about the nature of mathematics (Section 3.5.4). Twenty items, drawn from four existing instrument were modified for language and context, and one new item was added by the researcher. The items were organised into three scales: Beliefs about the Nature of Mathematics; Beliefs about the Usefulness of Mathematics; and Beliefs about Learning and Doing Mathematics.

Finally, the modified version of the What is Happening in the Class (WIHIC), originally used by Afari et al (2013), was utilised to examine Emirati pre-service teachers' perceptions of the learning environments in their college mathematics classes. This version involved 48 items in six scales, these being: Student Cohesiveness; Teacher Support; Involvement; Cooperation; Equity; and Personal Relevance (originally from the Constructivist Learning Environment Survey, P. C. Taylor et al., 1997).

The analyses conducted to address each of the research objectives were described in Section 3.7. In the first instance, analysis was carried out to provide support the reliability and validity of the instruments, and included examining: factor structure (using principal axis factoring with oblique rotation); and scale internal consistency reliability (using the Cronbach alpha coefficient). Second, the skewness, kurtosis, means, and standard deviation were calculated for each of the scales for the five surveys, and box and whisker plots were developed, to describe the anxiety, teaching efficacy, beliefs and perceptions of the learning environment of the participants (Section 3.7.2). Third, to examine whether relationships exist between pre-service teachers' self-efficacy and their mathematics anxiety, mathematics teaching anxiety, and beliefs about the nature of mathematics, simple correlation and multiple regression analyses were used (Section 3.7.3). Fourth, MANOVA was used to examine whether differences exist between pre-service teachers in different year levels, in relation to their perception of the learning environment, mathematics anxiety and teaching mathematics anxiety, self-efficacy and beliefs about the nature of mathematics (Section 3.7.4). Finally, simple correlation analysis and multiple regression analysis were used to investigate whether relationships exist between pre-service teachers' perceptions of the learning environment and their mathematics anxiety, mathematics teaching anxiety, teaching self-efficacy and beliefs in mathematics (Section 3.7.5).

The ethical considerations made throughout the study were reviewed in Section 3.8. The permissions sought, including informed consent (Section 3.8.1), anonymity and confidentiality (Section 3.8.2) were described, and how issues related to the research design were overcome (Section 3.8.3). The ability to infer causal directionality between variables was also discussed in relation to the research objectives and research design.

The next chapter, Chapter 4, reports the results of the study, which was implemented based on the methods described in the current chapter, and informed by the review of literature in Chapter 2.

Chapter 4

DATA ANALYSIS AND RESULTS

4.1 Introduction

In this chapter, the data analysis and results with respect to the four research objectives of this study (introduced in Chapter 1) are described. As such this chapter is organised around each of the objectives using the following headings:

- Validity and reliability of the instruments (Section 4.2);
- Descriptive analysis: Self-reports of anxiety, self-efficacy, beliefs and learning environment perceptions (Section 4.3)
- Relationships between self-reports of self-efficacy, anxiety and beliefs about mathematics (Section 4.4);
- Differences in year groups in terms of anxiety, beliefs about mathematics and self-efficacy (Section 4.5) and
- Relationship between perceptions of the learning environment and anxiety, beliefs about mathematics and self-efficacy (Section 4.6).

Finally, the chapter is summarised in Section 4.7.

4.2 Validity and Reliability of the Instruments

To provide support for subsequent research questions, evidence was sought to verify the reliability and validity of the instruments used to collect the data for this study. Four of the surveys (Anxiety for Mathematics, Teaching Anxiety for Mathematics, Modified Self-efficacy for Teaching Mathematics and Beliefs about Mathematics), were either new or modified and had not been used in previous research (see Chapter 3, Section 3.5 for descriptions of the instruments). The WIHIC, on the other hand, was a well-established survey which has been found to have factorial validity and internal consistency reliability in a range of contexts (Aldridge et al., 1999; Fraser, 2012). Given, however, that the WIHIC has not been used with Emirati pre-service teachers.

It was important, therefore, to establish its reliability with this sample. Therefore, the first research objective was:

a. To modify and validate scales to assess pre-service teachers':
b. anxiety towards mathematics in general;
c. anxiety towards teaching mathematics;
d. self-efficacy towards teaching the 'new mathematics'
e. beliefs about the nature of mathematics;
f. perceptions of their mathematics learning environments.

This section reports the reliability and validity of each of the five surveys: the Anxiety for Mathematics Survey (AMS; Section 4.2.1); Teaching Anxiety for Mathematics Survey (TAMS; Section 4.2.2); Modified Self-efficacy for Teaching Mathematics Instrument (M-SETMI; Section 4.2.3); Beliefs about Mathematics Survey (BAMS; Section 4.2.4); and the What Is Happening In this Class? (WIHIC; Section 4.2.5).

4.2.1 Anxiety for Mathematics Survey (AMS)

The Anxiety for Mathematics Survey (AMS) was developed to assess pre-service teachers' self-reported anxiety towards learning, doing, and being evaluated in mathematics. As a first step, the multivariate normality and sampling adequacy of the data were examined. Bartlett's test of sphericity indicated that the Chi squared value was 4848.338 and was statistically significant ($p<0.001$). The Kaiser-Maiyer-Olkin measure of adequacy was high (0.905), confirming the appropriateness of the data for further analysis. To determine whether the AMS was valid and reliable, the data collected using the AMS was analysed to examine the: factor structure (reported in Section 4.2.1.1); the internal consistency reliability (reported in Section 4.2.1.2); and the discriminant validity (reported in Section 4.2.1.3).

4.2.1.1 Factor Structure of the AMS

Principal axis factor analysis with oblique rotation was used to examine the factor structure of the AMS. During item analysis, ten items were determined not to meet the criteria and were removed from further analysis. These ten items were item 1 for the

Anxiety Caused by Mathematics Learning scale, items 19 and 20 for the Anxiety caused by Mathematics Evaluation scale, items 21, 28 and 30 for the Anxiety caused by Numerical Tasks scale, items 31 and 32 for the Anxiety caused by Mathematics in Real-life Situations, and items 42 and 47 for the Anxiety caused by Non-Mathematics Situations scale. Removal of these items improved the internal consistency reliability and factorial validity of their respective scales and resulted in the acceptance of a revised version of the instrument comprising of 40 items in the five scales. The factor loadings for the remaining 40 items, reported in Table 4.1, show that all of the remaining items had a factor loading of at least .40 on their own scale and a loading of less than .40 on the other four scales (as recommended by Pituch & Stevens, 2016).

The bottom of Table 4.1 reports the percentage of variance and eigenvalue for each AMS scale. The percentage variance for the different scales ranged from 3.67% to 36.05%, with the cumulative percentage variance, explained by all factors, being 61.27%. The eigenvalue for different scales ranged from 1.47 to 14.42 for the sample. These results indicate that the eigenvalue for each factor satisfy Kaiser's (1960) recommendation that values be greater than 1.

4.2.1.2 Internal Consistency Reliability of the AMS

The Cronbach alpha reliability coefficient was used as an index of scale internal consistency. Table 4.2 reports the Cronbach alpha coefficient, for each scale of the revised 40-item version of the AMS. The Cronbach alpha coefficient for each scale was 0.88 or higher, confirming a satisfactory reliability of the constructs, as per Cohen, Manion, & Morrison's (2000) cut-off value of 0.6.

4.2.1.3 Discriminant validity of the AMS

To provide an indication of discriminant validity, the factor correlations generated during oblique rotation testing were used. The results, reported in Table 4.3, indicate that the highest correlation between the different factors was 0.48. Based on Brown's (2015) recommendations that factor correlations above .80 imply an overlap of concepts, these results met the requirement for the discriminant validity for the AMS scales.

Table 4.1 Factor Loadings, Percentage of Variance, and Eigenvalues for the Mathematics Anxiety Survey (AMS)

Factor Loading					
Item No	Anxiety - Mathematics Learning	Anxiety - Mathematics Evaluation	Anxiety - Numerical Tasks	Anxiety - Mathematics in Real-life Situations	Anxiety -Non-Mathematics Situations
2	.68				
3	.68				
4	.60				
5	.56				
6	.77				
7	.61				
8	.52				
9	.46				
10	.59				
11		.70			
12		.63			
13		.72			
14		.81			
15		.74			
16		.64			
17		.75			
18		.49			
22			.49		
23			.59		
24			.79		
25			.66		
26			.71		
27			.55		
29			.44		
33				.55	
34				.56	
35				.54	
36				.75	
37				.74	
38				.82	
39				.73	
40				.71	
41					.70
43					.71
44					.82
45					.75
46					.54
48					.76
49					.64
50					.56
% Variance	3.67	9.91	4.07	36.05	7.57
Eigenvalue	1.47	3.96	1.63	14.42	3.03

Factor loadings smaller than .40 have been omitted.
N= 176 teachers in 2 higher education institutes.

Table 4.2 Internal Consistency Reliability (Cronbach Alpha Coefficient) for the Anxiety for Mathematics Survey (AMS)

Scale	Alpha Reliability
Anxiety - Mathematics Learning	.89
Anxiety - Mathematics Evaluation	.91
Anxiety - Numerical Tasks	.91
Anxiety - Mathematics In Real-Life Situations	.91
Anxiety - Non-Mathematics Situations	.88

N= 176 teachers in 2 higher education institutes.

Table 4.3 Component Correlation Matrix for the Anxiety for Mathematics Survey (AMS)

Component	Anxiety - Mathematics Learning	Anxiety - Mathematics Evaluation	Anxiety - Numerical Tasks	Anxiety - Mathematics in Real-life Situations	Anxiety - Non-Mathematics Situations
Anxiety - Mathematics Learning	—	.48	.24	.41	.23
Anxiety - Mathematics Evaluation		—	.08	.30	.25
Anxiety - Numerical Tasks			—	.39	.22
Anxiety - Mathematics in Real-life Situations				—	.32
Anxiety - Non-Mathematics Situations					—

N= 176 teachers in 2 higher education institutes.

In summary, this section has reported the results for the reliability and validity of the AMS instrument. Overall, the results of the factor analysis, internal consistency and discriminant validity indicated that the data collected from the AMS could be considered reliable and valid when used in this context.

4.2.2 Teaching Anxiety for Mathematics Survey (TAMS)

The TAMS was developed to assess pre-service teachers' self-reported anxiety towards teaching mathematics. Firstly, the multivariate normality and sampling adequacy of the data were examined. Bartlett's test of sphericity indicated that the Chi squared value $\chi^2 = 3007.831$ and this value was statistically significant ($p<0.001$). The Kaiser-Maiyer-Olkin measure of adequacy was high (0.89), confirming the appropriateness of the data for further analysis. To establish whether the TAMS was valid and reliable, the data collected were analysed to examine the: factor structure (reported in Section 4.2.2.1); internal consistency reliability (reported in Section 4.2.2.24.2.1.2); and discriminant validity (reported in Section 4.2.2.3).

4.2.2.1 Factor Structure of the TAMS

Principal axis factor analysis with oblique rotation was used to examine the factor structure of the TAMS. During the item analysis, five items were found not to meet the criteria and were removed from further analysis. These five items (items 11, 12, 13, 14, and 15), were all from the Anxiety caused by Teaching Mathematics scale. Removal of these five items improved the factorial validity and internal consistency reliability and of the remaining scales and resulted in the acceptance of a revised version of the TAMS instrument consisting of 22 items in three scales. Factor loadings for the remaining 22 items, reported in Table 4.4, show that all of the remaining items had a factor loading of at least .40 on their own scale and a loading of less than .40 on the other two scales.

The bottom of Table 4.4 states the percentage of variance and eigenvalue for each of the TAMS scales. The percentage variance for the different scales ranged from 8.85% to 37.31%, with the cumulative percentage variance, explained by all factors, being 62.11%. The eigenvalue for different scales ranged from 1.95 to 8.21 for the sample. These results denote that the eigenvalue for each factor satisfy Kaiser’s (1960) recommendation that values be greater than 1.

4.2.2.2 Internal Consistency Reliability of the TAMS

The Cronbach alpha coefficient was used as an index of scale internal consistency. Table 4.5 reports the internal consistency reliability (Cronbach alpha coefficient), for the revised 22-item version of the TAMS. The Cronbach alpha coefficient for each scale was .82 or higher, thus confirming a high reliability of the constructs (Cronbach, 1951), and were all well above the cut-off value of .6 recommended by Cohen et al. (2011)

Table 4.4 Factor Loadings, Percentage of Variance, and Eigenvalues for the Teaching Anxiety for Mathematics Survey (TAMS)

Factor Loading			
Item No	Anxiety - Content Knowledge	Anxiety - Teaching Mathematics	Anxiety - Methodological Knowledge
1	.69		
2	.73		
3	.74		
4	.75		
5	.63		
6	.64		
7	.70		
8	.72		
9	.69		
10	.58		
16		.62	
17		.80	
18		.84	
19			.60
20			.74
21			.77
22			.83
23			.79
24			..55
25			..86
26			.79
27			.79
% Variance	15.95	8.85	37.31
Eigenvalue	3.51	1.95	8.21

Factor loadings smaller than .40 have been omitted.
N= 168 teachers in 2 higher education institutes.

Table 4.5 Internal Consistency Reliability (Cronbach Alpha Coefficient) for the Teaching Anxiety for Mathematics Survey (TAMS)

Scale	Alpha Reliability
Anxiety - Content Knowledge	.90
Anxiety - Teaching mathematics	.82
Anxiety - Methodological Knowledge	.94

N= 168 teachers in 2 higher education institutes.

4.2.2.3 Discriminant Validity of the TAMS

As explained in the previous section (Section 4.2.1.3), oblique rotation in exploratory factor analysis offers a representation of how factors are interrelated (T. A. Brown, 2015).

The principal component correlation matrix generated during oblique rotation, reported in Table 4.6, indicates that the highest correlation was .35, meeting the requirements of discriminant validity. Based on Brown's (2015) recommendation that correlations above .80 indicate overlap of concepts, these results were considered acceptable.

Table 4.6 Component Correlation Matrix for scales of the Teaching Anxiety for Mathematics Survey (TAMS)

Component	Anxiety - Content Knowledge	Anxiety - Teaching mathematics	Anxiety - Methodological Knowledge
Anxiety - Content Knowledge	–	.35	.21
Anxiety - Teaching mathematics		–	.30
Anxiety - Methodological Knowledge			–

N= 168 teachers in 2 higher education institutes.

In summary, the factor loadings, internal consistency and discriminant validity measures supported the reliability and validity of the TAMS, in modified form. Therefore, the data collected from the TAMS was suitable to be used in subsequent analyses.

4.2.3 Self-efficacy for Teaching Mathematics Instrument (M-SETMI)

To assess pre-service teachers' self-reported efficacy for teaching mathematics, a modified version of the Self-efficacy for Teaching Mathematics Instrument (M-SETMI) was utilised. As with the previous surveys, the first step involved examining the multivariate normality and sampling adequacy of the data. Bartlett's test of sphericity indicated that the Chi squared value was 4081.521 and was statistically significant ($p<0.001$). The Kaiser-Maiyer-Olkin measure of adequacy was high (0.931), confirming the appropriateness of the data for further analysis. The data collected were analysed to examine the factor structure (reported in Section 4.2.1.14.2.3.1), internal consistency reliability (reported in Section 4.2.3.2), and discriminant validity (reported in Section 4.2.3.3).

4.2.3.1 Factor Structure of the M-SETMI

The results of the principal axis factor analysis with oblique rotation were used to examine the factor structure of the M-SETMI instrument. The SETMI had previously been found to be a valid and reliable measure of two aspects of in-service teacher's self-efficacy: 'Pedagogy in Mathematics' and 'Teaching Mathematics Content' (McGee & Wang, 2014), however criticism that the factor structure is often less distinct for pre-service teachers (Tschannen-Moran & Woolfolk Hoy, 2005), prompted the separation of 'Pedagogy in Mathematics' items, and the development of three new items, into two scales. These two scales were found to not be distinct in the current study, therefore supporting McGee & Wang's (2014) findings. The combined scales were renamed Pedagogy in Mathematics, as per the original SETMI (see Table 4.7). The M-SETMI also included a 'Self-Confidence' scale to assess how the participants feel about teaching mathematics. The factor loadings, reported in Table 4.7, show that all of the items except one (item 14) for the Self-confidence scale had a factor loading of at least .40 on their own scale and a loading of less than .40 on the other scale (as recommended by Pituch & Stevens, 2016). Item 4 from the Self-confidence scale was removed from further analysis, leaving a total of 34 items in three scales.

The percentage of variance and eigenvalue for each M-SETMI scale are recorded at the bottom of Table 4.7. The percentage variance for the different scales ranged from 6.25% to 48.29%, with the cumulative percentage variance, explained by all factors, being 66.34%. The eigenvalue for different scales ranged from 2.13 to 16.42 for the sample. These results indicate that the eigenvalue for each factor satisfy Kaiser's (1960) recommendation that values be greater than 1.

4.2.3.2 Internal Consistency Reliability of the M-SETMI

The Cronbach alpha coefficient was calculated for each factor to provide an indication of the internal consistency reliability. Table 4.8 reports the internal consistency reliability (Cronbach alpha coefficient), for each M-SETMI scale, which shows that the each scale was 0.95 or higher, therefore verifying a high reliability of the constructs (Cronbach, 1951).

Table 4.7 Factor Loadings, Percentage of Variance, and Eigenvalues for the Modified Self-Efficacy for Teaching Mathematics Instrument (M-SETMI)

Factor Loading			
Item No	Pedagogy in Mathematics	Self-confidence	Mathematics Content
1	.88		
2	.82		
3	.75		
4	.77		
5	.64		
6	.79		
7	.78		
8	.73		
9	.72		
10	.59		
11		.63	
12		.72	
13		.70	
15		.71	
16		.91	
17		.92	
18		.78	
19			.69
20			.78
21			.67
22			.74
23			.71
24			.70
25			.68
26			.82
27			.69
28			.87
29			.87
30			.77
31			.62
32			.81
33			.72
34			.84
35			.78
% Variance	6.25	11.82	48.29
Eigenvalue	2.13	4.02	16.42

Factor loadings smaller than .40 have been omitted.
N= 160 teachers in 2 higher education institutes.

Table 4.8 Internal Consistency Reliability (Cronbach Alpha Coefficient) for the Modified Self-efficacy for Teaching Mathematics Instrument (M-SETMI)

Scale	Alpha Reliability
Pedagogy in Mathematics	.95
Self-Confidence	.93
Mathematics Content	.96

N= 160 teachers in 2 higher education institutes.

4.2.3.3 Discriminant validity of the M-SETMI

During oblique rotation, the principal component correlation matrix that was generated represented how the factors were interrelated. The correlation matrix for the M-SETMI, reported in Table 4.9, indicates that the correlation between the three scales was .66, meeting the requirements of discriminant validity (as recommended by T. A. Brown, 2015).

Table 4.9 Component Correlation Matrix for scales of the Modified Self-efficacy for Teaching Mathematics Instrument (M-SETMI)

Component	Pedagogy in Mathematics	Self-confidence	Mathematics Content
Pedagogy in Mathematics	–	.50	.65
Self-confidence		–	.35
Teaching Mathematics Content			–

N= 160 teachers in 2 higher education institutes.

This section has reported the reliability and validity of the M-SETMI instrument. Overall, the factor analysis, internal consistency, and discriminant validity results indicated that the data collected from the M-SETMI could be considered valid and reliable when used in this context.

4.2.4 Beliefs about Mathematics Survey *(BAMS)*

The BAMS was developed to assess pre-service teachers' beliefs about mathematics. Initially, the multivariate normality and sampling adequacy of the data were examined. Bartlett's test of sphericity indicated that the Chi squared value was 1287.34 and this value was statistically significant (p<0.001). The Kaiser-Maiyer-Olkin measure of adequacy was high (0.86), confirming the appropriateness of the data for further analysis. To establish the validity and reliability of the BAMS, the data collected were analysed to examine the: factor structure (reported in Section 4.2.4.1); the internal consistency reliability (reported in Section 4.2.4.24.2.1.2), and the discriminant validity (reported in Section 4.2.4.3).

4.2.4.1 Factor Structure of the BAMS

Principal axis factor analysis with oblique rotation was used to examine the factor structure of the BAMS instrument. During the item analysis, six items were determined not to meet the criteria and were removed from further analysis. These six items were items 1, 2, 4, 8 for the Beliefs about the Nature of Mathematics scale, item 9 for the Beliefs about the Usefulness of Mathematics scale, and item 17 for the Beliefs about Doing Mathematics scale. Elimination of these six items strengthened the internal consistency reliability and factorial validity of the remaining scales and resulted in the acceptance of a revised version of the BAMS instrument consisting of 15 items in three scales. Factor loadings for the remaining 15 items, reported in Table 4.10, shows that all of the remaining items had a factor loading of at least .40 on their own scale and a loading of less than .40 on the other two scales.

Table 4.10 Factor Loadings, Percentage of Variance, and Eigenvalues for the Beliefs About Mathematics Survey (BAMS)

	Factor Loading		
Item No	Beliefs about the Nature of Mathematics	Beliefs about the Usefulness of Mathematics	Beliefs about Doing Mathematics
3	.68		
5	.85		
6	.60		
7	.78		
10		.50	
11		.73	
12		.90	
13		.74	
14		.78	
15			.57
16			.79
19			.65
% Variance	18.11	36.85	8.75
Eigenvalue	2.53	5.16	1.23

Factor loadings smaller than .40 have been omitted.
N= 160 teachers in 2 higher education institutes.

The bottom of Table 4.10 states the percentage of variance and eigenvalue for each of the BAMS scales. The percentage variance for the different scales ranged from 8.75% to 36.85%, with the cumulative percentage variance, explained by all factors, being 65.38%. The eigenvalue for different scales ranged from 1.23 to 5.16 for the sample.

These results denote that the eigenvalue for each factor satisfy Kaiser's (1960) recommendation that values be greater than 1.

4.2.4.2 Internal Consistency Reliability of the BAMS

The Cronbach alpha coefficient was calculated as an index of scale internal consistency. Table 4.11 reports the Cronbach alpha coefficient for the amended 15-item version of the BAMS. For each scale, the Cronbach alpha coefficient was 0.70 or higher, thus confirming a high reliability of the constructs (Cronbach, 1951).

Table 4.11 Internal Consistency Reliability (Cronbach Alpha Coefficient) for the Beliefs about Mathematics Survey (BAMS)

Scale	Alpha Reliability
Beliefs about the Nature of Mathematics	.81
Beliefs about the Usefulness of Mathematics	.89
Beliefs about Doing Mathematics	.70

N= 160 teachers in 2 higher education institutes.

4.2.4.3 Discriminant validity of the BAMS

The principal component correlation matrix, generated during oblique rotation, is reported in Table 4.12. The results indicate that the highest correlation was 0.66 and, therefore, meets the requirements of discriminant validity (as recommended by T. A. Brown, 2015).

Table 4.12 Component Correlation Matrix for scales of the Beliefs About Mathematics Survey (BAMS)

Factor	Beliefs about the Nature of Mathematics	Beliefs about the Usefulness of Mathematics	Beliefs about Doing Mathematics
Beliefs about the Nature of Mathematics	-	.18	.66
Beliefs about the Usefulness of Mathematics		-	.23
Beliefs about Doing Mathematics			-

N= 160 teachers in 2 higher education institutes.

This section has reported the results for the reliability and validity of the BAMS instrument. Overall, the factor loadings, internal consistency, and discriminant validity measures indicated that the data collected from the AMS could be considered reliable and valid for the purposes of this study.

4.2.5 What is Happening in this Class? (WIHIC) Survey

The modified What is Happening in the Class (WIHIC) survey was used to assess Emirati pre-service teachers' perceptions of their mathematics classroom environments. As a first step, the multivariate normality and sampling adequacy of the data were examined. Bartlett's test of sphericity indicated that the Chi squared value was 5304.015 and this value was statistically significant (p<0.001). The Kaiser-Maiyer-Olkin measure of adequacy was high (0.892), confirming the appropriateness of the data for further analysis. The data collected were analysed to determine the validity and reliability of the instrument when used in this context: the factor structure of the WIHIC (reported in Section 4.2.1.14.2.5.1, the internal consistency reliability (reported in Section 4.2.5.2), and the discriminant validity (reported in Section 4.2.5.3).

4.2.5.1 Factor Structure of the WIHIC

Principal axis factor analysis with oblique rotation was used to analyse assess the factor structure of the WIHIC instrument. During the item analysis, six items did not meet the criteria and were removed from further analysis. These items were item 1 for the Student Cohesiveness scale, items 19, 20, and 21 for the Involvement scale, and items 25 and 26 for the Collaboration scale. Removal of these items improved the factorial validity and internal consistency reliability of the remaining scales, resulting in a revised version of the WIHIC consisting of 42 items in six scales. Factor loadings for these 42 items, reported in Table 4.13, shows that all of the remaining items had a factor loading of at least .40 on their own scale and a loading of less than .40 on the other five scales.

The percentage of variance and eigenvalue for each of the eight WIHIC scales are reported at the bottom of Table 4.13. The percentage variance for the different scales ranged from 3.85% to 39.35% with the cumulative percentage variance, explained by all factors, being 66.471%. The eigenvalue for different scales ranged from 1.62 to 16.53 for the sample, thereby satisfying Kaiser's (1960) recommendation that values be greater than 1.

Table 4.13 Factor Loadings, Percentage of Variance, and Eigenvalues for the What Is Happening In this Class? Survey (WIHIC)

	Factor Loading					
Item No	Student Cohesiveness	Teacher Support	Involvement	Collaboration	Equity	Personal Relevance
2	.55					
3	.48					
4	.77					
5	.73					
6	.63					
7	.60					
8	.50					
9		.59				
10		.65				
11		.53				
12		.67				
13		.80				
14		.78				
15		.70				
16		.54				
17			.69			
18			.80			
22			.52			
23			.49			
24			.63			
27				.57		
28				.62		
29				.73		
30				.75		
31				.73		
32				.61		
33					.43	
34					.55	
35					.45	
36					.66	
37					.82	
38					.79	
39					.66	
40					.59	
41						.55
42						.65
43						.76
44						.68
45						.78
46						.74
47						.68
48						.52
% Variance	7.51	6.40	4.20	3.85	39.35	5.15
Eigenvalue	3.16	2.69	1.76	1.62	16.53	2.16

Factor loadings smaller than .40 have been omitted.
N= 157 teachers in 2 higher education institutes.

4.2.5.2 Internal Consistency Reliability of the WIHIC

The Cronbach alpha coefficient was calculated for each factor of the WIHIC to provide an indication of the internal consistency reliability. The Cronbach alpha coefficient, reported in Table 4.14, for each WIHIC scale was .88 or higher, verifying a high reliability of each construct.

Table 4.14 Internal Consistency Reliability (Cronbach Alpha Coefficient) for the What Is Happening In this Class? Survey (WIHIC)

Scale	Alpha Reliability
Student Cohesiveness	.88
Teacher Support	.91
Involvement	.90
Collaboration	.90
Equity	.91
Personal Relevance	.91

N= 157 teachers in 2 higher education institutes.

4.2.5.3 Discriminant validity of the WIHIC

The principal component correlation matrix generated during oblique rotation represented how factors were interrelated, the results for which are reported in Table 4.15. The highest correlation was 0.45, which met the requirements of discriminant validity, as recommended by T. A. Brown (2015).

The reliability and validity of the WIHIC instrument when used in this context has been reported in this section. Overall, the factor loadings, internal consistency, and discriminant validity measures confirmed the reliability and validity of the WIHIC.

In this section, the results supporting for the reliability and validity of the five instruments used to collect the data for this study were reported. Overall, the evidence suggests that the instruments were valid and reliable, and therefore the data collected using these instruments were suitable for further analysis. The next section reports the results for the analysis used to examine the relationships between the variables (self-efficacy, anxiety, and beliefs about mathematics).

Table 4.15 Component Correlation Matrix for Scales of the What Is Happening In this Class? Survey (WIHIC)

Factor	Student Cohesiveness	Teacher Support	Involvement	Collaboration	Equity	Personal Relevance
Student Cohesiveness	-	.171	.225	.399	.330	.247
Teacher Support		-	.294	.428	.417	.377
Involvement			-	.354	.392	.335
Collaboration				-	.447	.345
Equity					-	.436
Personal Relevance						-

N= 157 teachers in 2 higher education institutes.

4.3 Descriptive analysis: Self-reports of anxiety, self-efficacy, beliefs and learning environment perceptions

To provide an overview of the current status of Emirati pre-service teachers' anxiety, teaching efficacy, beliefs and perceptions of the learning environment, the second research objective was:

To examine Emirati pre-service teachers':

a. mathematics anxiety;
b. mathematics teaching anxiety;
c. self-efficacy for teaching mathematics;
d. beliefs about mathematics; and
e. perceptions of the learning environment

As discussed in Chapter 3, the data for each survey was used to calculate the skewness, kurtosis, means, and standard deviation. A box and whisker plots was also developed to represent the variation of responses for each scale. This section reports these descriptive statistics for the data collected using each of the surveys: mathematics anxiety (Section 4.3.1), mathematics teaching anxiety (Section 4.3.2), teaching self-efficacy (Section 4.3.3), beliefs about mathematics (Section 4.3.4), and perceptions of the learning environment (Section 4.3.5).

4.3.1 Mathematics Anxiety

Descriptive statistics were generated for each of the five Mathematics Anxiety scales: Anxiety caused by: Mathematics Learning, Mathematics Evaluation; Numerical Tasks; Mathematics in Real-life; and Non-Mathematics Situations. Table 4.16 reports the skewness, kurtosis, means, and standard deviations, for each of these scales and Figure 4.1 provides a box and whiskers plot to portray the variation in responses.

Table 4.16 Descriptive Statistics for the Anxiety for Mathematics Survey (AMS), including the Skewness, Kurtosis, Mean, and Standard Deviation

Scale	Skewness	Kurtosis	Mean	Std. Deviation
Anxiety - Mathematics Learning	.33	-.81	2.31	.90
Anxiety - Mathematics Evaluation	.10	-.97	2.95	1.05
Anxiety - Numerical Tasks	.82	-.11	2.05	.91
Anxiety - Mathematics in Real-life Situations	.56	-.43	2.25	.90
Anxiety - Non-Mathematics Situations	.51	-.37	2.32	.88

N = 176 pre-service teachers in 2 higher education institutes.

The skewness indices ranged between 0.10 and 0.82. This was deemed to be acceptable, based on Kline's (2010) recommendation (that the skew indices should be below an absolute value of 3.0). Further, the kurtosis indices ranged from -0.11 to -0.97, below the recommended cut-off (Kline, 2010). Given that the skewness and kurtosis all were within Kline's (2010) recommendations, the univariate normality in the data were supported. This provides evidence to support the suitability of the data for further analysis.

The means for all of the scales were fell between 2.05 and 2.95, and below the midpoint of 3.00. The responses to the items indicate that pre-service teachers' mathematics anxiety was moderate, with pre-service teachers rating their Anxiety caused by Mathematics Evaluation the highest (mean=2.95) for the five scales. Based on the descriptors used in the response format, teachers' rated their mathematics mean anxiety to be a little to somewhat anxious. The standard deviations for the five scales ranged between 0.88 and 1.05.

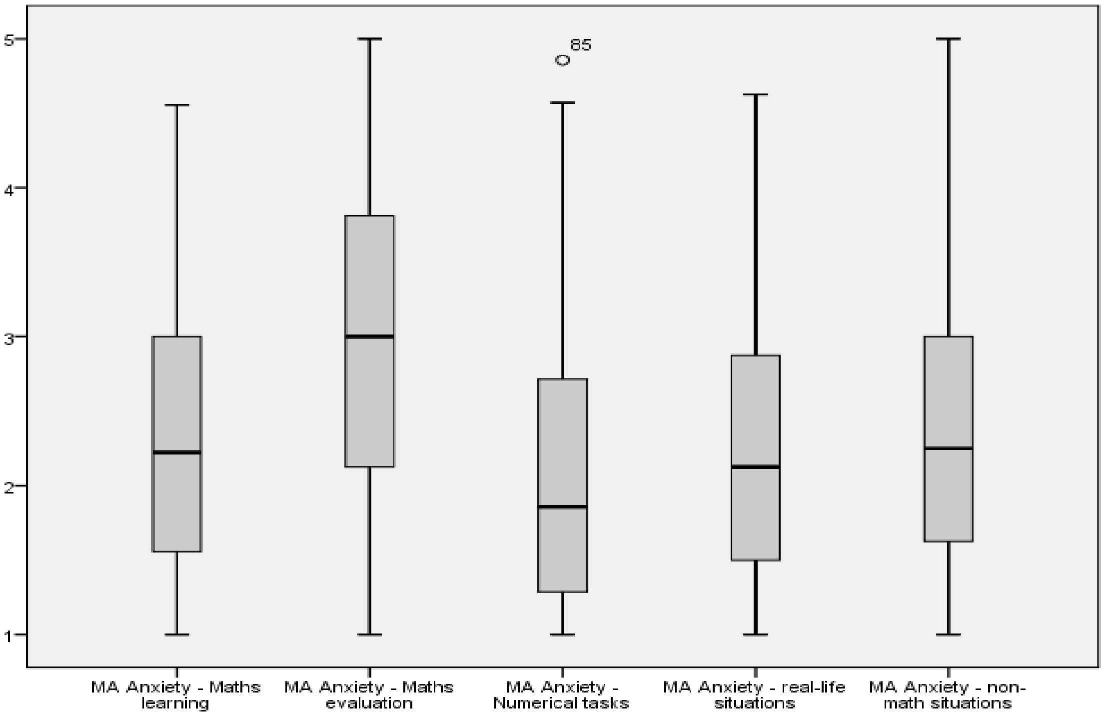

Figure 4.1 Box and Whiskers Plot for Scales of the Anxiety for Mathematics scale

The box and whiskers plot, see Figure 4.1, shows the variation in responses. For all five scales, some participants were anxious or very anxious about mathematics, with at least 50% of participants indicating that they were somewhat or more anxious for three out of the four Mathematics Anxiety scales. Interestingly, participants responded similarly to the scale with analogous situations, indicating a similar anxiety for other subjects and activities required for their degree.

4.3.2 Mathematics Teaching Anxiety

The descriptive statistics for the three scales of the Mathematics Teaching Anxiety survey (Anxiety caused by; Content Knowledge, Teaching Mathematics, Methodological Knowledge) were generated. Table 4.17 presents the skewness, kurtosis, mean, and standard deviation for each of these scales.

Table 4.17 Descriptive Statistics for the Teaching Anxiety for Mathematics Survey (TAMS), including the Skewness, Kurtosis, Mean, and Standard Deviation

Scale	Skewness	Kurtosis	Mean	Std. Deviation
Anxiety - Content Knowledge	-.36	-.31	3.01	.93
Anxiety - Teaching Mathematics	-.14	-.74	2.97	1.07
Anxiety - Methodological Knowledge	-.66	.30	3.50	.93

N = 168 pre-service teachers in 2 higher education institutes.

The skewness indices ranged between -0.66 and 0.62. This was deemed to be acceptable, based on Kline’s (2010) recommendation (that the skew indices should be below an absolute value of 3.0). Further, the kurtosis indices ranged from -0.74 to 0.30, below recommended the cut-off (Kline, 2010), thereby supporting the univariate normality in the data.

The means for all three TAMS scales fell between 2.97 and 3.50, indicating that pre-service teachers experience moderate levels of teaching mathematics anxiety. Interestingly, these pre-service teachers reported higher levels of Teaching mathematics anxiety than they did mathematics anxiety (see Table 4.16). The standard deviations range between 0.93 and 1.07.

The box and whisker plot for the scales of the TAMS (Figure 4.2) shows that, for two of the scales, Anxiety caused by Content Knowledge and Teaching Mathematics, approximately 50% of the participants reported being in the more anxious end of the scale for the Anxiety caused by Methodological Knowledge, approximately 75% of the participants reported being at the more anxious end of the scale, with several outliers below the first quartile.

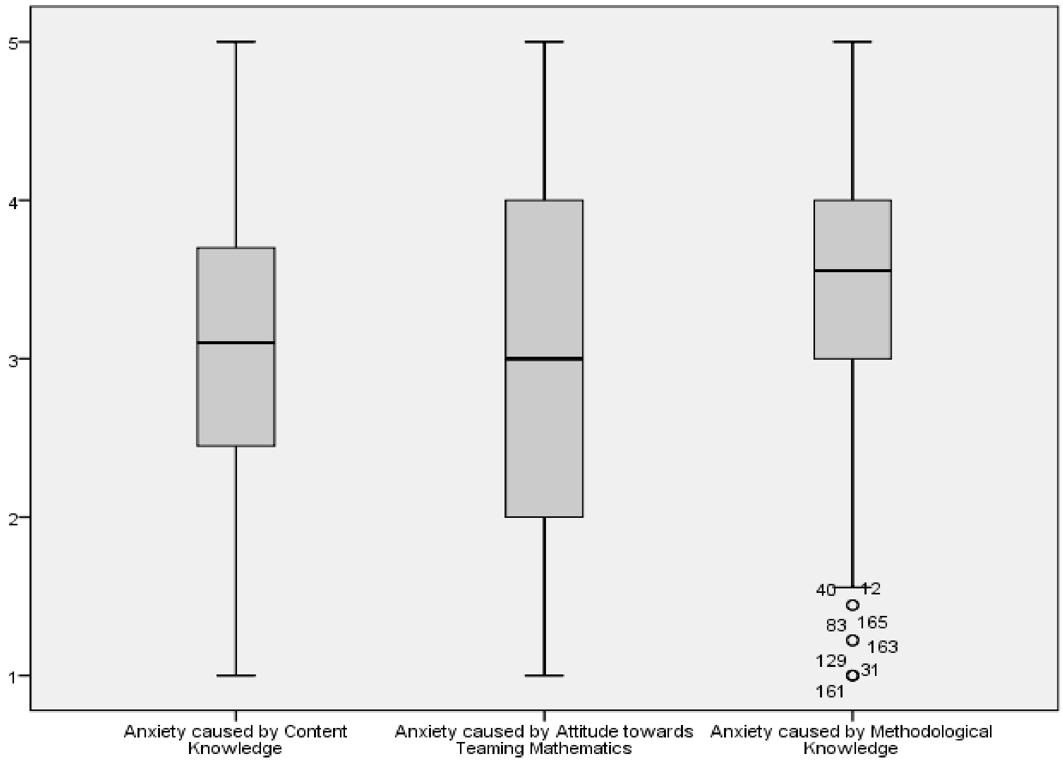

Figure 4.2 Box and Whiskers Plot for Scales of the Teaching Anxiety for Mathematics scale

4.3.3 Self-efficacy for Teaching Mathematics

The skewness, kurtosis, mean, and standard deviation for the three dimensions related to self-efficacy (Pedagogy in Mathematics, Efficacy for Teaching Mathematics Content, and Self-confidence) are reported in Table 4.18 and a portrayal of the variations are shown in Figure 4.2. The skewness indices ranged between .88 and .62, and the kurtosis indices ranged from -0.31 to 0.14. These results supported the univariate normality in the data.

Table 4.18 Descriptive Statistics for the Modified Self-Efficacy for Teaching Mathematics Instrument (M-SETMI), including the Skewness, Kurtosis, Mean, and Standard Deviation

Scale	Skewness	Kurtosis	Mean	Std. Deviation
Pedagogy in Mathematics	-.87	-.31	3.54	.87
Mathematics Content	-.88	.14	3.49	.79
Self-Confidence	.62	.14	2.71	.97

N = 160 pre-service teachers in 2 higher education institutes.

The means for the three scales were between 2.71 and 3.54, suggesting that pre-service teachers held moderate self-efficacy beliefs for teaching mathematics. The standard deviations for the three scales were between 0.79 and 0.97.

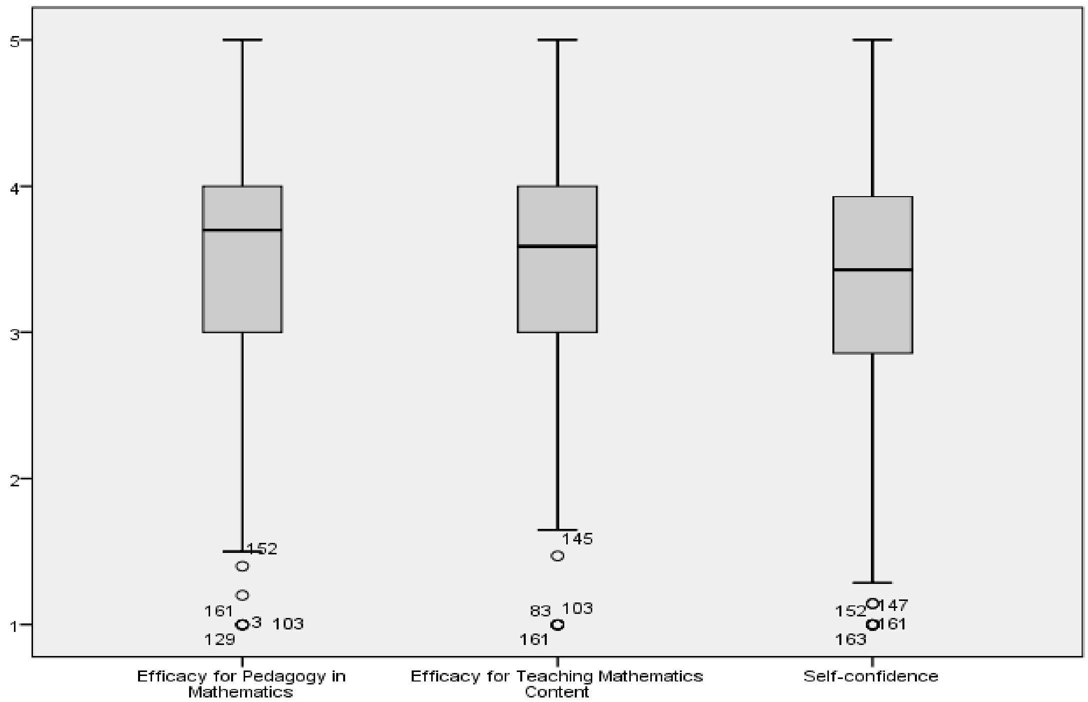

Figure 4.3 Box and Whiskers Plot for Scales of the Modified Self-Efficacy for Teaching Mathematics scale

The box and whiskers plot, depicted in Figure 4.3, shows that approximately 75% of participants self-reported above the mid-point of 3 for each of the scales, that is, the agree end of the response continuum (‘I can…’). Although, these results suggest that the pre-service teachers held generally self-efficacy beliefs, the outliers below the first quartile for each scale, indicate that some pre-service teachers reported very low self-efficacy beliefs.

4.3.4 Beliefs about Mathematics

The skewness, kurtosis, mean, and standard deviation are reported in Table 4.19, for the three BAMS scales (Pedagogy in Mathematics, Teaching Mathematics Content, and Self-confidence).

Table 4.19 Descriptive Statistics for the Beliefs about Mathematics Survey (BAMS), including the Skewness, Kurtosis, Mean, and Standard Deviation

Scale	Skewness	Kurtosis	Mean	Std. Deviation
Beliefs about the Nature of Mathematics	-.07	-.34	2.98	.93
Beliefs about the Usefulness of Mathematics	.78	.90	2.55	.87
Beliefs about Doing Mathematics	-.52	.38	3.32	.80

N = 160 pre-service teachers in 2 higher education institutes.

The skewness indices, which ranged between -0.52 and 0.78, were considered to be acceptable, based on Kline's (2010) recommendation. Further, the kurtosis indices, which ranged from -0.34 to 0.90, also were within Kline's (2010) recommendations. Means for individual BAMS scales, reported in Table 4.19, ranged from 2.55 to 3.32, indicating that pre-service teachers held moderately traditional beliefs about mathematics. The standard deviations for the three scales were between 0.80 and 0.93.

The results indicate that approximately 50% of the participants reported more traditional beliefs towards the Nature of Mathematics, and 75% of the participants reported more traditional beliefs towards Doing Mathematics. Conversely, 25% of the participants held more traditional beliefs about the Usefulness of Mathematics. Figure 4.4 shows the range of responses.

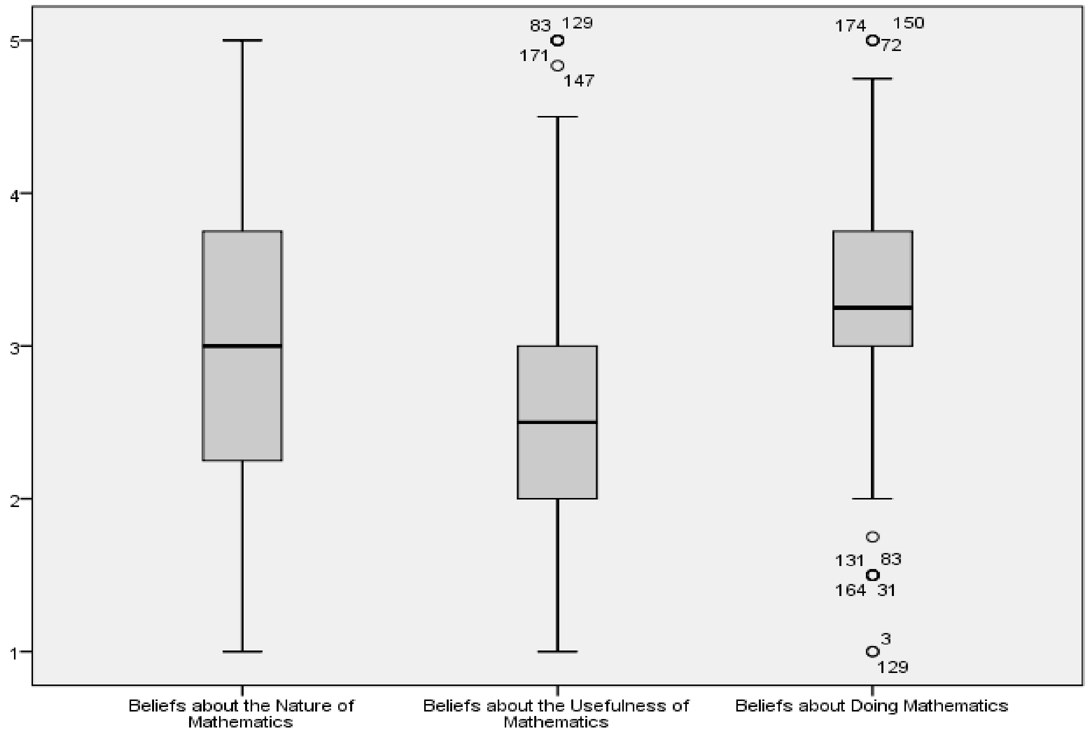

Figure 4.4 Box and Whiskers Plot for Scales of the Beliefs about Mathematics scale

4.3.5 Perceptions of the learning environment.

The skewness, kurtosis, mean, and standard deviation, reported in Table 4.20, for the six WIHIC scales were generated. The skewness indices ranged between -0.47 and 0.07, which was deemed to be acceptable, based on Kline's (2010) recommendation. Further, the kurtosis indices, which ranged from -0.35 to 0.10, all were below the cut-off. Given that the skewness and kurtosis all were within Kline's (2010) recommendations, the univariate normality in the data were supported.

The means for individual the scales, ranged from 3.48 to 3.79, indicating that the pre-service teachers held moderately positive perceptions of their mathematics learning environments. The standard deviations range between 0.81 and 0.91. Approximately 75% of participants reported perceptions of the learning environment to be above the mid-point of 3 for all six scales, indicating that the events specified by the scales happened more often than not. Figure 4.5 illustrates the range of responses.

Table 4.20 Descriptive Statistics for the What Is Happening In this Class? Survey (WIHIC), including the Skewness, Kurtosis, Mean, and Standard Deviation

Scale	Skewness	Kurtosis	Mean	Std. Deviation
Student Cohesiveness	-.47	.10	3.79	.85
Teacher Support	-.17	-.06	3.48	.88
Involvement	-.22	-.35	3.55	.91
Collaboration	-.17	-.17	3.62	.86
Equity	-.17	-.15	3.60	.84
Personal Relevance	.07	-.30	3.54	.81

N = 157 pre-service teachers in 2 higher education institutes.

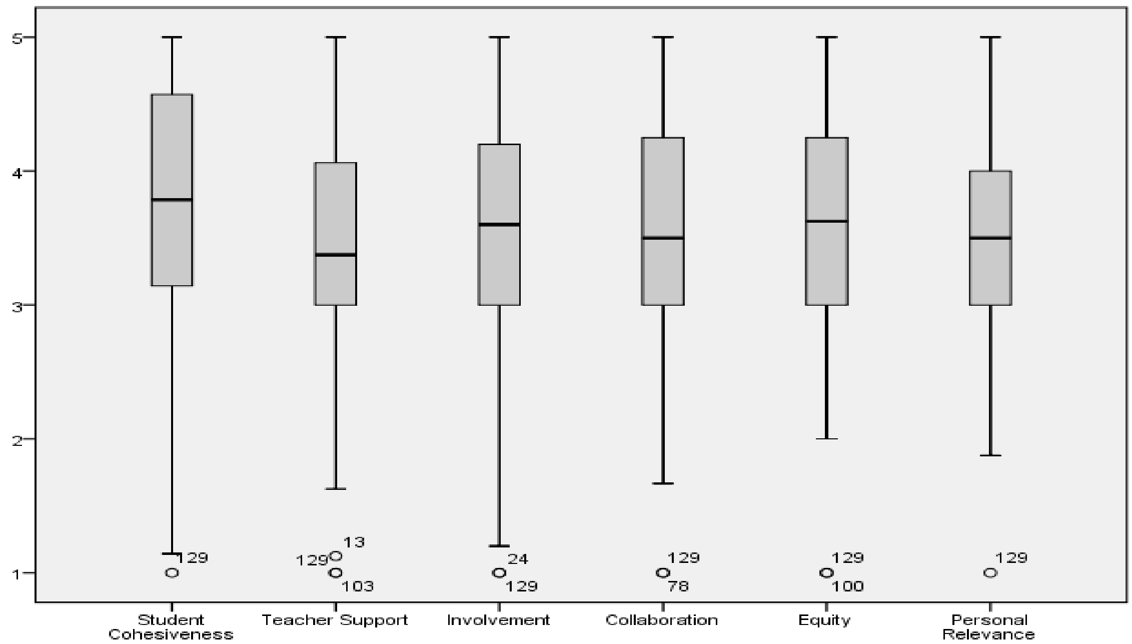

Figure 4.5 Box and Whiskers Plot for Scales of the What is Happening in this Class? (WIHIC)

4.4 Relationships between pre-service teachers' reports of self-efficacy, anxiety, and beliefs about mathematics

The matched data collected from 157 preservice teachers was analysed, using simple correlation and multiple regression to address the third research objective which was:

To examine whether relationships exist between pre-service teachers self-efficacy towards teaching the new mathematics and their:

a. anxiety towards mathematics in general;
b. anxiety towards teaching mathematics; and
c. beliefs about the nature of mathematics.

As described in Chapter 3, simple correlation analysis was used to provide information about bivariate association between the different variables, and multiple regression analysis was used to examine how much variance in the dependent variables the independent variable were able to explain. For this research objective, the independent variables were the pre-service teacher's mathematics anxiety, their anxiety for teaching mathematics, and their beliefs about mathematics. Self-efficacy was used as the dependent variable. To provide information about the unique contribution of the pre-service teachers' anxiety and beliefs about the nature of mathematics to their self-efficacy, the beta values were examined. This section reports on the relationships found between pre-service teachers' self-efficacy and their: anxiety towards mathematics in general (reported in Section 4.4.1); anxiety towards teaching mathematics (reported in Section 4.4.2); and beliefs about mathematics (reported in Section 4.4.3).

4.4.1 Relationships between Pre-service Teachers Self-efficacy and their Mathematics Anxiety

The results for the simple correlation and multiple regression analyses found statistically significant relationships for only one of the teaching self-efficacy scales, Self-confidence. The results of the simple correlation analysis, reported in Table 4.21, found that pre-service teachers' reports of self-confidence was statistically significant, and positively related to two of the five AMS scales: Anxiety caused by Mathematics Learning (p<.05), Anxiety caused by Mathematics Evaluation (p<.01). The multiple correlation (R) was .31 and statistically significant (p<.05). Examination of the beta values indicated that three of the five mathematics anxiety scales were statistically significant predictors of pre-service teachers' self-confidence: Anxiety caused by Mathematics Learning ($\beta = -.29, p<.05$); Anxiety caused by Numerical Tasks ($\beta = -.24, p<.05$); and Anxiety caused by Non-mathematics Situations

($\beta = -.24$, $p<.05$). In all three cases, the more anxiety experienced by the pre-service teacher, the less self-confidence they reported. The implications of these results are discussed in Chapter 5.

Table 4.21 Simple Correlation and Multiple Regression Analyses for Associations between Pre-service Teachers' Self-efficacy towards Teaching Mathematics and their Mathematics Anxiety

Modified Self-efficacy for Teaching Mathematics Instrument						
Scale	Pedagogy in Mathematics		Mathematics content		Self-confidence	
	r	β	r	β	r	β
Anxiety - Mathematics Learning	-.05	-.02	-.11	-.09	-.16*	-.29*
Anxiety - Mathematics Evaluation	-.02	.03	-.02	-.02	-.05**	.05
Anxiety - Numerical Tasks	-.13	-.17	-.13	-.20	-.11	-.24*
Anxiety - Mathematics in Real-life Situations	-.08	-.01	-.08	.05	-.02	.19
Anxiety - Non-Mathematics Situations	.03	.11	.03	.17	-.12	-.24*
Multiple Correlation (*R*)		.21		.16		.31*

*$p<0.05$ ** $p<0.01$
N= 157 teachers in 2 higher education institutes.

The other two self-efficacy scales (Pedagogy in Mathematics and Mathematics Content) were not statistically significantly related to any of the five mathematics anxiety scales.

4.4.2 Relationships between Pre-service Teachers Self-efficacy and their Anxiety for Teaching Mathematics

The results for the simple correlation, reported in Table 4.22, indicates that all three teaching self-efficacy scales were statistically significantly and positively related to one TAMS scale; the Anxiety caused by Methodological Knowledge ($p<.01$). The multiple correlation (R) between the three scales of the Teaching Anxiety for Mathematics was positive and statistically significant for all three self-efficacy scales ($p<.01$). To examine which of the anxiety scales were independent predictors of pre-service teaching self-efficacy, the beta scores were interpreted. As with the simple correlation analysis, one TAMS of the three TAMS scales, Anxiety caused by Methodological Knowledge, was a statistically significant ($p<.001$) and positive predictor of all three self-efficacy scales. This positive relationship suggests that the more anxiety pre-service teachers report with respect to their methodological knowledge, the higher their self-efficacy. These findings are discussed further in Chapter 5.

Table 4.22 Simple Correlation and Multiple Regression Analyses for Associations between Pre-service Teachers' Self-efficacy towards Teaching Mathematics and their Anxiety towards Teaching Mathematics

Modified Self-efficacy for Teaching Mathematics Instrument						
Scale	Pedagogy in Mathematics		Mathematics content		Self-confidence	
	r	β	r	β	r	β
Anxiety - Content Knowledge	.02	-.17	.03	-.13	.01	-.13
Anxiety - Methodological Knowledge	.52**	.64**	.40**	.47**	.40**	.50**
Anxiety - Teaching Mathematics	-.03	-.18	.04	-.07	-.05	-.16
Multiple Correlation (*R*)		.58**		.43**		.45**

*p<0.05 ** p<0.01
N= 157 teachers in 2 higher education institutes.

4.4.3 Relationships between Pre-service Teachers' Self-efficacy and their Beliefs about Mathematics

The results of the simple correlation analysis, reported in Table 4.23, suggests that there were statistically significant relationships between all three beliefs scales and pre-service teachers' self-confidence. The Beliefs about the Nature of Mathematics scale was statistically significant and positively related to one self-efficacy scale, Self-efficacy for Mathematics Content (p<.01). The Beliefs about the Usefulness of Mathematics scale was statistically significant (p<.01) and positively related to all three self-efficacy scales. Finally, the Beliefs about Doing Mathematics scale was positively and statistically significantly (p<.01) related to all three self-efficacy scales.

Table 4.23 Simple Correlation and Multiple Regression Analyses for Associations between Pre-service Teachers' Self-efficacy towards Teaching Mathematics and their Beliefs about Mathematics

Modified Self-efficacy for Teaching Mathematics Instrument						
Scale	Pedagogy in Mathematics		Mathematics Content		Self-confidence	
	r	β	r	β	r	β
Beliefs about the nature of mathematics	.12	-.04	.25**	.11*	-.03	-.12
Beliefs about the usefulness of mathematics	.69**	.49**	.69**	.56**	.46**	.46**
Beliefs about doing mathematics	.63**	.33**	.54**	.17*	.29**	.03
Multiple Correlation (*R*)		.74**		.71**		.47**

*$p<0.05$ ** $p<0.01$
N= 157 teachers in 2 higher education institutes.

The multiple correlation (*R*) for each of the beliefs and self-efficacy scales was positive and statically significant ($p<.01$). To examine which of the beliefs scales were independent predictors of self-efficacy, beta values were interpreted. The results indicated that two of the three beliefs scales were statistically significantly ($p<.01$) related to pre-service teachers' self-efficacy with respect to pedagogy in mathematics: Beliefs about the Usefulness of Mathematics and Beliefs about Doing Mathematics. All three beliefs scales were found to be statistically significant ($p<.05$) predictors of teachers' self-efficacy with respect to mathematics content, Finally, one of the beliefs scales, Beliefs about the Usefulness of Mathematics, was positively and significantly ($p<.01$) related to pre-service teachers' self-confidence. These findings suggest that the more traditional the beliefs that pre-service teachers hold, the higher their self-efficacy. These findings are discussed further in chapter 5.

This section has reported on the relationships between Pre-service Teachers Self-efficacy and their Mathematics Anxiety, Anxiety for Teaching Mathematics, a Beliefs about Mathematics. In the next section, the differences between year levels of pre-service teachers for mathematics anxiety, mathematics teaching anxiety, teaching self-efficacy and beliefs about mathematics are reported.

4.5 Differences for Year Groups: Anxiety, Beliefs about Mathematics and Self-efficacy

This study also sought to determine whether the time spent in a teacher education programme could affect how pre-service teachers feel and believe about mathematics. As such, the fourth research objective was to:

> Investigate whether pre-service teachers in different year levels differ in terms of:
>
> a. anxiety towards mathematics in general;
> b. anxiety towards teaching mathematics;
> c. beliefs about the nature of mathematics; and
> d. self-efficacy for teaching mathematics.

Multivariate analysis of variance (MANOVA), carried out separately for data collected using four of the five surveys (AMS, TAMS, M-SETMI and BAMS), was used to examine whether differences existed for pre-service teachers across the year groups. The analyses was conducted with year level as the independent variable and the scales of the survey in question as the dependent variable.

Once it was determined that the significance level of the Wilk's Lambda was less than .05, the between subject effects and ANOVA results were interpreted. Given that there were more than two groups, post-hoc testing was carried out to examine whether there were statistically significant differences between specific groups. To guard against the possibility of an increased Type 1 error, Bonferonni adjustment was used.

The Wilks Lambda for three of the four surveys, the AMS, TAMS and BAMS, reported no significant difference between the year levels, therefore the univariate ANOVA was not interpreted. See Appendix 10 for the tabulated data for these instruments. Therefore, this section details the differences, between the four year levels of the Bachelor of Education programmes at the two higher education institutes for the M-SETMI instrument only.

4.5.1 Differences in Year Level for the Variables

The only statistically significant difference between year levels reported, is for the Self-confidence scale of the M-SETMI (F=3.29, p<.05). Results of the post hoc tests indicated that, of the six sets of possible differences, only one pair was statistically significant, the difference between students in year 1 and year 2. The effect size, reported in Table 4.25, for this difference was 0.57 which, according to Cohen's (2011) criteria, can be considered moderate. An examination of the means indicates that the self-confidence levels for teaching mathematics for second year students was higher than for first year students (see Table 4.24).

Table 4.24 Average Item Mean, Average Item Standard Deviation and MANOVA Results for Differences between Years 1 to 4 in Teaching Self-efficacy using the Individual Student as the Unit of Analysis

	Average Item Mean				Average Item Standard Deviation				Difference between Years
Scale	Year 1	Year 2	Year 3	Year 4	Year 1	Year 2	Year 3	Year 4	F
Pedagogy in Mathematics	3.51	3.49	3.58	3.65	0.87	0.73	0.99	1.27	0.17
Mathematics content	3.50	3.42	3.63	3.35	0.63	0.67	0.90	1.39	0.74
Self-confidence	3.11	3.42	3.63	2.38	1.02	0.90	0.95	1.09	3.29*

***p<0.01*
N=38 students in Year 1, 70 students in Year 2, 44 students in Year 3, and 11 students in Year 4.

Table 4.25 Effect Size and Tukey's HSD Multiple Comparison for Statistical Significance of Difference Between each Pair of Years for Teaching Self-efficacy

	Effect Size & Tukey HSD					
Scale	Year 1-Year 2	Year 2-Year 3	Year 3-Year 4	Year 1-Year 4	Year 1 – Year 3	Year 2-Year 4
Pedagogy in Mathematics	0.02	-0.10	-0.06	-0.13	-0.08	-0.15
Mathematics content	0.13	-0.26	0.23	0.14	-0.16	0.06
Self-confidence	0.57*	0.15	0.31	0.69	0.42	0.18

**p<0.05*
N=38 students in Year 1, 70 students in Year 2, 44 students in Year 3, and 11 students in Year 4.

This section has reported on the difference between year levels of pre-service teachers for mathematics anxiety, mathematics teaching anxiety, teaching self-efficacy and beliefs about mathematics, based on the data collected for Research Objective 4. The next section, (Section 4.6), reports the relationships between pre-service teachers' perceptions of the learning environment and their mathematics anxiety, mathematics teaching anxiety, teaching self-efficacy and their beliefs about mathematics.

4.6 Relationship between perceptions of the learning environment and anxiety, beliefs about mathematics and self-efficacy

To examine whether relationships exist between pre-service teachers' perceptions of the learning environment and the other variables, the data collected was analysed using simple correlation and multiple regression analyses. Therefore, the fifth research objective was to:

> Examine whether the learning environment perceived by pre-service teachers is related to their:
>
> a. anxiety towards mathematics in general;
> b. anxiety towards teaching mathematics;
> c. beliefs about the nature of mathematics; and
> d. self-efficacy for teaching mathematics.

For this research objective, the independent variables was pre-service teacher's mathematics anxiety, their anxiety for teaching mathematics their beliefs about mathematics, and their self-efficacy. The pre-service teachers' perceptions of their mathematics learning environment was used as the dependent variable. To provide information about the unique contribution of the pre-service teachers' anxiety, beliefs and self-efficacy to their perceptions of the learning environment, the beta values were examined. This section reports on the relationships reported between pre-service teachers' perceptions of the mathematics learning environment and their: mathematics anxiety (reported in Section 4.6.1); anxiety for teaching mathematics (reported in Section 4.6.2); teaching self-efficacy (reported in Section 4.6.3); and beliefs about mathematics (reported in Section 4.6.4).

4.6.1 Relationships between the Learning Environment and Mathematics Anxiety

The results of the simple correlation analysis between pre-service teachers' perceptions of the learning environment and their reports of mathematics anxiety found negative and statistically significant relationships ($p<.05$) between: Involvement and Anxiety caused by Mathematics Learning; and Student Cohesiveness and Anxiety caused by Numerical Tasks (see Table 4.26). The multiple correlations between the learning environment scales was statistically significant for three of the five mathematics anxiety scales, these being: Anxiety caused by Mathematics Learning; Anxiety caused by Mathematics Evaluation; and Anxiety caused by Numerical Tasks.

Table 4.26 Simple Correlation and Multiple Regression Analyses for Associations between Perceptions of the Learning Environment and Mathematics Anxiety

Learning Environment Scale	Mathematics Anxiety Scale									
	Anxiety - Maths learning		Anxiety - Maths evaluation		Anxiety - Numerical tasks		Anxiety - Real-life Situations		Anxiety - Non-math Situations	
	r	β	r	β	r	β	r	β	r	β
Student Cohesiveness	-.024	.013	.034	.013	-.167*	-.296**	-.071	-.139	-.119	-.102
Teacher Support	.055	.176	-.018	-.045	.110	.176	.069	.114	-.075	.000
Involvement	-.182*	-.327**	-.135	-.314**	-.027	-.056	-.034	-.088	-.086	-.006
Collaboration	.033	.121	.108	.246*	.013	.061	.029	.060	-.095	-.024
Equity	-.035	.004	.003	-.006	.045	.094	.037	.062	-.128	-.207
Personal Relevance	-.066	-.044	.036	.106	-.004	-.015	-.009	-.023	.029	.215
Multiple Correlation (*R*)		.278*		.271*		.280*		.162		.231

*$p<0.05$ ** $p<0.01$
N= 157 teachers in 2 higher education institutes.

Interpretation of the beta values was used to examine which learning environment scales were independent predictors for these three scales. One of the six learning environment scales, Involvement, was found to be statistically significantly ($p<.01$) and independently related to Anxiety caused by Mathematics Learning. Two of the six learning environment scales, were statistically significantly related to Anxiety caused by Mathematics Evaluation: Involvement ($p<.01$); and Anxiety caused by Numerical

(p<.05). One learning environment scale, Student Cohesiveness, was statistically significantly (p<.01) and independently related to Anxiety caused by Numerical Tasks. In all cases, the statically significant relationships were negative, suggesting that the more frequently pre-service teachers perceived these dimensions to be present in the mathematics learning environment, the less anxiety the reported. These findings are discussed further in chapter 5.

4.6.2 Relationships between the Learning Environment and Anxiety towards Teaching Mathematics

The results of the simple correlation analysis (see Table 4.27) between pre-service teachers' perceptions of the learning environment and their reports of mathematics teaching anxiety found a negative and statistically significant relationship (p<.05) between Involvement and Anxiety caused by Content Knowledge. Positive and statistically significant relationships were found between Anxiety caused by Methodological Knowledge and all six of the learning environment scales: Student Cohesiveness (p<.01); Teacher Support (p<.05) Involvement (p<.01); Collaboration (p<.01); Equity (p<.01); and Personal Relevance (p<.01).

Table 4.27 Simple Correlation and Multiple Regression Analyses for Associations between the Learning Environment and Teaching Anxiety

Learning Environment Scale	Anxiety for Teaching Mathematics Scale (TAMS)					
	Anxiety - Content Knowledge		Anxiety - Methodological Knowledge		Anxiety - Teaching Mathematics	
	r	β	r	β	r	β
Student Cohesiveness	.00	-.06	.30**	-.05	.00	.21*
Teacher Support	-.05	-.10	.17*	-.07	-.17	-.09
Involvement	-.16*	-.35*	.22**	-.40	-.15	.15
Collaboration	.11	.31*	.30**	.15	.07	-.08
Equity	-.01	.01	.28**	.19	.76	.06
Personal Relevance	.03	.14	.26**	.17	.09	.11
Multiple Correlation (R)		.32*		.34**		.32*

*p<0.05 ** p<0.01
N= 157 teachers in 2 higher education institutes.

The multiple correlations between the learning environment scales was statistically significant for all three of the mathematics teaching anxiety scales: Anxiety caused by Content Knowledge ($p<.05$); Anxiety caused by Methodological Knowledge ($p<.01$); and Anxiety caused by Teaching Mathematics ($p<.05$). Interpretation of the beta values indicated that one of the six learning environment scales, Student Cohesiveness, was statistically significantly ($p<.05$) related to Anxiety caused by Teaching Mathematics. Two of the six learning environment scales, Involvement and Collaboration, were statistically significantly ($p<.05$) related to Anxiety caused by Content Knowledge. Statistical significant correlations between these findings are discussed further in chapter 5.

4.6.3 Relationships between the Learning Environment and Self-efficacy

The results of the simple correlation analysis, reported in Table 4.28, between pre-service teachers' perceptions of the learning environment and their self-efficacy found positive and statistically significant ($p<.01$); relationships for both the Pedagogy in Mathematics and Mathematics Content scales. Positive and statistically significant ($p<.01$); relationships were also found between the Self-confidence scale and five of the six learning environment scales, these being: Student Cohesiveness ($p<.01$); Involvement ($p<.01$); Collaboration ($p<.05$); Equity ($p<.01$); and Personal Relevance ($p<.01$).

The multiple correlations between the learning environment scales was statistically significant ($p<.01$) for two of the three M-SETMI scales, Pedagogy in Mathematics and Mathematics Content. Interpretation of the beta values was used to examine which learning environment scales were independent predictors for these two scales. One of the six learning environment scales, Student Cohesiveness, was statistically significant and independently related to both the Pedagogy in Mathematics and Mathematics Content scales, and also for the Self-confidence scale. In all cases, the statistically significant relationships were positive, suggesting that the more frequently pre-service teachers perceived these dimensions to be present in the mathematics learning environment, the more anxiety they reported. These findings are further discussed in chapter 5.

Table 4.28 Simple Correlation and Multiple Regression Analyses for Associations between Perceptions of the Learning Environment and Teaching Efficacy

Learning Environment Scale	Modified Self-Efficacy for Teaching Mathematics Scale (M-SETMI)					
	Pedagogy in Mathematics		Mathematics Content		Self-confidence	
	r	β	r	β	r	β
Student Cohesiveness	.52**	.36*	.40**	.27*	.31**	.21*
Teacher Support	.29**	.00	.22**	.01	.11	-.09
Involvement	.41**	.08	.30**	.00	.28**	.15
Collaboration	.40**	.03	.27**	-.09	.18*	-.08
Equity	.43**	.09	.38**	.19	.26**	.06
Personal Relevance	.37**	.09	.30**	.10	.24**	.11
Multiple Correlation (*R*)		.54**		.43**		.34

*p<0.05 ** p<0.01
N= 157 teachers in 2 higher education institutes.

4.6.4 Relationships between the Learning Environment and Beliefs about Mathematics

The results of the simple correlation analysis (see table 4.29) between pre-service teachers' perceptions of the learning environment and their beliefs about mathematics were negative and statistically significant for the Beliefs about the Usefulness of Mathematics scale and all six learning environment scales: Student Cohesiveness (p<.01); Teacher Support (p<.05) Involvement (p<.01); Collaboration (p<.01); Equity (p<.01); and Personal Relevance (p<.01). The simple correlation analysis also was positive and statistically significant for the Beliefs about the Doing Mathematics scale and all six learning environment scales: Student Cohesiveness (p<.01); Teacher Support (p<.01) Involvement (p<.01); Collaboration (p<.01); Equity (p<.05); and Personal Relevance (p<.01).

The multiple correlations between the learning environment scales was statistically significant (p<.01) for two of the three BAMS scales, Beliefs about the Usefulness of Mathematics and Beliefs about Doing Mathematics. Interpretation of the beta values was used to examine which learning environment scales were independent predictors for these two scales. Two of the six learning environment scales were statistically significant and independently related to Beliefs about the Usefulness of Mathematics: Student Cohesiveness (p<.01); and Personal Relevance (p<.05). Student Cohesiveness was also statistically significant (p<.01) and independently related to Beliefs about Doing Mathematics. In all cases, the statistically significant relationships were positive, suggesting that the more frequently pre-service teachers perceived these dimensions to be present in the mathematics learning environment, the more anxiety they reported.

Table 4.29 Simple Correlation and Multiple Regression Analyses for Associations between the Learning Environment and Pre-service Teachers' Beliefs About Mathematics

Learning Environment Scale	Beliefs About Mathematics Scale (BAMS)					
	Beliefs about the Nature of Mathematics		Beliefs about the Usefulness of Mathematics		Beliefs about Doing Mathematics	
	r	β	r	β	r	β
Student Cohesiveness	.081	-.037	-.519**	.382**	.457**	.214**
Teacher Support	.118	.065	-.173*	-.145	.212**	-.031
Involvement	.144	.105	-.380**	.078	.253**	-.145
Collaboration	.129	.051	-.308**	-.080	.249**	.099
Equity	.124	-.035	-.410**	.147	.163*	.145
Personal Relevance	.106	.029	-.368**	.189*	.275**	.161
Multiple Correlation (R)		.162		.540**		.497**

*p<0.05 ** p<0.01
N= 157 teachers in 2 higher education institutes.

This section (Section 4.6), has reported the relationships between pre-service teachers' perceptions of the learning environment and their mathematics anxiety, mathematics teaching anxiety, teaching self-efficacy and their beliefs about mathematics. The chapter will be summarised in the next section (Section 4.7).

4.7 Chapter Summary

This chapter presented the results of the data analysis used to address each of the five research objectives in this study. The data were collected from preservice teachers at two higher education institutes using five instruments that were either modified from existing surveys or developed for the purpose of this study.

As a first step, evidence to support the reliability and validity of the five instruments used in this study (AMS, TAMS, M-SETMI, BAMS, and WIHIC) was provided. The multivariate normality and sampling adequacy of the data were examined for each instrument. Bartlett's test of sphericity indicated that the Chi squared value was statistically significant ($p<0.001$), and the Kaiser-Maiyer-Olkin measure of adequacy of each instrument was high, confirming the appropriateness of the data for further analysis. Principal axis factor analysis with oblique rotation was used to examine the factor structure of the instruments, and any problematic items were removed from further analysis, improving the internal consistency reliability and factorial validity. The percentage of variance and eigenvalue for each scale were also examined and found to satisfy Kaiser's (1960) recommendation that values be greater than 1. The Cronbach alpha reliability coefficient was used as an index of scale internal consistency. As per Cohen, Manion, and Morrison's (2000) advice, a cut-off value of 0.6 was required for the current study. Oblique rotation in exploratory factor analysis was conducted to represent the interconnectivity of components, and as per Brown's (2015) advice, factor correlations were required to be under 0.80. Overall, the factor loadings, the internal consistency measures, and the discriminant validity for the five scales were supported, indicating that the data collected from the five instruments utilised in this study could be considered valid and reliable in this context.

To address the second research objective, the skewness, kurtosis, means, and standard deviation were calculated, to provide descriptive statistics for each of the five instruments. The skewness and kurtosis indices were deemed to be acceptable for all instruments, as per Kline's (2010) recommendation, supporting the univariate normality data for further analysis. The means for each scale were examined and found that mathematics anxiety was moderate (a little to somewhat anxious), with Anxiety caused by Mathematics Evaluation rated the highest (mean = 2.95), indicating higher anxiety for this scale. Teaching mathematics anxiety was also moderate, although slightly higher than mathematics anxiety (scale means ranged from 2.97 to 3.50). Moderate self-efficacy for teaching (scale means ranged from 2.71 to 3.54) was reported; 75% of participants self-reported above the mid-point of 3, indicating positive self-efficacy, however outliers with low self-efficacy have reduced the mean overall. Pre-service teachers also responded moderately to the beliefs about mathematics items, although two or three times more participants reported traditional beliefs about the Nature of Mathematics and Doing Mathematics, than traditional beliefs about the Usefulness of Mathematics. Pre-service teachers' perceptions of the learning environment were moderately positive (scale means ranged from 3.48 to 3.79). Box and whisker plots were presented to show the variation in responses for all instruments.

Simple correlation and multiple regression analyses were used to examine the relationship between pre-service teachers' self-efficacy and their anxiety and beliefs about mathematics to address the third research objective. The results indicated that, for the pre-service teacher participants, self-efficacy was related to mathematics anxiety, teaching anxiety, and beliefs about mathematics.

For Research Objective 4, Multivariate analysis of variance (MANOVA), involving four of the five surveys (AMS, TAMS, M-SETMI and BAMS), was used to compare the differences in responses between students from students in different year groups. The only statistically significant difference between year levels reported, was for the Self-confidence scale of the M-SETMI, which showed a difference between year 1 and year 2, with the self-reported confidence levels for teaching mathematics of Year 2 students higher than those of Year 1 students.

Finally, simple correlation and multiple regression analyses were used to examine the relationship between pre-service teachers' perceptions of their mathematics learning environment and the other variables, for Research Objective 5. The results indicated that statistically significant relationships were present between all six WIHIC scales and mathematics anxiety, teaching anxiety, self-efficacy and beliefs.

The next chapter, Chapter 5, provides a discussion of these results and the educational implications of them. Chapter 5 also describes the research limitations and the significance of the research, and provides a summary of recommendations.

Chapter 5

DISCUSSION, CONCLUSIONS, AND RECOMMENDATIONS

5.1 Introduction

This study investigated Emirati pre-service teachers' mathematics anxiety, their anxiety and self-efficacy for teaching mathematics, their beliefs about the nature of mathematics and their perceptions of the learning environment. The study took place amidst a period of major educational reform and, as a result, the pre-service teachers were required to teach in decidedly different ways to which they had been taught themselves.

Data were collected from184 Emirati pre-service teacher participants enrolled at two higher education institutes in Abu Dhabi, UAE. Of these, matched data from 157 participants across all five surveys was complete and useable. These pre-service teachers are enrolled in Bachelor of Education programmes. Approximately 21 percent were in their first year of the programme, 44 percent were in their second year and 28 percent and 7 percent in their third and fourth years, respectively. The participants were predominantly between 18 and 27 years of age, and mostly female. The eight male participants made up 4 percent of the sample, which is representative of the total male pre-service teacher population in Abu Dhabi.

Data collection involved the administration of five surveys that were either developed for the purpose of this study or modified from previously validated surveys. The surveys sought to assess the mathematics anxiety, the teaching anxiety for mathematics, the self-efficacy for teaching mathematics, the beliefs about mathematics and the perceptions of the mathematics learning environment of the pre-service teachers.

This chapter starts by providing a summary and discussion of the results (Section 5.2). The educational implications (Section 5.3), research limitations (Section 5.4), and a summary of recommendations (Section 5.5) are then provided. The chapter goes on to outline the significance of the research (Section 5.6), and finishes with some concluding remarks (Section 5.7).

5.2 Summary and Discussion of Results

This section provides a summary and discussion of the results pertaining to each of the research objectives. The section has five subsections, corresponding to each of the five research objectives (first introduced in Section 1.4 of Chapter 1). The section is organised under the following headings:

- Validation of the new or modified surveys (Section 5.2.1);
- Descriptions of pre-service teachers' anxiety, self-efficacy, beliefs, and perceptions of the learning environment (Section 5.2.2);
- Relationships between pre-service teachers self-efficacy and their anxiety and beliefs (Section 5.2.3);
- Differences between the anxiety, self-efficacy and beliefs of pre-service teachers in different year levels (Section 5.2.4); and
- Relationships between learning environment perceptions and pre-service teachers' anxiety, self-efficacy and beliefs (Section 5.2.5).

5.2.1 Validation of the New or Modified Surveys

The first research objective sought to:

Modify and validate scales to assess:

a. pre-service teachers' anxiety towards mathematics in general;
b. pre-service teachers' anxiety towards teaching mathematics;
c. pre-service teachers' self-efficacy towards teaching the 'new mathematics'
d. pre-service teachers' beliefs about the nature of mathematics;
e. pre-service teachers' perceptions of their mathematics learning environments.

Once the surveys had been developed (described in Chapter 3), data collected from the pre-service teachers was used to provide evidence to support the reliability and validity of the instruments in terms of their factor structure, internal consistency, and reliability. This section summarises and discusses the evidence used to support the reliability and validity of each of the surveys used in the study: Anxiety for Mathematics Survey (AMS; Section 5.2.1.1); Teaching Anxiety in Mathematics Survey (TAMS; Section 5.2.1.2); Modified Self-efficacy for Teaching Mathematics Instrument (M-SETMI; Section 5.2.1.3); Beliefs About Mathematics Survey (BAMS; Section 5.2.1.4); and, What Is Happening In this Class? survey (WIHIC; Section 5.2.1.5).

5.2.1.1 Anxiety for Mathematics Survey (AMS)

The AMS was developed for the purpose of this study to assess the participants' self-reported levels of mathematics anxiety. The AMS drew on existing mathematics anxiety instruments, including 29 existing or modified items from the MARS A-MARS (Alexander & Martray, 1989; Peker, 2009b; Yazici et al., 2011), R-MARS (Suinn & Winston, 2003), and R-MANX (Plake & Parker, 1982), both of which were organised into four scales: Anxiety caused by Mathematics Learning; Anxiety caused by Mathematics Evaluation; Anxiety caused by Numerical Tasks; and Anxiety caused by Mathematics in Real-life Situations. A fifth scale, Anxiety caused by Non-mathematics Situations, was developed to examine pre-service teachers' anxiety related to mathematics specific anxiety as opposed to general anxiety. Additional items (*n*=21) were developed by the researcher to ensure that each scale had equal representation (see Section 3.5.1 for details of the instrument development). The key findings for the validity and reliability of the AMS are summarised below.

- Once the problematic items (*n*=10) were removed during the item analysis, the remaining 40 items (in five scales), all had a factor loading of at least .40 on its a *priori* scale and less than .40 on all other scales. The eigenvalues for all scales were above 1 and the total proportion of variance accounted for was 61.27%.
- The internal consistency reliability coefficients for the five AMS scales, calculated using Cronbach alpha reliability, ranged from .88 to .91.

- The discriminant validity results indicated that all five AMS scales were distinctive, with the highest correlation between factors being .48.

Overall, the findings suggest that the AMS questionnaire is a sound and reliable survey for future research into the mathematics anxiety of pre-service teachers in this context. The AMS, while drawing, in part, on existing instruments (see Section 3.5.1), is a new instrument that was developed for use in this study. While the statistical data for the instruments from which the AMS drew is limited, the Cronbach alpha for the MARS, R-MARS, and R-MANX instruments ranged from .96 to .98, which is comparable to the results of the current study (Plake & Parker, 1982; F. C. Richardson & Suinn, 1972; Suinn & Winston, 2003). The evidence, summarised above, supported the validity and reliability of the AMS.

5.2.1.2 Teaching Anxiety in Mathematics Survey (TAMS)

The TAMS, developed for the purpose of this study, was used to assess pre-service teachers' anxiety related to teaching mathematics. The descriptions of three of the four scales developed for the MATAS (Peker, 2006), were used as a guide for developing the TAMS, see Table 3.3 in Chapter 3. One item from each of the existing scales was modified for use and an additional 24 new items were developed by the researcher (see Section 3.5.2 for details of the instrument development). The key findings for the validity and reliability of the TAMS are summarised below.

- Problematic items (*n*=5) were removed during the item analysis, leaving a 22-item, three-scale instrument which displayed satisfactory factorial validity. All of the remaining items had a factor loading of at least .40 on its a *priori* scale and less than .40 on all other scales. The eigenvalues for all scales were above 1 and the total proportion of variance accounted for was 62.11%.
- The internal consistency reliability coefficients for the three TAMS scales, calculated using Cronbach alpha reliability, ranged from .82 to .94.
- The discriminant validity results indicated that all three TAMS scales were distinctive, with the highest correlation between factors being .35.

Overall, the evidence provides support for the newly-developed Teaching Anxiety in Mathematics Scale (TAMS). As reported in Chapter 3, the Mathematics Teaching Anxiety Scale (MATAS, Peker, 2006) provided a starting point for the development of the TAMS, with the scale headings and one modified item for each scale being drawn on for the development of the new instrument. Although the majority of the items were new, the Cronbach's alpha measure for each subscale was equal to or greater than those for the original MATAS (Peker, 2006). The results, outlined above, provided strong evidence to support the reliability and validity of the TAMS when used with this sample.

5.2.1.3 Modified Self-efficacy for Teaching Mathematics Instrument (M-SETMI)

The M-SETMI was used in this study to assess pre-service teachers' self-efficacy for teaching mathematics. The key findings for the reliability and validity of the M-SETMI are summarised below.

- The first two scales of the M-SETMI, Efficacy for Teaching Mathematics and Efficacy for Making a Difference, did not assess two distinct constructs, and these scales were, therefore, combined. All of the items, except item 4 which was subsequently removed, had a factor loading of at least .40 on its a *priori* scale and less than .40 on all other scales. This resulted in a 3-scale, 34-item instrument which displayed satisfactory factorial validity. The eigenvalues for all scales were above 1 and the total proportion of variance accounted for was 66.36%.
- The internal consistency reliability coefficients for the three M-SETMI scales, calculated using Cronbach alpha reliability, ranged from .93 to .96.
- The discriminant validity results indicated that the combined scale and the other two scales were distinctive, with the highest correlation between factors being .65.

Overall, the evidence suggests that the M-SETMI was reliable for use with the sample included in this study. The M-SETMI is a modified version of the SETMI instrument, developed originally by McGee (2012) that was adapted for use in the UAE context for this study (see Section 3.5.3 for details on modifications). The SETMI had previously been found to be a valid and reliable measure of two aspects of in-service teacher's self-efficacy: 'Pedagogy in Mathematics' and 'Teaching Mathematics Content' (McGee & Wang, 2014), however criticism that the factor structure is often less distinct for pre-service teachers (Tschannen-Moran & Woolfolk-Hoy, 2007), prompted the separation of 'Pedagogy in Mathematics' items, and the development of three new items, into two scales. These two scales were found to not be distinct in the current study, thereby supporting McGee and Wang's (2014) factor structure. The resulting scale was renamed Pedagogy in Mathematics, as per the original SETMI. The Cronbach's alpha measure for each subscale was equal to or greater than those for the original SETMI (McGee & Wang, 2014). The results, outlined above, provided strong evidence to support the reliability and validity of the M-SETMI when used with this sample.

5.2.1.4 Beliefs About Mathematics Survey (BAMS)

The BAMS was used to assess pre-service teachers' beliefs about mathematics. The development of the BAMS drew on four existing instruments: the Mathematics and Mathematical Educational Values Scale (Durmus & Bicak, 2006); the Maths Beliefs Survey Instrument (MBSI, Austin et al., 1992); the Beliefs about Mathematics Survey (BMS, Aksu et al., 2002); and the Conceptions of Mathematics Inventory-Revised (CMI-R, Briley et al., 2009). Section 3.5.4 details the instrument development. The key findings for the validity and reliability of the BAMS are summarised below.

- Problematic items (n=6) were removed during the item analysis, leaving a 15-item, three-scale instrument which displayed satisfactory factorial validity. All of the remaining items had a factor loading of at least .40 on its a priori scale and less than .40 on all other scales. The eigenvalues for all scales were above 1 and the total proportion of variance accounted for was 65.38%.
- The internal consistency reliability coefficients for the three BAMS scales, calculated using Cronbach alpha reliability, ranged from .82 to .90.
- The discriminant validity results indicated that all three BAMS scales were distinctive, with the highest correlation between factors being .66.

The results, summarised above, present evidence to support the reliability and validity of the BAMS when used with this sample. The original items, drawn from several existing instruments, were modified for language and context from (see Section 3.5.4) and organised into three scales similar to those from the Beliefs about Mathematics Survey instrument (Aksu, Demir & Sumer, 2002). It is notable that this study represented the first use of any such instrument in the UAE, to the author's knowledge, and the first ever use of this version. This study confirmed the three factors measured by the BMS (Aksu et al, 2002), and the internal consistency reliability (Cronbach alpha coefficient) of the BAMS was higher for two of the three scales (Nature of Mathematics and Usefulness of Mathematics) than the original BMS.

5.2.1.5 What Is Happening In this Class survey (WIHIC)

The WIHIC was used in this study to assess Emirati pre-service teachers' perceptions of their recent mathematics learning environments. The WIHIC was originally modified for use in the United Arab Emirates by Afari et al. (2013). This version was modified further for the current study (see Section 3.5.5 for details). The key findings for the validity and reliability of the WIHIC are summarised below.

- Problematic items (n=6) were removed during the item analysis, leaving a 42-item, six-scale WIHIC which displayed satisfactory factorial validity. All of the remaining items had a factor loading of at least .40 on its a *priori* scale and less than .40 on all other scales. The eigenvalues for all scales were above 1 and the total proportion of variance accounted for was 66.47%.
- The internal consistency reliability coefficients for the six WIHIC scales, calculated using Cronbach alpha reliability, ranged from .88 to .91.
- The discriminant validity results indicated that all six WIHIC scales were distinctive, with the highest correlation between factors being .44.

The WIHIC has been used extensively worldwide (see Section 3.5.5), and in the UAE, specifically (Afari et al., 2013). However, this study was the first time the instrument has been used with pre-service teachers in the UAE. It is notable that the results of the present study was comparable to the study carried out by Afari et al (2013) using an

Arabic version of the WIHIC. The evidence, outlined above, supports the validity and reliability of the WIHIC, and therefore provides support for this questionnaire as a sound and reliable survey for future research into the learning environments of pre-service teachers.

Overall, the results provide strong support for the validity and reliability of the five instruments when used with this sample: the Anxiety for Mathematics Survey (AMS), the Teaching Anxiety in Mathematics Survey (TAMS), the Modified Self-efficacy for Teaching Mathematics Instrument (M-SETMI), the Beliefs About Mathematics Survey (BAMS), and the What Is Happening In this Class survey (WIHIC). The Cronbach alpha for all scales were comparable to, or greater than, previously used instruments. This may be due to the rewording of items for language and context. These findings suggest that the data could be used with confidence to address subsequent research objectives.

This section has summarised and discussed the reliability and validity of the five surveys utilised in this study; the Anxiety for Mathematics Survey (AMS), the Teaching Anxiety in Mathematics Survey (TAMS), the Modified Self-efficacy for Teaching Mathematics Instrument (M-SETMI), the Beliefs About Mathematics Survey (BAMS), and the What Is Happening In this Class survey (WIHIC). The next section summarises and discusses the relationships found between pre-service teachers self-efficacy towards teaching the new mathematics and their anxiety towards mathematics in general; anxiety towards teaching mathematics; and beliefs about the nature of mathematics.

5.2.2 Self-reported Anxiety, Self-efficacy, Beliefs and Perceptions of the Learning Environment

The second research objective was to:

> Examine Emirati pre-service teachers':
>
> a. mathematics anxiety;
> b. mathematics teaching anxiety;
> c. self-efficacy for teaching mathematics;

d. beliefs about mathematics; and
e. perceptions of the learning environment

To describe the anxiety, teaching efficacy, beliefs and perceptions of the learning environment as self-reported by the participants, the means, standard deviation, skewness, kurtosis and variations (using box plots) were calculated (see Chapter 3 for details). The responses came from pre-service teachers at two different institutions with one group likely having more mathematics content and mathematics pedagogical courses than the other. The results are summarised and discussed separately for pre-service teachers' responses to each of the surveys: anxiety for mathematics (Section 5.2.2.1); teaching anxiety for mathematics (Section 5.2.2.2), self-efficacy for teaching mathematics (Section 5.2.2.3), beliefs about mathematics (Section 5.2.2.4), and perceptions of the learning environment (Section 5.2.2.5).

5.2.2.1 Anxiety for Mathematics

The means, standard deviation, skewness and kurtosis were generated for the five scales of the AMS. The key findings are summarised below.

- The skewness indices were acceptable, ranging between 0.10 and 0.82.
- The kurtosis indices were acceptable, ranging from -0.11 to -0.97.
- The means for individual AMS scales ranged from 2.05 to 2.95. All means were below the midpoint of 3.00.
- The standard deviations range between 0.88 and 1.05.

The results indicate that the Emirati pre-service teachers that participated in this study were 'a little' to 'somewhat anxious' about mathematics. These results indicate a lower anxiety than anticipated by the researcher, based on experience and past research that has often found high incidences of mathematics anxiety among pre-service teachers. Further, this finding contradicts past research (see for example, Novak & Tassell, 2017; Sloan, 2010). However, it is noted that any mathematics anxiety in pre-service teachers is cause for concern as it has been linked to: mathematics teaching anxiety (Peker & Ertekin, 2011); teaching efficacy (Peker, 2016); beliefs about mathematics (Haciomeroglu, 2013); and negatively related to teacher behaviour and student achievement (Haciomeroglu, 2014; Hadley & Dorward, 2011; Hembree, 1990; Muijs & Reynolds, 2015; Peker & Ulu, 2018). Section 5.3.1 provides information about the educational implications related to these findings.

5.2.2.2 Teaching Anxiety for Mathematics

The means, standard deviation, skewness and kurtosis were generated for the three scales of the TAMS. The key findings are summarised below.

- The skewness indices were acceptable, ranging between -0.66 and -0.14.
- The kurtosis indices were acceptable, ranging from -0.74 to 0.30.
- The means for individual TAMS scales ranged from 2.97 to 3.50.
- The standard deviations range between 0.93 and 1.07.

The results indicate that the Emirati pre-service teachers that participated in this study were neutral in regards to the Anxiety caused by Content Knowledge (3.01) and Anxiety caused by Attitude towards Teaching Mathematics scales (2.97). However, the Anxiety caused by Methodological Knowledge scale was reported as causing the most anxiety, with the mean at 3.50. Over half of the respondents agreed or strongly agreed to feeling anxious for six of the nine items in this scale. These items included anxiety related to: thinking of hands-on mathematics activities for my students; using a variety of mathematics materials in my lessons; thinking about what I want my students to achieve in mathematics and how to get them there; planning ways to differentiate mathematics lessons; planning ways to use real-life examples when teaching mathematics; and thinking about how to turn the rules of mathematics into concrete experiences. This reflects previous findings that pre-service teachers expressed concerned that they will not be able to present mathematics content effectively, explain procedures adequately, nor answer students' questions (Ball, 1988; Romeo, 1987).

This anxiety may be a result of their need to teach in a different way than that which they experienced themselves as school students, as reflected by the items in this scale, and therefore do not have a model for such teaching. Levine (cited in, Peker, 2009b) found that mathematics teaching anxiety decreased by the end of a methods course in which primary pre-service teachers were introduced to instructional practices more consistent with a constructivist philosophy, such as the ‘new’ way required in the context for this study. However, Peker (2009b) found a positive correlation between the requirement to find concrete examples for teaching, as encouraged as part of the reform, and mathematics teaching anxiety. Given this, it would appear that, when pre-service teachers are required to teach based on constructivist values, using concrete examples, such as are endorsed by the Abu Dhabi Education Council, it is important to provide many opportunities to observe and participate in model lessons (Yazici, et al, 2011). Please see Section 5.3.2 for more information regarding the educational implications of these findings.

5.2.2.3 Self-efficacy for Teaching Mathematics

The means, standard deviation, skewness and kurtosis were generated for the three scales of the M-SETMI. The key findings are summarised below.

- The skewness indices were acceptable, ranging between -0.88 and 0.62.
- The kurtosis indices were acceptable, ranging from -0.31 to 0.14.
- The means for individual M-SETMI scales ranged from 2.71 to 3.54.
- The standard deviations ranged from0.79 to 0.97.

The responses to items on the M-SETMI, reported as scale means, indicate that pre-service teachers’ self-efficacy for teaching mathematics was moderately positive, although the mean for self-confidence was below the mid-point of 3. These results are comparable to previous research that found pre-service teachers held moderate self-efficacy beliefs for teaching mathematics (Charalambous et al., 2008). The results suggest that, while the pre-service teachers harboured some anxiety regarding mathematics teaching methodologies (see Section 5.2.2.2), they still had some belief in their ability to teach it effectively.

Given that past research has commonly found a negative relationship between pre-service teachers’ mathematics anxiety and self-efficacy for teaching, and given that the participants of this study reported moderate mathematics anxiety, the reported scale means for self-efficacy could have been expected to be lower. These results, while somewhat positive, are not overwhelming, and, given that high teaching self-efficacy has been linked with positive teacher behaviours and strategies, and subsequently, greater student achievement, it seems fitting that pre-service teacher education be designed to enhance such beliefs. See Section 5.3.3 for educational implications related to these findings.

5.2.2.4 Beliefs about Mathematics

The means, standard deviation, skewness and kurtosis were generated for the three scales of the BAMS. The key findings are summarised below.

- The skewness indices were acceptable, ranging between -0.52 and 0.78.
- The kurtosis indices were acceptable, ranging from -0.34 to 0.90.
- The means for individual BAMS scales ranged from 2.55 to 3.32.
- The standard deviations range between 0.80 and 0.93.

The results indicate that the pre-service teachers had relatively neutral beliefs about mathematics, although they had slightly more traditional beliefs about doing mathematics, and slightly more sophisticated beliefs about the usefulness of mathematics. While these results indicate a less traditional view than anticipated by the researcher, given much past research that found many pre-service teachers to hold naïve views about mathematics (see for example, Briley, 2012; Paolucci, 2015), they do not indicate that Emirati pre-service teachers hold sophisticated beliefs about mathematics. The mean score for Beliefs about the Nature of Mathematics was moderate (2.98), contrasting previous research that found pre-service teachers hold strong traditional beliefs about the same (Jackson, 2008; Szydlik et al., 2003). Past research has also shown that students believe mathematics involves memorising formulas and answers, and producing them upon request; a finding that is supported by the current research in which participants reported the highest mean for the Beliefs about Doing Mathematics scale, suggesting more traditional beliefs. See Section 5.3.4 for the educational implications of these findings.

5.2.2.5 Perceptions of the Learning Environment

The means, standard deviation, skewness and kurtosis were generated for the four scales of the WIHIC. The key findings are summarised below.

- The skewness indices were acceptable, ranging between -0.47 and 0.07.
- The kurtosis indices were acceptable, ranging from -0.35 to 0.10.
- The means for individual WIHIC scales ranged from 3.48 to 3.79.
- The standard deviations range between 0.81 and 0.91.

The results indicate that Emirati pre-service teachers perceptions of their mathematics learning environments during teacher education were, overall, generally positive, with the means reported for all scales between 'sometimes' and 'often'. No comparable research could be located, making this an important finding. This finding is encouraging given the relationship between negative perceptions of the learning environment and mathematics anxiety (see Chapter 2). However, the findings suggest that there could be room for improvement in pre-service teachers' perceptions of their mathematics learning environments. It is possible that such an improvement could alleviate the mild anxiety that the participants of this study reported, as has been found in previous studies (B. A. Taylor & Fraser, 2013).

This section has summarised and discussed the anxiety, teaching efficacy, beliefs and perceptions of the learning environment as self-reported by the participants. The next section discusses the relationships between the teaching self-efficacy of pre-service teachers, and their anxiety and beliefs about mathematics.

5.2.3 Relationships between Pre-service Teachers' Reports of Self-efficacy, Anxiety, and Beliefs about Mathematics

The third research objective was to:

> Examine whether relationships exist between pre-service teachers' self-efficacy towards teaching the new mathematics and their:
> a. anxiety towards mathematics in general;
> b. anxiety towards teaching mathematics; and
> c. beliefs about the nature of mathematics.

To examine these relationships, the data collected from 157 pre-service teachers was analysed using simple correlation (to provide information about bivariate association between the different variables), and multiple regression analyses (to examine how much variance in the dependent variables the independent variable were able to explain). The independent variables were pre-service teacher's mathematics anxiety, their anxiety for teaching mathematics and their beliefs about mathematics. Self-efficacy was used as the dependent variable. To provide information about the unique contribution of the pre-service teachers' anxiety and beliefs about the nature of mathematics to their self-efficacy, the beta values were examined. These results are discussed below in terms of: the relationship between self-efficacy and anxiety towards mathematics (Section 5.2.3.1); the relationship between self-efficacy and anxiety towards teaching mathematics (Section 5.2.3.2); and the relationship between self-efficacy and beliefs about the nature of mathematics (Section 5.2.3.3).

5.2.3.1 Self-efficacy — Anxiety for Mathematics Relationships

The relationship between self-efficacy and anxiety for teaching mathematics was examined, and the key findings are summarized below.

- The results of the simple correlation found that Self-confidence was statistically significantly and negatively related to Anxiety caused by Mathematics Evaluation *(p*<.01).

- The multiple correlation (R) for each of the Teaching Anxiety for Mathematics scales was positive and statistically significant for all three self-efficacy scales ($p<.05$).
- Interpretation of the beta values suggests that Anxiety caused by Mathematics Learning and Anxiety caused by Numerical Tasks were statistically significant ($p<.01$), and negative predictors of Self-confidence.
- The remaining scales of the M-SETMI (Pedagogy in Mathematics and Mathematics Content scales) were not statistically significantly related to mathematics anxiety.

Past research has found mixed results regarding the relationship between mathematics anxiety and self-efficacy for teaching mathematics, with some studies finding a strong negative relationship between the two constructs, and others finding that sufferers of mathematics anxiety may still believe that they are capable of teaching it (see for example, Gresham, 2008; Peker, 2016; Stoehr, 2017; Ural, 2015). The current study found no significant relationship between mathematics anxiety and the Pedagogy for Mathematics and Mathematics Content scales scale of the M-SETMI, which aimed to assess the extent to which pre-service teachers believe they can teach mathematics and make a difference. Therefore, further research into why mathematics anxious pre-service teachers are able to hold the beliefs that they can be effective mathematics teachers is recommended (*Recommendation #1*).

Only one of three self-efficacy scales, Self-confidence, was statistically significantly related to pre-service teachers' mathematics anxiety. Examination of the beta values indicate that, of the five mathematics anxiety scales, three were statistically significant and independent predictors of self-confidence, these being: Anxiety caused by Mathematics Learning; Anxiety caused by Numerical Tasks; and Anxiety caused by Non-mathematics situations. In all cases, the relationships were negative, suggesting that the more pre-service teachers were anxious about mathematics, the less confidence that were to teach mathematics. This finding makes intuitive sense and supports the findings of several past studies which reported negative correlations between teaching self-efficacy for mathematics and mathematics anxiety (Akin & Kurbanoglu, 2011; Bursal & Paznokas, 2006; Gresham, 2008; Isiksal, 2010; Peker, 2016; L. J. Smith, 2010; Ural, 2015). Conversely, these findings contradict other past research which found that pre-service teachers who suffer with mathematics anxiety, may still believe that they are capable of teaching it, perhaps because they feel empathy towards their students, have developed strategies for anxiety, or feel confident about teaching mathematics at the level required at primary school (see for example, McGlynn-Stewart, 2010; Stoehr, 2017; Swars et al., 2006; Trujillo & Hadfield, 1999).

This study also found a negative relationship between the Self-confidence and Anxiety caused by Mathematics Evaluation. As the Self-confidence scale was a new addition to the original SETMI (McGee, 2012), this finding cannot be compared to previous studies. However, the finding supports previous findings of negative relationships between mathematics anxiety and teaching self-efficacy, as discussed above. Only one study could be found that specifically related mathematics evaluation anxiety with teaching self-efficacy, and, conversely, that study found that there was a positive relationship (Isiksal, 2010). This results of the study reported in this thesis suggest that alleviating mathematics evaluation may have a positive effect on pre-service teachers' self-confidence for teaching mathematics. If mathematics evaluation in teacher education programmes is reviewed and effective study skills are explicitly taught, this may also have a positive effect on anxiety related to learning and doing mathematics, both factors which have been found to be negative predictors of self-confidence. Therefore it is recommended that teacher education programmes review the way in which pre-service teachers enrolled in mathematics courses are assessed with the aim of assuaging anxiety, and develop effective study skills in pre-service teachers (*Recommendation #2*).

5.2.3.2 Self-efficacy — Teaching Anxiety for Mathematics Relationships

The relationship between self-efficacy and anxiety for teaching mathematics was examined, and found to exist. The key findings are summarized below.

- The results of the simple correlations found that all three self-efficacy scales were statistically significantly and positively related to Methodological Knowledge ($p<.01$).
- The multiple correlation (R) was positive and statistically significant for one of the three self-efficacy scales, Self-confidence ($p<.05$).

- Of the three anxiety scales, Anxiety caused by Methodological Knowledge was a statistically significant and positive predictor of all three self-efficacy scales.

Anxiety caused by Methodological Knowledge (TAMS), was positively related to all M-SETMI scales, indicating that the higher the anxiety, the higher the self-efficacy. As there is no research (to the best of the researcher's knowledge) that specifically considers the relationship between teaching anxiety and self-efficacy for teaching mathematics, this is an important, albeit counter-intuitive, finding. This may be related to previous findings of positive relationships between mathematics anxiety and teaching self-efficacy (see for example, Gresham, 2008; Peker, 2016; Stoehr, 2017; Ural, 2015), given that mathematics anxiety and mathematics teaching anxiety have also previously been found to be positively related (see for example, Peker & Ertekin, 2011; Uusimaki & Nason, 2004). The current study did not provide the relationship between mathematics anxiety and mathematics teaching anxiety, however, the mean scores were relatively comparable for the two constructs. Research into why this positive relationship exists is recommended (*Recommendation #3*). Anxiety caused by Methodological Knowledge was the TAMS scale that was rated most highly by the participants in this study revealing that this is where the highest anxiety lies. In order to promote high self-efficacy, it is recommended that efforts be undertaken during teacher education to reduce such anxiety (*Recommendation 4*; also see related recommendations: *Recommendations #10; #11; #13-#16*).

As pre-service teachers' beliefs about mathematics have been found to relate with self-efficacy, it is recommended that they be identified and addressed during teacher education programmes (see *Recommendation #20*). Support in this area may need to extend beyond graduation (see *Recommendation #22*). Teacher education programmes should also aim to promote mathematics as a useful endeavour. This could be accomplished by connecting learning to real-life contexts (see *Recommendation #11*).

5.2.3.3 Self-efficacy — Beliefs Relationships

The relationship between self-efficacy and belief about mathematics was examined. The key findings for which are summarized below.

- The results of the simple correlations found that:
  - all three self-efficacy scales were related to pre-service teachers' Beliefs about the Usefulness of Mathematics and their Beliefs about Doing Mathematics.
  - Self-efficacy was statistically significantly and positively related to both Beliefs about the Usefulness of Mathematics and Beliefs about Doing Mathematics ($p<.01$).
  - One beliefs scale, Beliefs about the Nature of Mathematics, was statistically significantly ($p<.01$) and positively related to pre-service teachers' self-efficacy with respect to the Mathematics Content scale.
- The multiple correlation (R) between the three scales of the Beliefs about Mathematics Survey was positive and statistically significant ($p<.01$) for all three self-efficacy scales.
- Interpretation of the beta values suggest that:
  - Beliefs about the Usefulness of Mathematics was a statistically significant ($p<.01$) and positive predictor of all three M-SETMI scales.
  - Beliefs about Doing Mathematics was a statistically significant and positive predictor of two of the M-SETMI scales: Pedagogy in Mathematics ($p<.01$) and Maths Content ($p<.05$).

These results suggest that the more that pre-service teachers hold traditional beliefs about mathematics, the greater their sense of efficacy is for teaching the subject. These results contradict previous research which found that pre-service teachers with greater self-efficacy for teaching mathematics had more sophisticated mathematical beliefs (see for example, Briley, 2012; Haciomeroglu, 2013; Swars et al., 2007). However, this finding supports the contention that beliefs that are developed over many years of apprenticeship in traditional mathematics classes, such as the participants of the current study experienced, and are difficult to change (Manouchehri & Goodman, 2000). A traditional mathematics class may be more familiar to the pre-service teachers, which may explain this interesting finding. See Section 5.3.4 for more information about the educational implications of these findings.

This section has summarised and discussed the findings concerning the relationship between teaching self-efficacy and pre-service teachers' anxiety and beliefs. The next section summarises and discusses the differences the variables of this study across the B.Ed. year groups.

5.2.4 Differences in Year Groups in terms of Anxiety, Beliefs about Mathematics and Self-efficacy

The fourth research objective was to:

> Investigate whether pre-service teachers in different year levels differ in terms of:
>
> a. anxiety towards mathematics in general;
> b. anxiety towards teaching mathematics;
> c. beliefs about the nature of mathematics; and
> d. self-efficacy for teaching mathematics.

To address this objective, multivariate analysis of variance (MANOVA) was carried out separately using the data provided from the first four surveys: Anxiety for Mathematics (AMS), Teaching Anxiety for Mathematics (TAMS), Modified Self-Efficacy for Teaching Mathematics Instrument (M-SETMI), and the Beliefs about Mathematics Survey (BAMS). The key findings are summarised below.

- A statistically significant difference was reported for the Self-confidence scale of the M-SETMI, which was higher for students enrolled in second year than for those enrolled in first year.
- No statistically significant differences were reported for maths anxiety, maths teaching anxiety and beliefs about mathematics between the four year groups of pre-service teachers.

The results indicate that there is an increase between pre-service teachers' self-reported confidence levels for teaching mathematics, with second year students reporting higher self-confidence than first year students. The increase in self-confidence between the first and second year is certainly in the desired direction and could indicate that students enter the programme unsure about teaching mathematics, but by the second year have experienced enough within the programme to make them feel more confident to teach mathematics. This, however, is not a longitudinal study, so the first year participants could simply be less confident about teaching mathematics as a group. The findings also indicate that self-reported confidence levels remain relatively constant across year 3 and 4. Whilst these findings appear to contradict past studies which indicates that that anxiety levels could fluctuate at different stages of the pre-service teachers' course (Thomas, 2006), they appear to support previous research which found that pre-service teachers are likely to graduate holding many of the same beliefs with which they arrive at teacher education programmes (Pajares, 1992). This past research also suggests that, in some cases, pre-service teachers' initial biases may even be reinforced throughout their training (Kagan, 1992).

Given that this was not a longitudinal study, it is not possible to tell whether the only difference found (in self-confidence), or the lack of differences found for all other factors, are related to the pedagogy of the B.Ed. programmes, or just the cohort of pre-service teachers. Therefore it is recommended that further study involving a longitudinal design be carried out (*Recommendation #5*).

5.2.5 Relationship between Perceptions of the Learning Environment and Anxiety, Beliefs about Mathematics and Self-efficacy

The fifth research objective was to:

> Examine whether the learning environment perceived by pre-service teachers is related to their:
>
> a. anxiety towards mathematics in general;
> b. anxiety towards teaching mathematics;
> c. beliefs about the nature of mathematics; and
> d. self-efficacy for teaching mathematics.

The results for the simple correlations and multiple regression used to address this research objective are summarised and discussed below in terms of: the relationship between perceptions of the learning environment and anxiety towards mathematics (Section 5.2.5.1); the relationship between perceptions of the learning environment and anxiety towards teaching mathematics (Section 5.2.5.2); the relationship between perceptions of the learning environment and self-efficacy (Section 5.2.5.2); and the relationship between perceptions of the learning environment and beliefs about the nature of mathematics (Section 5.2.5.4).

5.2.5.1 Relationships between the Learning Environment and Mathematics Anxiety

The key findings for the relationships between perceptions of the learning environment and anxiety for mathematics are summarised below.

- The results of the simple correlations suggest that statistically significant (p<.05) relationships exist for:
  - Anxiety caused by Mathematics Learning and Involvement
  - Anxiety caused by doing Numerical Tasks and Student Cohesiveness
- The multiple correlation (R) was statistically significant for three of the five anxiety scales, these being, Anxiety caused by; Mathematics Learning, Mathematics Evaluation, and Numerical Tasks.
- Interpretation of the beta values suggest that:
  - Involvement is an independent predictor of Anxiety caused by Mathematics Learning (β=.33, p<.01).
  - For Anxiety caused by Mathematics Evaluation, two learning environment scales were independent predictors: Involvement (β=.31, p<.01); and Collaboration (β=.24, p<.05).
  - For Anxiety caused by Numerical Tasks, one learning environment scale, Student Cohesiveness (β=.30, p<.01), was an independent predictor .

All of the statistically significant relationships, with the exception of one, were negative, suggesting that the more favourably pre-service teachers' perceive the learning environment to be for these scales, the less anxiety they report. For the exception, pre-service teachers report more anxiety when they perceive there to be more collaboration in their mathematics education classes. This sections discusses each of these statistically significant relationships in turn.

First, Involvement had a statistically significant and negative relationship with Anxiety caused by Mathematics Learning and Anxiety caused by Mathematics Evaluation.

This finding suggests that the more pre-service teachers are given opportunities to give their opinions, discuss ideas, and are listened to by their peers, the lower in the anxiety. While research relating these two variables specifically could not be found, Involvement has been previously found to relate positively to student outcomes in middle and secondary mathematics classes (Ogbuehi & Fraser, 2007; Opolot-Okurut, 2010). These results suggest that, in order to lower mathematics anxiety, increasing involvement within the classroom should be a focus for teacher educators.

Second, the statistically significant and negative relationship between Student Cohesiveness and Anxiety caused by Numerical Tasks suggests that the more comfortable, supported, and safe pre-service teachers feel around their peers, the lower the anxiety for doing numerical tasks (such as being watched while adding up a list of numbers, and vice versa). These findings support those of B. A. Taylor and Fraser's (2013) who also report negative relationships between anxiety and the learning environment, especially when there was more peer interaction and acceptance, and suggest that pre-service teachers' mathematics anxiety is likely to be reduced through creating a more positive classroom environment.

Third, the results of the present study did not find any statistically significant relationship between the Teacher Support scale of the WIHIC and the mathematics anxiety of pre-service teachers. This was surprising given that past studies have found teachers influence students' mathematics anxiety (see for example, Buckley et al., 2016; Byrd, 1982; Whyte & Anthony, 2012).

Fourth, the positive and statistically significant relationship between Collaboration and Anxiety caused by Mathematics Evaluation suggests that the more collaboration within the learning environment, the higher the mathematics evaluation anxiety. Given that three items of the Collaboration scale referred to collaborating or sharing resources for assignments and projects, this finding might suggest that students felt more anxious about mathematics evaluation when collaboration is involved. While no previous research into the relationship between these scales could be found, this finding supports the researchers' experience with pre-service teachers who are reluctant to work with others when grades are at stake, usually due to differences in abilities and/or personalities. On the surface, this may indicate that pair or group activities and assignments are not appropriate in mathematics courses within a Bachelor of Education programme, as they exacerbate anxiety. However, removing such tasks in favour of individual assignments would go against the model teacher educators are often trying to espouse. It is recommended that the weighting of such evaluative tasks be reviewed and revised, in order to reduce the pressure on collaborative tasks (*Recommendation #6*). It is recommended that further research to investigate whether improvements to student cohesiveness and involvement, to where pre-service teachers felt truly supported and heard, would decrease anxiety related to collaboration in evaluative activates, be carried out (see *Recommendation #7*). Identification of students' perceptions and preferences of their involvement and cohesiveness in class could be obtained using the actual and preferred forms of the What Is Happening In this Classroom (WIHIC) survey.

5.2.5.2 Relationships between the Learning Environment and Teaching Anxiety for Mathematics

The key findings for the relationships between perceptions of the learning environment and anxiety for mathematics are summarized below.

- For the results of the simple correlations, statistically significant relationships were reported between the learning environments and two of the three teaching anxiety scales:
    - Involvement was statistically significantly and negatively related to Anxiety caused by Content Knowledge
    - All six WIHIC scales were statistically significantly and positively related to Anxiety caused by Methodological Knowledge.
- The multiple correlation (R) was statistically significant for only one of the three TAMS scales, Anxiety caused by Content Knowledge.
- Interpretation of the beta values indicated that:
    - Two learning environment scales independently predicted pre-service teachers' Anxiety caused by Content Knowledge: Involvement ($\beta = -.35$, $p < .05$); and Collaboration ($\beta = .31$, $p < .05$).

- One learning environment scale, Student Cohesiveness (*β*=.21, *p*<.05), was an independent predictor of Anxiety caused by Teaching Mathematics.

All of the statistically significant relationships, with the exception of one, were positive. These results suggest that, for the Anxiety caused by Methodological Knowledge scale of the TAMS, the more favourable the learning environment is, the more anxious pre-service teachers become about their own teaching of mathematics. Given this strong relationship, and that Anxiety caused by Methodological Knowledge is also related to self-efficacy for teaching mathematics, and had the highest mean for the TAMS scale (mean = 3.50), this relationship needs to be investigated further. While no previous research could be found that considers the relationship between the learning environment and anxiety for teaching mathematics, past research has suggested that mathematics teaching anxiety may be caused by due to a lack of confidence in an individual's ability to communicate mathematical concepts (A. B. Brown et al., 2011). Communication about mathematical concepts would necessarily be higher in a learning environment in which students are working together. Although the causal explanations were not provided, given the nature of the data collected, one possibility is that, when pre-service teachers are friendly and supportive of each other, they are sharing and fuelling anxieties regarding mathematics teaching attitudes, and when they work with each other during activities, anxiety related to their methodological and content knowledge increases, perhaps in comparison with group members (correctly or not). Content knowledge has been repeatedly linked with mathematics teaching anxiety (see for example, Akinsola, 2014; Peker & Ulu, 2018), with one study suggesting a perceived lack of content knowledge is the most influential casual factor (Ural, 2015). It is recommended, therefore, that further research into why a more favourable learning environment is related to higher mathematics teaching anxiety be carried out (*Recommendation #8*).

Collaboration and Student Cohesiveness were found to be statistically significant and positive predictors of Anxiety caused by Content Knowledge and Anxiety caused by Teaching Mathematics, respectively. Given that these findings were unexpected and, to some extent, unusual, it is recommended that further investigation involving qualitative information be used to provide causal explanations that examines this relationship (*Recommendation #9*).

Finally, the results suggest that Involvement is a negative predictor of Anxiety caused by Content Knowledge, indicating that the more involvement per-service teachers perceive, the less anxious they are about their content knowledge. The Involvement scale aimed to assess the extent to which students have attentive interest and participate in discussions. This supports previous research which found mathematics teaching anxiety was reduced when pre-service teachers were involved in micro-teaching and model lessons as part of their mathematics education classes (Peker, 2009b; Yazici et al., 2011). As Involvement is also a negative predictor for Anxiety caused by Content Knowledge, it seems pertinent that teacher educators seek greater involvement from their students within the learning environment. Identification of students' perceptions and preferences of their involvement in class could be obtained using the actual and preferred forms of the What Is Happening In this Classroom (WIHIC) survey (see *Recommendation #7*). No previous studies could be found that examined the relationship between mathematics teaching anxiety and the learning environment, making these important findings.

5.2.5.3 Relationships between the Learning Environment and Self-efficacy for Teaching Mathematics

The key findings of the relationships between perceptions of the learning environment and self-efficacy are summarized below.

- The results of the simple correlations suggest that statistically significant and positive relationships exist for:
  - Pedagogy in Mathematics and Mathematics Content scales.
  - Self-confidence scale and five of the six learning environment scales, Student Cohesiveness, Involvement, Collaboration, Equity, and Personal Relevance.
- The multiple correlation (*R*) was statistically significant (p<.01) for two of the three self-efficacy scales, Pedagogy in Mathematics and Mathematics Content.

- Interpretation of the beta values indicated that:
    - One of the six learning environment scales, Student Cohesiveness, was statistically significant and independently related to both the Pedagogy in Mathematics and Mathematics Content scales, and also statistically significant and independently related to the Self-confidence scale.

The positive correlation between the learning environment and teaching self-efficacy is an encouraging finding, as it implies that, by improving the mathematics learning environment, self-efficacy for teaching the subject could be enhanced. The learning environment has been previously found to relate positively to many student outcomes, such as achievement, attitudes, interest in and enjoyment of mathematics (See Chapter 2 for more information), including a positive relationship between learning environments and mathematics self-efficacy (Gilbert et al., 2014), however to date, no studies have examined the relationship between the learning environment and teaching anxiety for mathematics. Therefore, this finding is significant, and emphasises the importance of attending to the learning environment (see *Recommendation #7*).

5.2.5.4 Relationships between the Learning Environment and Beliefs about Mathematics

The relationship between perceptions of the learning environment and beliefs about mathematics was examined. The key findings are summarized below.

- The results of the simple correlations suggest that statistically significant and positive relationships exist between all six WIHIC scales (Student Cohesiveness, Teacher Support, Involvement, Collaboration, Equity, and Personal Relevance) and two of the three beliefs scales, Beliefs about the Usefulness of Mathematics, and Beliefs about Doing Mathematics.
- The multiple correlation (R) was statistically significant (p<.01) for two of the three beliefs scales, Beliefs about the Usefulness of Mathematics, and Beliefs about Doing Mathematics.
- Interpretation of the beta values indicated that:
    - Two of the six learning environment scales (Student Cohesiveness (p<.01); and Personal Relevance (p<.05) were statistically significant

and independently related to Beliefs about the Usefulness of Mathematics.

- Student Cohesiveness was statistically significantly ($p<.01$) and independently related to Beliefs about Doing Mathematics.

All of the statistically significant relationships were positive. These results suggest that for these scales the more favourably pre-service teachers perceived these dimensions, the more traditional beliefs they reported, particularly for Beliefs about Doing Mathematics and Beliefs about the Usefulness of Mathematics. Given that the results of this study also indicate that the more traditional beliefs held, the higher the self-efficacy, this indicates that improving the perceived learning environment may improve self-efficacy. However, traditional beliefs about mathematics have been positively related to mathematics anxiety (Byrd, 1982; Miller & Mitchell, 1994; Sloan et al., 2002) and negatively related to teaching self-efficacy (Briley, 2012), see Section 5.3.4 for more information about the educational implication. It is of note that no significant relationships between the learning environment and Beliefs about the Nature of Mathematics was found, supporting past findings that beliefs are generally well-formed before entering higher education, and very challenging to change (Kagan, 1992; Pajares, 1992).

Based on the significant positive relationships between the learning environment, and Beliefs about the Usefulness of Mathematics and Beliefs about Doing Mathematics, it seems prudent that teacher educators increase student cohesiveness, teacher support, involvement, collaboration, equity and relevance within all mathematics classes (see *Recommendation #7*). Given that, in this study, the learning environment was not related to Beliefs about the Nature of Mathematics, improvements to the learning environment will not affect such beliefs. It is recommended, therefore, that Beliefs about the Nature of Mathematics held by pre-service teachers be challenged explicitly as early as possible during teacher education *(*see *Recommendation #20*).

This section has discussed the findings regarding the relationship between the learning environment and the other variables in this study; mathematics anxiety, mathematics teaching anxiety, teaching self-efficacy, and beliefs about mathematics. The next section presents the educational implications of this study.

5.3 Educational Implications

The research reported in this thesis contributes to wider research related to the fields of mathematics anxiety, teaching anxiety, self-efficacy, beliefs, and learning environments, and their impact on pre-service teacher education. The findings of this research indicate that Emirati pre-service teachers report moderate mathematics anxiety and teaching self-efficacy, slightly higher anxiety for teaching mathematics, mixed beliefs about mathematics and a positive perception of their mathematics learning environment. This study also found relationships between self-efficacy, and learning environments, and the other variables.

In this section, the educational implications of the results (see Chapter 4) are discussed, and recommendations are made. This section first looks at the implications for pre-service teachers' anxiety for mathematics (Section 5.3.1), then their teaching anxiety for mathematics (Section 5.3.2), their self-efficacy for teaching mathematics (Section 5.3.3), and, their beliefs about mathematics (Section 5.3.4).

5.3.1 Anxiety for Mathematics

The results of this study indicate that the Emirati pre-service teachers participants were 'a little' to 'somewhat anxious' about mathematics. Given that mathematics anxiety has been related to mathematics teaching anxiety, teaching efficacy, beliefs about mathematics, teacher behaviour, and student achievement, the finding that Emirati teachers have moderate mathematics anxiety may have negative implications for the future of mathematics education in Abu Dhabi primary schools, unless addressed. This section explores the educational implications for pre-service teachers' mathematics anxiety.

Early intervention of mathematics anxiety with pre-service teachers is likely to have significant benefits (Buckley, 2016), especially as mathematics anxious teachers spend less time planning and teaching mathematics and teach in ways that have been linked with cultivating mathematics anxiety in their students (see Chapter 2). Students in the current context participate in teaching practicum placements from the first year of study. Given these findings, and the findings of the current study, it is recommended that a component of all teacher education programs be explicitly aimed at addressing mathematics anxiety (as purported by Gresham, 2007; Harper & Daane, 1998), and a number of strategies for doing so have been suggested.

Openly addressing students' attitudes toward mathematics (L. Taylor & Brooks, 1986) and providing opportunities for pre-service teachers to reflect about any anxiety or negative attitudes through writing about mathematics, sharing experiences and discussing the implications (Harper & Daane, 1998), could serve to reduce anxiety (*Recommendation #10*). The literature reviewed also recommends treatments for mathematics anxiety such as cognitive-behavioural therapy, student-centred teaching approaches and mathematics workshops (see for example, Hembree, 1988). This could be done through mathematics methods courses, as exposure to such courses can also act as an intervention, and learning to teach mathematics during pre-service teacher training seems to reduce mathematics anxiety (Buckley, 2016; Hadley & Dorward, 2011). Several studies have shown that pre-service teachers' mathematics anxiety is reduced after the completion of a standards-based mathematics methods course (Gresham, 2007; Harper & Daane, 1998; Sloan, 2010; Tooke & Lindstrom, 1998).

Relating mathematics experiences to real-life contexts has also been espoused as reducing mathematics anxiety in pre-service teachers. (Gresham, 2007). Given the more sophisticated beliefs about the usefulness of mathematics self-reported by the participants, and links found between beliefs and mathematics anxiety in previous studies (see for example, Haciomeroglu, 2013; F. C. Richardson & Suinn, 1972; Swars et al., 2009), it is recommended that mathematics courses in teacher education programmes incorporate links to real-life wherever appropriate (*Recommendation #11)*. One obvious example is the frequent use of geometric patterns in Islamic art, and with the recent opening of the Louvre, and the planned Guggenheim Museum, this could be extended into a variety of art forms. Simple budgeting is another relevant way to make connections to real-life, for example, pre-service teachers could investigate costs related to pre- and post-paid mobile phone plans, or which campus coffee shop offers best value for money.

Having extensive fieldwork experiences and familiarising pre-service teachers with the world of mathematics teaching (Harper & Daane, 1998; Tooke & Lindstrom, 1998) have also been suggested as a method for lowering mathematics anxiety such as that reported by participants in this study. Therefore, it is recommended that teacher education programmes increase fieldwork experiences (*Recommendation #12*). This could be in the form of additional practicum experiences, micro-teaching, and/or observations of model lessons by in-service teachers, and these experiences should occur early on in the programme, rather than waiting to the end.

Also, Wood (1988) looked into several programs designed to reduce pre-service teachers' mathematics anxiety, as was reported in this study, and found that programs that improved attitudes towards mathematics and lowered mathematics anxiety all had one thing in common: the students were taught well. These programs used effective teaching techniques, such as not assuming prior knowledge, teaching new material slowly, and encouraging students to talk through their thought processes. Tobias (1990) suggests similar techniques, through the development of mathematics workshops, ideally utilizing mathematics instructors and counsellors in tandem. She also recommends the development of study skills from passive to active, in order to offer "mathematical mental health" (Tobias, 1990, p. 49) which involves students reflecting on their mathematics learning, and developing a willingness to learn.

Furthermore, Sloan (2010) found that the majority of pre-service teachers she interviewed indicated that the use of manipulatives in their mathematics methods course reduced mathematics anxiety, which may be useful in the current context given the moderate anxiety reported. The participants claimed the manipulatives facilitated conceptual understanding of mathematics, which enhanced their confidence and improved their attitudes toward mathematics. Other studies with pre-service teachers and mathematics anxiety found similar results regarding the use of manipulatives (Gresham, 2007; Harper & Daane, 1998; Vinson, 2001). It is recommended that all teacher education programmes incorporate manipulatives into both content and methodology courses wherever possible to enhance learning and provide a model for best practice (*Recommendation #13*). Manipulatives should be used in the students' own learning, and as an overt model for their future teaching. These manipulatives should be comparable to those the pre-service teachers will find in a standard classroom during teaching practicum, so they are familiar.

As the mean for the Anxiety caused by Evaluation in Mathematics scale was the highest in the current study (AMS), at 2.95, this could suggest that this is an area that teacher educators should consider addressing. The development of effective study skills could help. It is possible that this could be accomplished through games and activities, and lots of practice in simulated evaluative situations with material starting out easy, and progressing in difficulty. Additionally, a longitudinal study involving pre-service teachers (*n = 20*) in a B.Ed. programme in the United Kingdom found that college mathematics classes helped alleviate anxiety by promoting mathematical processes and reducing the focus on getting the right answer (see *Recommendation #2*).

Finally, it is also recommended that teacher education programmes regularly monitor the levels of pre-service teachers' maths anxiety to ensure they are being reduced, and offer extra support for those who maintain higher anxiety levels (*Recommendation #14*).

5.3.2 Teaching Anxiety for Mathematics

The educational implications for the mathematics teaching anxiety of pre-service teachers' are summarised and discussed in this section. The results of the descriptive analysis indicated that the participants of this study hold moderate levels of anxiety regarding teaching mathematics, a slightly higher range of means was found for mathematics teaching anxiety as opposed to anxiety for learning, doing, or being evaluated in mathematics. Given that mathematics teaching anxiety can have a great influence on pre-service teachers' potential effectiveness when teaching mathematics (A. B. Brown et al., 2012; Bursal & Paznokas, 2006; Haciomeroglu, 2014; Peker & Ertekin, 2011), and its relationship to student mathematics achievement (Hadley & Dorward, 2011), even a moderate level of mathematics teaching anxiety may have implications for future teaching effectiveness.

The results of this study indicate that, of the Teaching Anxiety for Mathematics (TAMS) scales, Emirati pre-service teachers are most anxious about their methodological knowledge for teaching mathematics. This may be due to them being asked to teach in a way different to that which they experienced as school students.

Therefore, it is recommended that teacher education programmes focus on how to teach mathematics effectively as well as how to introduce mathematical concepts and skills to primary-aged students, using a constructivist approach (*Recommendation #15).* This could include offering a variety of activities that are well-defined yet still allow for creativity, using a range of grouping strategies and encouraging pre-service teachers to share their ideas.

Haciomeroglu (2014) suggested that mathematics methods courses and practicum placements that intended to give real life experiences was a possible reason for the primary pre-service teachers in his study having low mathematics teaching anxiety, unlike the participants in this study who reported some anxiety. He suggests that working successfully with school students during their teacher education can help pre-service teachers reduce their mathematics teaching anxiety. Likewise, in a study with pre-service secondary mathematics teachers, the use of microteaching in a real classroom setting during a teaching practicum course reduced teaching anxiety in mathematics (Peker, 2009). Additional fieldwork experiences (see *Recommendation #12*) will help to facilitate this. It would seem prudent that pre-service teachers be well prepared for working with students by their college teachers, prior to fieldwork experiences, in order to best ensure a successful and positive experience is had. It is recommended that teacher education programmes develop practicum preparation sessions either within mathematics methodology courses or supplementary to them (*Recommendation #16*). These courses could cover, among other things; how to prepare for teaching (methodological knowledge), how to manage the classroom, and how to positively respond to students' questions to which you do not know the answer.

A requirement for concrete examples for teaching has been linked to increased mathematics teaching anxiety (Peker, 2009). However, positively, research has shown that the effective modelling of manipulatives to develop conceptual understanding during teacher education has increased confidence, improved attitudes towards mathematics, and reduced teaching anxiety for the subject (Peker 2009; Sloan, 2010). This relates to both the instructor's use of the materials and the pre-service teachers use of them when learning to plan creative lessons to introduce mathematical concepts to students (Peker, 2009). The use of manipulatives in mathematics courses has already been suggested as a way to reduce mathematics anxiety (see *Recommendation #13*).

In order to reduce mathematics teaching anxiety, teacher education programmes should require pre-service teachers to include the (appropriate) use of manipulatives in activity and lesson planning assignments, micro-teaching, and other practicum teaching experiences (*Recommendation #17*).

It has also been suggested that mathematics teaching anxiety be brought to the fore during teacher education, discussed openly and honestly, and monitored throughout the programme (*Recommendation #18*), and instructors should anticipate and acknowledge that anxiety levels may fluctuate throughout the course (Thomas, 2006).

5.3.3 Self-efficacy for Teaching Mathematics

The educational implications for teaching self-efficacy for mathematics are summarised and discussed in this section. The results of the current study indicated that Emiratis pre-service teachers have moderately positive self-efficacy for teaching mathematics, although the mean score for Self-Confidence was below the mid-point. Past research has shown that, similarly to mathematics teaching anxiety, teaching self-efficacy is related to teacher behaviours and student achievement, but unlike mathematics teaching anxiety, this relationship is positive (see for example, Klassen & Tze, 2014; Muijs & Reynolds, 2015; Woodcock, 2011b).

Although teaching self-efficacy has been found to be relatively stable (Tschannen-Moran & Woolfolk-Hoy, 2007), Bandura (1997) believes that self-efficacy beliefs are most malleable during their early stages of development. For pre-service teachers these early stages are likely to be during teacher training. However, researchers have found both improving (Charalambous et al., 2008; Isiksal-Bostan, 2015; Palmer, 2006; Sloan, 2010) and reducing (Hoy & Woolfolk, 1990; Plourde, 2002; Woolfolk-Hoy & Spero, 2005; Woodcock, 2011) self-efficacy beliefs during this training period.

Those that support the notion that teaching efficacy can be developed with pre-service teachers suggest that teacher training should provide opportunities for both vicarious experiences (e.g. observing model lessons) and verbal persuasion (e.g. feedback, encouragement, and praise) through college coursework, and opportunities for mastery experiences through teaching practice (Hoy & Woolfolk, 1990; Isiksal-Bostan, 2015;

Poulou, 1997; Woodcock, 2011; see *Recommendation #12*). Mastery experiences need to be structured and supported appropriately as they have the potential to enhance teaching self-efficacy, particularly when pre-service teachers realise they can support student learning (Tschannen-Moran et al. 1998). However, Tschannen-Moran et al. (1998) warn that pre-service teachers that are left to 'sink or swim' may experience negative feelings and attitudes that are likely to be detrimental to their teaching self-efficacy beliefs (see *Recommendation #16*).

Specifically with mathematics teaching, participation in mathematics methodology courses has been linked to significant increases in mathematics teaching efficacy for pre-service teachers (Cakiroglu, 2000, Huinker & Madison, 1997) (see *Recommendation #10*). Mathematics methodology courses have also been shown to reduce mathematics anxiety (Sloan, 2010), which, in turn, improves teaching efficacy (Bursal & Paznokas, 2006; Peker, 2016; Sloan, 2010). Indeed, Bandura (1986) claimed that emotional states, such as anxiety, must be addressed in order to develop positive efficacy. Therefore attending to mathematics anxiety during pre-service training is key (see *Recommendations #10 & #18*). Research has indicated that methodology courses that make use of manipulatives (Gresham, 2008; Sloan, 2010; Swars, et al, 2006) have been shown to reduce mathematics anxiety and to increase mathematics teaching efficacy (see *Recommendation #13*). Teacher education programmes should also be helping pre-service teachers make connections between mathematics and the quality of mathematics education needed for everyone (Gresham, 2008), through real-life connections (see *Recommendation #11*).

5.3.4 Beliefs about Mathematics

The educational implications for pre-service teachers' beliefs about mathematics are summarised and discussed in this section. The results of this study indicated that Emirati preservice teachers had relatively neutral beliefs about mathematics, although they had slightly more traditional beliefs about doing mathematics, and slightly more sophisticated beliefs about the usefulness of mathematics. Given that pre-service teachers' beliefs about mathematics have been linked to mathematics anxiety, teaching self-efficacy and teachers' instructional practices (see for example, Başpinar & Peker, 2016; Briley, 2012; Haciomeroglu, 2013; Hughes, 2016; Welder et al., 2011), there may be educational implications for these pre-service teachers not holding more sophisticated beliefs.

Addressing pre-service teachers' naïve beliefs about mathematics is essential in order to ensure their future instructional practices align with reform practices and philosophies, and improve the mathematical learning of their students. If such beliefs are not attended to "… future elementary teachers will be barriers to, instead of catalysts of, change" (Harper & Daane, 1998, p.29). Unfortunately, pre-existing beliefs about mathematics, and about the teaching and learning of it, tend to be tenacious (Pajares, 1992). Pre-service teachers have been found to graduate holding many of the same beliefs with which they arrive at teacher education programmes, and in some cases, their initial biases have been reinforced throughout their training (Kagan, 1992). Fortunately, several researchers have highlighted strategies that teacher educators can use to modify the beliefs of pre-service teachers, and have reported success in affecting desirable change (Beswick, 2006; Beswick & Dole, 2001; Hart, 2002; Swars et al., 2007). Many researchers have suggested that, in order to alter beliefs about mathematics, pre-service teachers must first be given opportunities to acknowledge what their beliefs are (Kagan, 1992; Muis, 2004; Welder et al, 2011). "If beliefs are established through classroom experiences, then pre-service teachers' naïve mathematical beliefs might be recognized, challenged, and reflected upon in the classroom environment" (Briley, 2012, p. 9). Often, however, teacher education programmes concentrate on content and pedagogical knowledge and do not consider pre-service teachers' beliefs (Tillema, 1995). When beliefs are considered, efforts are made to modify them during methodology courses after subject courses have been completed, and therefore are applied too late (Ambrose et al, 2004). It is recommended that mathematics classes (content and methodology) in teacher education programmes reflect sophisticated beliefs that are linked to more effective teaching and learning, incorporate constructivist principals, align with the current reform (*Recommendation #19*). It is also recommended that educators of pre-service teachers examine and, where required, consider how these can be modified, that is, made more sophisticated, as early as possible in teacher education programmes (*Recommendation #20*). This could be possible through open classroom discussions and student reflections. Given that the results of this study indicate that the more traditional the mathematics beliefs, the greater the self-efficacy, any interventions to modify traditional beliefs would need to be monitored carefully to ensure pre-service teachers' self-efficacy was not being negatively affected (*Recommendation #21*).

Pajares advises that the longer a belief has been held that more resistant it is to change; "[N]ewly acquired beliefs are most vulnerable to change" (1992, p. 325). The resilience of beliefs formed during teacher education against the culture of the school and the pressures of being a practicing teacher is difficult to predict (Hart, 2002), nonetheless the research suggests with the right programmes and support, the prospects are hopeful. Given this, it is recommended that teacher education programmes provide post-graduation support to ensure sophisticated beliefs endure (*Recommendation #22*). This may include providing a context for beginning teachers to meet and discuss their mathematics beliefs in relation to their new teacher position, as a way of keeping such beliefs, and any challenges to them, at the forefront of teachers' minds, avoiding any reversion. A teacher educator, who can act as a 'devil's advocate' and challenge any less than sophisticated beliefs, could moderate such meetings. Mathematics curriculum leaders from the new teachers' schools can also be included as representatives of the school to ensure beliefs and school culture align in a sophisticated way.

Research has also shown that in order to promote and maintain sophisticated beliefs about mathematics, pre-service teachers need opportunities to engage with real-life applications of mathematics (Paolucci, 2015; see *Recommendation #11*), and collaborate and communicate in small groups in order to construct mathematical knowledge (Hughes, 2016; Muis, 2004), and experience carefully planned and monitored practicums and other field experiences (Haciomeroglu, 2013; Malone, 1995; see *Recommendations #12 & #16*).

This section has presented the educational implications of this study, and made recommendations for teacher education programmes and future research. The next section considers the limitations of the study.

5.4 Limitations

Although this research has met its objectives, as with all research, there were possible limitations. Although every effort has been made to ensure that these were minimised, the limitations of this study are acknowledged and discussed in this section.

A basic objective of the research reported in this thesis was to examine associations between or among multiple variables, without manipulating variables, therefore a cross-sectional research design was considered to be appropriate. It is acknowledged, however, that the inclusion of qualitative data would have made possible the examination of causal explanations.

It is acknowledged that the internal validity of a cross-sectional design is typically weaker than an experimental design, however, a decision about the research design took into account ethical considerations and the ability for the researcher to access participation. Given these restraints and considerations, it was decided that a cross-sectional design would be appropriate. Despite the reduced internal validity, this cross-sectional design still allowed causal relationships to be inferred (Bryman, 2012).

A further limitation of the study, was that it involved the collection of data at a point in time, a characteristic of the cross-sectional research design. As such, it is not possible to tell whether the only difference found between year groups (in self-confidence), or the lack of differences found for all other factors, are related to the pedagogy of the B.Ed. programmes, or just the cohort of pre-service teachers. Further, this 'snapshot' of information regarding pre-service teachers' mathematics anxiety, mathematics teaching anxiety, self-efficacy, beliefs and perceptions of the learning environment could not take into account that these factors may fluctuate throughout their teacher education. It is recommended, therefore, that future studies involve a longitudinal design to examine pre-service teachers' mathematics anxiety, mathematics teaching anxiety, self-efficacy, beliefs and learning environment perceptions across a four year B.Ed. programme (see *Recommendation #5*).

This study is based on self-reported data, which cannot be independently verified, and therefore must be considered at face-value. Every attempt was made to minimize this risk by providing clear information and ensuring confidentiality.

The sample involve pre-service teachers from only two higher education institutes in Abu Dhabi. Whilst selection of these institutes provided pre-service teachers enrolled in courses with very different structures, generalising these results to other institutions and, indeed, emirates within the UAE, should be done with caution. It is recommended, therefore, that future studies involve different samples including institutions located in other emirates (*Recommendation #23*). The fact that these two institutes were dissimilar in approach (and, therefore, were not controlled), can also be considered a limitation.

Finally, although individual instruments garnered data from a greater number of participants, only the data from 157 participants was complete and useable across all five surveys. This is a relatively small sample size. Furthermore, the sample involved only eight male pre-service teachers. Whilst this number was generally representative of the total pool, caution should be taken when generalising the results of this study to other male pre-service teachers.

5.5 Summary of Recommendations

This section provides a summary of the recommendations that have been identified within this chapter.

Recommendation #1 Research into why mathematics anxious pre-service teachers are able to hold positive self-efficacy beliefs for teaching mathematics should be conducted

Recommendation #2 Teacher education programmes should review the way in which mathematics courses are assessed, and develop effective study skills in pre-service teachers.

Recommendation #3 Research to examine the positive relationship between teaching anxiety and self-efficacy for teaching mathematics.

Recommendation #4 Teacher education programs should identify and explicitly address students' anxiety toward teaching mathematics.

Recommendation #5 Longitudinal research into the difference (or lack thereof) in anxiety, teaching self-efficacy, beliefs, and perceptions of the learning environment across years in a B.Ed. programme should be conducted.

Recommendation #6 Teacher education programmes should review the weightings of collaborative assessment tasks, with the aim to reduce the pressure on such tasks.

Recommendation #7 Research to investigate whether improvements to student cohesiveness and involvement, would decrease anxiety related to collaboration in evaluative activates, should be conducted.

Recommendation #8 Research into why a more favourable learning environment is related to higher mathematics teaching anxiety should be conducted.

Recommendation #9 Research investigating the relationship between the learning environment and teaching anxiety for mathematics should be conducted.

Recommendation #10 Teacher education programs should explicitly address students' attitudes toward mathematics, and provide treatments for mathematics anxiety and opportunities for pre-service teachers to reflect on anxiety or negative attitudes through writing about mathematics, sharing experiences and discussing the implications. Well-taught methodological courses must include student-centred teaching approaches and active study skills, using counsellors and faculty in tandem.

Recommendation #11 Teacher education programmes should make real-life connections to link mathematics learning.

Recommendation #12 Teacher education programmes should increase fieldwork experiences.

Recommendation #13 Teacher education programmes should incorporate manipulatives into both content and methodology courses, and provide a model for best practice.

Recommendation #14 Pre-service teachers' mathematics anxiety should be monitored throughout teacher education programmes, and extra support should be provided for those who maintain higher anxiety levels.

Recommendation #15 Teacher education programmes should focus on how to introduce mathematical concepts and skills to primary-aged students and how to teach mathematics effectively, using a constructivist approach.

Recommendation #16 Teacher education programmes should develop practicum preparation sessions either within mathematics methodology courses or supplementary to them.

Recommendation #17 Pre-service teachers should be required to include the (appropriate) use of manipulatives in activity and lesson planning assignments, micro-teaching, and other practicum teaching experiences.

Recommendation #18 Mathematics teaching anxiety should be discussed openly and honestly during teacher education, and monitored throughout the programme.

Recommendation #19 Mathematics classes in teacher education programmes should reflect sophisticated mathematics beliefs, which incorporate constructivist principals and align with the current reform, and acknowledge and confront beliefs.

Recommendation #20 Teacher education programmes identify pre-service teachers' mathematics beliefs as early as possible, and modify where required.

Recommendation #21 Interventions to modify traditional beliefs should be monitored carefully to ensure pre-service teachers' self-efficacy is not negatively affected.

Recommendation #22 Teacher education programmes should provide post-graduation support of sophisticated mathematics beliefs.

Recommendation #23 Replicative research involving different samples including institutions located in other emirates.

5.6 Significance of the Study

The findings of this study offers a range of contributions to teacher education for a variety of educational stakeholders. This section discusses the significance of the findings within this study in relation to: the contribution to research in relation to pre-service teachers' mathematics anxiety, self-efficacy, beliefs and the perceived learning environment (Section 5.6.1), the contribution of the study towards the teacher education in Abu Dhabi for a variety of stakeholders (Section 5.6.2), and the methodological contributions of the study (Section 5.6.3).

5.6.1 Contribution to Research

The research reported in this thesis is positioned within the context of Abu Dhabi, UAE, however, the findings make a contribution to the fields of pre-service teacher education, mathematics anxiety, teaching anxiety, teaching self-efficacy, mathematics beliefs and learning environments beyond this milieu. This research contributes to the literature by building upon previous research in the aforementioned areas, and filling research gaps.

This study built upon and contributed to the existing literature by supporting past research in the following areas:

- Pre-service teachers hold anxiety related to mathematics.
- Pre-service teachers are most anxious about teaching mathematics in regards to Methodological Knowledge.
- Relationships exist between teaching self-efficacy and mathematics anxiety.
- Mathematics anxious pre-service teachers may still hold high self-efficacy beliefs about teaching mathematics.
- Relationships exist between teaching self-efficacy and mathematical beliefs.
- Pre-service teachers with greater self-efficacy for teaching mathematics had more sophisticated mathematical beliefs.
- Relationships exist between the learning environment and mathematics anxiety.
- Relationships exist between teaching the learning environment and mathematical beliefs.
- The Pedagogy in Mathematics scale (used in this study in the M-SETMI), was previously criticised as less distinct for pre-service teachers, and therefore separated into two scales. These two scales were found to not be distinct in the current study, thereby supporting the original construct.

Furthermore, the gap in literature, related to the lack of research into the mathematics anxiety, mathematics teaching anxiety, teaching self-efficacy, and perceptions of the learning environment of pre-service teachers within the current context has been bridged by this study. No such research to date has been carried out in the UAE, nor in any of the surrounding Gulf Cooperation Council (GCC) countries. Similarly, to the best of the researcher’s knowledge, no previous research has examined the impact of the tertiary-level mathematics learning environment on pre-service teachers’ anxiety. This research is also the first of its kind involving Emirati pre-service teachers in the UAE, and has provided insights into their attitudes, feelings, and beliefs about learning, doing, being evaluated in, and teaching mathematics. This study also fills a gap in the existing literature by examining: the relationship between mathematics teaching anxiety and both teaching self-efficacy and the mathematics learning environment; and the relationship between mathematics teaching anxiety and self-efficacy. These findings will enable higher educational institutions and teacher educators to modify existing mathematics content and pedagogy courses to address anxiety, low self-efficacy, and naïve beliefs explicitly from the very beginnings of programmes. The findings also highlight the aspects of the learning environment that may reduce or exacerbate these constructs, thereby informing teacher educators to consider and implement those aspects that will create positive environments for learning mathematics.

This study is also significant as being the first to look at pre-service teachers and mathematics education amidst large-scale educational reform. Educational reform initiatives have similarly been called for across several countries within the wider region, including Bahrain, Jordan, Qatar, and the Kingdom of Saudi Arabia (Barber, Mourshed, & Whelan, 2007; Booz & Company, 2013). While this study was specifically situated within Abu Dhabi teacher education institutes, other higher education institutes offering teacher education programmes throughout the UAE and the wider region may also make use of these findings.

5.6.2 Contributions to Stakeholders

The results of this study are also likely to be of significance to the two higher educational institutions involved. This study has provided important information about the self-reported levels of anxiety, self-efficacy and beliefs regarding mathematics, which previously could only be inferred from research conducted in other settings, and informal, anecdotal observations of teacher educators. This study has suggested that improvements can be made, and are necessary, in all of the variables of this study (mathematics anxiety, mathematics anxiety, teaching self-efficacy, beliefs about mathematics, and perceptions of the learning environment), in order to graduate highly efficacious and effective teachers of mathematics. The findings, in conjunction with existing literature, have suggested strategies to alleviate mathematics anxiety and boost teaching self-efficacy during the pre-service teachers' education in order to optimize their future classroom teaching. Policy makers, curriculum developers and teaching faculty at teachers' colleges in the region may also find the results of this study of significance. All stakeholders will be able to implement the recommendations based on solid, contextual evidence. New nationwide Teacher Standards, benchmarked against international best-practice criteria, are about to be officially announced in the UAE, and with the Abu Dhabi 2030 Vision aim to have 90 percent Emiratis in the education sector by 2030 (The Abu Dhabi Government, 2008), it is essential that local teacher education programmes build capacity by producing fully prepared pre-service teachers to teach the 'new mathematics' effectively and with confidence. The recommendations suggested in this thesis, if implemented, will enable this to transpire. Moreover, as mathematics anxiety, mathematics teaching anxiety, self-efficacy and beliefs about have all been linked with retention (Gresham, 2018; Hemmings, 2015; Nurlu, 2015; Peker & Ertekin, 2011), the implemented recommendations will increase the chances that these teachers stay in the profession.

The findings of this study will also be significant to a number of other stakeholders. Science, technology, engineering and mathematics education (STEM) is at the top of the list of the 2030 UAE Strategic Vision. As such, mathematics teachers have an important role to play in the fruition of this vision. Therefore, the research will be of significance to the Ministry of Education, the Abu Dhabi Education Council and the Knowledge and Human Development Authority, also in the link to national developmental needs in the UAE. Past research (Aslan et al., 2016; Hadley & Dorward, 2011; Muijs & Reynolds, 2015; Ramirez, et al, 2013) has shown clear relationships between teachers' mathematics related anxiety, self-efficacy and beliefs, and their teaching methodologies, and subsequently the achievement of their students. Therefore, implementing strategies to improve these phenomena in pre-service teachers are imperative, as left unattended; these issues could undermine the on-going reform effort (see Section 5.3 for educational implications and recommendations).

The results of this study may also have positive implications for current and future pre-service teachers. Simply acknowledging issues exist, as this study has done, is the first step towards resolving them. Considering the physical effects anxiety can have on an individual (see Section 2.2), and the fact that teaching mathematics will subsume approximately a third of the job pre-service teachers are training for, addressing mathematics anxiety issues is important, not only for their future students, but for their own health and well-being, and will also positively impact retention rates.

5.6.3 Methodological Contributions

This study has made methodological contributions by developing or modifying instruments to assess: pre-service teachers' anxiety in regards to mathematics; their anxiety towards teaching mathematics; their self-efficacy for teaching mathematics; their beliefs about mathematics; and their perceptions of their mathematics classroom environments during their teacher training. These surveys are: the Anxiety for Mathematics Survey (AMS); the Teaching Anxiety in Mathematics Scale (TAMS); the modified Self-efficacy for Teaching Mathematics Instrument (M-SETMI); the Beliefs about Mathematics Survey (BAMS); and the What Is Happening in This Class? (WIHIC) survey, all of which were tested for reliability and validity for the context of this study. The results for the new instruments, in terms of the Cronbach alpha, were comparable or higher than the original instruments.

The above section discussed the significance of the current study in terms of three main areas. First, the contribution of this study to research in relation to pre-service teachers’ mathematics anxiety, self-efficacy, beliefs and the perceived learning environment was discussed (Section 5.6.1). Second, the significance of the study for a variety of stakeholders with an interest in teacher education in Abu Dhabi was discussed (Section 5.6.2), and finally, the methodological contributions of the study were considered (Section 5.6.3).

5.7 Concluding Remarks

In the context of an on-going educational reform project in Abu Dhabi, and in view of the Abu Dhabi 2030 Vision aim to have 90 percent Emiratis in the education sector by 2030 (The Abu Dhabi Government, 2008), this study’s findings provide important information the Ministry of Education, Abu Dhabi Education Council, and Knowledge and Human Development Authority, as well as higher educational institutes offering teacher education programmes. Drawing on the findings, and recommendations made, teacher education programmes can be modified to ensure that mathematics anxiety is identified and addressed, and that graduates are self-efficacious, and hold sophisticated beliefs about the nature of mathematics. Not only will this ensure quality teaching of mathematics in Abu Dhabi schools, and promote the reform efforts, but it is also likely to positively affect teacher retention and contribute to the Abu Dhabi 2030 Vision.

This study examined the mathematics anxiety, the teaching anxiety for mathematics, the self-efficacy for teaching mathematics, the beliefs about mathematics and the perceptions of the mathematics learning environment of the Emirati pre-service teachers in two Abu Dhabi B.Ed. programmes, and whether there were significant differences between year levels. This study also examined how self-efficacy for teaching mathematics and perceptions of the learning environments are related to the other variables.

The results of this study indicate that Emirati pre-service teachers, on average, do harbour moderate anxiety for mathematics and mathematics teaching, however despite this, their reported self-efficacy is still moderately positive. The pre-service teachers in this study also hold moderate beliefs about mathematics, but slightly more sophisticated beliefs about the usefulness of mathematics. Relationships were found between teaching self-efficacy and mathematics anxiety, mathematics teaching anxiety, and pre-service teachers' perceptions of the learning environment. Relationships were also found between the perceived mathematics learning environment and mathematics anxiety, mathematics teaching anxiety, and beliefs about mathematics. The only difference found across year levels was in Self-confidence, between years 1 and 2.

The results from my study suggest that relatively simple modifications to teacher education programmes (teaching approaches, assessments, the learning environment, awareness of anxiety and beliefs, etc.) could reduce mathematics anxiety and teaching anxiety, and improve self-efficacy and beliefs about mathematics. Areas for further research have also been recommended.

REFERENCES

Abelson, R. P. (1979). Differences between belief and knowledge systems. *Cognitive Science, 3*(4), 355-366. doi:10.1016/S0364-0213(79)80013-0

Abu Dhabi Education Council. (n.d.). Private schools. Retrieved from https://www.adek.abudhabi.ae/en/Students/PrvtS/Pages/default.aspx

Afari, E., Aldridge, J. M., & Fraser, B. J. (2012). Effectiveness of using games in tertiary-level mathematics classrooms. *International Journal of Science and Mathematics Education, 10*(6), 1369-1392. doi:10.1007/s10763-012-9340-5

Afari, E., Aldridge, J. M., Fraser, B. J., & Khine, M. S. (2013). Students' perceptions of the learning environment and attitudes in game-based mathematics classrooms. *Learning Environments Research, 16*(1), 131-150. doi:10.1007/s10984-012-9122-6

Ahmed, A. (2011). The UAE's history lesson. *The National*. Retrieved from https://www.thenational.ae/uae/the-uae-s-history-lesson-1.460608

Ajzen, I., & Fishbein, M. (1980). *Understanding attitudes and predicting social behavior*. Englewood Cliffs, N.J.: Prentice-Hall.

Akin, A., & Kurbanoglu, I. N. (2011). The relationships between math anxiety, math attitudes, and self-efficacy: A structural equation model. *Studia Psychologica*, *53*(3), 263-273.

Akinsola, M. K. (2014). Assessing pre-service teachers' teaching anxiety. *American Journal of Educational Research, 2*(12A), 41-44.

Aksu, M., Demir, C. E., & Sumer, Z. H. (2002). Students' beliefs about mathematic: A descriptive study. *Education and Science, 27*(123), 72-77.

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

Aldridge, J. M., Fraser, B. J., & Huang, T.-C. I. (1999). Investigating classroom environments in Taiwan and Australia with multiple research methods. *The Journal of Educational Research, 93*(1), 48-62. doi:10.1080/00220679909597628

Alexander, L., & Martray, C. R. (1989). The development of an abbreviated version of the Mathematics Anxiety Rating Scale. *Measurement and Evaluation in Counseling and Development, 22*(3), 143-150.

Alhebsi, A., Pettaway, L. D., & Waller, L. (2015). A history of education in the United Arab Emirates and Trucial Sheikdoms. *The Global eLearning Journal, 4*(1), 1-6.

Allinder, R. M. (1994). The relationship between efficacy and the instructional practices of special education teachers and consultants. *Teacher Education and Special Education, 17*(2), 86-95. doi:10.1177/088840649401700203

Alnabah, N. (1996). *Education in the United Arab Emirates*. Abu Dhabi, UAE: Alflah.

AlNaqbi, A. (2009). *The British educational policies in the Trucial States (1953-1971)* Ras Al Khaimah, United Arab Emirates: Research Book Series.

Ameen, E. C., Guffey, D. M., & Jackson, C. (2002). Evidence of teaching anxiety among accounting educators. *Journal of Education for Business, 78*(1), 16-22. doi:10.1080/08832320209599692

Anderman, E. M. (2002). School effects on psychological outcomes during adolescence. *Journal of Educational Psychology, 94*(4), 795-809. doi:10.1037//0022-0663.94.4.795

Ashcraft, M. H. (2002). Math anxiety: Personal, educational, and cognitive consequences. *Current Directions in Psychological Science, 11*(5), 181-185. doi:10.1111/1467-8721.00196

Ashcraft, M. H., & Kirk, E. P. (2001). The relationships among working memory, math anxiety, and performance. *Journal of Experimental Psychology: General*, *130*(2), 224-237. doi:10.1037/0096-3445.130.2.224

Ashcraft, M. H., & Moore, A. M. (2009). Mathematics anxiety and the affective drop in performance. *Journal of Psychoeducational Assessment, 27*(3), 197-205. doi:10.1177/0734282908330580

Ashencaen Crabtree, S. (2010). Engaging students from the United Arab Emirates in culturally responsive education. *Innovations in Education and Teaching International*, *47*(1), 85-94. doi:10.1080/14703290903525929

Ashton, P. (1984). Teacher efficacy: A motivational paradigm for effective teacher education. *Journal of Teacher Education, 35*(5), 28-32. doi:10.1177/002248718403500507

Ashton, P., & Webb, R. B. (1986). *Making a difference: Teacher's sense of efficacy and student achievement*. New York, NY: Longman.

Aslan, D., Oğul, I. G., & Taş, I. (2016). The impacts of preschool teachers' mathematics anxiety and beliefs on children's mathematics achievement. *International Journal of Humanities and Social Science Invention, 2*(7), 45-49.

Atkinson, R. (1988). *An exploration of the factors relating to the system of mathematics anxiety*. (Doctoral Dissertation), Retrieved from https://search-proquest-com.dbgw.lis.curtin.edu.au/docview/303640816?accountid=10382 ProQuest Dissertations Publishing database. (303640816)

Austin, S., Wadlington, E., & Bitner, J. (1992). Effect of beliefs about mathematics on math anxiety and math self-concept in elementary teachers. *Education, 112*(3), 390-395.

Badri, M., & Khaili, M. A. (2014). Migration of P–12 education from its current state to one of high quality: The aspirations of Abu Dhabi. *Policy Futures in Education*, *12*(2), 200-220. doi:10.2304/pfie.2014.12.2.200

Bahgat, G. (1999). Education in the Gulf Monarchies: Retrospect and prospect. *International Review of Education / Internationale Zeitschrift für Erziehungswissenschaft / Revue Internationale de l'Education, 45*(2), 127-136. doi:10.1023/A:1003610723356

Ball, D. L. (1988). Unlearning to teach mathematics. *For the Learning of Mathematics, 8*(1), 40-48.

Ball, D. L. (1990). The mathematical understandings that prospective teachers bring to teacher education. *The Elementary School Journal, 90*(4), 449-466. doi:10.1086/461626

Baloğlu, M. (1999). *A comparison of mathematics anxiety and statistics anxiety in relation to general anxiety*. Retrieved from https://files.eric.ed.gov/fulltext/ED436703.pdf

Baloğlu, M., & Zelhart, P. F. (2007). Psychometric properties of the Revised Mathematics Anxiety Rating Scale. *The Psychological Record, 57*(4), 593-611. doi:10.1007/BF03395597

Bandura, A. (1977). Self-efficacy: Toward a unifying theory of behavioral change. *Psychological Review, 84*(2), 191-215. doi:10.1037/0033-295X.84.2.191

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

Bandura, A. (1993). Perceived self-efficacy in cognitive development and functioning. *Educational Psychologist, 28*(2), 117-148. doi:10.1207/s15326985ep2802_3

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

Bandura, A. (2006). Guide for constructing self-efficacy scales. In T. Urdan & F. Pajares (Eds.), *Self-efficacy beliefs of adolescents* (pp. 307–337). Greenwich, CN: Information Age Publishing.

Barber, M., Mourshed, M., & Whelan, F. (2007). Improving education in the Gulf. *McKinsey Quarterly, Special Edition*, 39–47.

Başpinar, K., & Peker, M. (2016). The relationship between pre-service primary school teachers' mathematics teaching anxiety and their beliefs about teaching and learning mathematics. *Kuramsal Eğitimbilim, 9*(1), 1-14. doi:10.5578/keg.10628

Beilock, S. L., Gunderson, E. A., Ramirez, G., Levine, S. C., & Smith, E. E. (2010, February). *Female teachers' math anxiety affects girls' math achievement.* Paper presented at the Proceedings of the National Academy of Sciences of the United States of America, United States.

Beilock, S. L., & Maloney, E. A. (2015). Math anxiety: A factor in math achievement not to be ignored. *Policy Insights from the Behavioral and Brain Sciences, 2*(1), 4-12. doi:10.1177/2372732215601438

Bekdemir, M. (2010). The pre-service teachers' mathematics anxiety related to depth of negative experiences in mathematics classroom while they were students. *Educational Studies in Mathematics, 75*(3), 311-328. doi:10.1007/s10649-010-9260-7

Bernstein, D. A. (1983). Dealing with teaching anxiety: A personal view. *Journal of the National Association of Colleges and Teachers of Agriculture, 27*, 4-7.

Bessant, K. C. (1995). Factors associated with types of mathematics anxiety in college students. *Journal for Research in Mathematics Education, 26*(4), 327-345. doi:10.2307/749478

Beswick, K. (2006). Changes in preservice teachers' attitudes and beliefs: The net impact of two mathematics education units and intervening experiences. *School Science and Mathematics*, *106*(1), 36-47. doi:10.1111/j.1949-8594.2006.tb18069.x

Beswick, K. (2012). Teachers' beliefs about school mathematics and mathematicians' mathematics and their relationship to practice. *Educational Studies in Mathematics, 79*(1), 127-147. doi:10.1007/s10649-011-9333-2

Beswick, K., & Dole, S. (2001, July). *Dispelling the myths: Influencing the beliefs of preservice primary teachers.* Paper presented at the Numeracy and Beyond: 24th Annual Conference of the Mathematics Education Research Group of Australasia, Turramurra, Australia.

Betz, N. E. (1978). Prevalence, distribution, and correlates of math anxiety in college students. *Journal of Counseling Psychology, 25*(5), 441-448. doi:10.1037/0022-0167.25.5.441

Booz & Company. (2013). Listening to students' voices: Putting students at the heart of education reform in the GCC. Retrieved from https://www.strategyand.pwc.com/media/file/Listening-to-studentsvoices.pdf

Brady, P., & Bowd, A. (2005). Mathematics anxiety, prior experience and confidence to teach mathematics among pre-service education students. *Teachers and Teaching, 11*(1), 37-46. doi:10.1080/1354060042000337084

Bramald, R., Hardman, F., & Leat, D. (1995). Initial teacher trainees and their views of teaching and learning. *Teaching and Teacher Education*, *11*(1), 23-31. doi:10.1016/0742-051X(94)E0009-T

Briley, J. S. (2012). The relationships among mathematics teaching efficacy, mathematics self-efficacy, and mathematical beliefs for elementary pre-service teachers. *IUMPST: The Journal, 5*, 1-13.

Briley, J. S., Thompson, T., & Iran-Nejad, A. (2009). Mathematical beliefs, self-regulation, and achievement by university students in remedial mathematics courses. *Research in the Schools, 16*(2), 15-28.

Brooks, R., Fuller, A., & Waters, J. L. (Ed.) (2012). *Changing spaces of education: New perspectives on the nature of learning*. Oxon, England: Routledge.

Brown, A. B., Westenskow, A., & Moyer-Packenham, P. S. (2011). Elementary pre-service teachers: Can they experience mathematics teaching anxiety without having mathematics anxiety? *Issues in the Undergraduate Mathematics Preparation of School Teachers: The Journal, 5*, 1-14.

Brown, A. B., Westenskow, A., & Moyer-Packenham, P. S. (2012). Teaching anxieties revealed: pre-service elementary teachers' reflections on their mathematics teaching experiences. *Teaching Education, 23*(4), 365-385. doi:10.1080/10476210.2012.727794

Brown, T. A. (2015). *Confirmatory factor analysis for applied research* (2nd ed.). New York, NY: Guilford Publications.

Bryman, A. (2012). *Social research methods* (4th ed.). Oxford: Oxford University Press.

Buckley, S., Reid, K., Goos, M., Lipp, O. V., & Thomson, S. (2016). Understanding and addressing mathematics anxiety using perspectives from education, psychology and neuroscience. *Australian Journal of Education, 60*(2), 157-170. doi:10.1177/0004944116653000

Bulmahn, B. J., & Young, D. M. (1982). On the transmission of mathematics anxiety. *The Arithmetic Teacher, 30*(3), 55-56.

Bursal, M., & Paznokas, L. (2006). Mathematics anxiety and preservice elementary teachers' confidence to teach mathematics and science. *School Science and Mathematics, 106*(4), 173-180. doi:10.1111/j.1949-8594.2006.tb18073.x

Bush, W. S. (1989). Mathematics anxiety in upper elementary school teachers. *School Science and Mathematics*, *89*(6), 499-509.

Buxton, L. (1981). *Do you panic about maths? Coping with maths anxiety*. London: Heinemann Educational.

Byrd, P. (1982). *A descriptive study of mathematics anxiety: Its nature and antecedents*. Indiana University. Indiana, IN.

Cady, J. A., & Rearden, K. (2007). Pre-service teachers' beliefs about knowledge, mathematics, and science. *School Science and Mathematics, 107*(6), 237-245. doi:10.1111/j.1949-8594.2007.tb18285.x

Calderhead, J., & Robson, M. (1991). Images of teaching: student teachers' early conceptions of classroom practice. *Teaching and Teacher Education, 7*(1), 1-8. doi:10.1016/0742-051X(91)90053-R

Carpenter, T. P., Lindquist, M. M., Matthews, W., & Silver, E. A. (1983). Results of the Third NAEP Mathematics Assessment: Secondary school. *The Mathematics Teacher, 76*(9), 652-659.

Çatlioğlu, H., Birgin, O., Coştu, S., & Gürbüz, R. (2009). The level of mathematics anxiety among pre-service elementary school teachers. *Procedia - Social and Behavioral Sciences, 1*(1), 1578-1581. doi:10.1016/j.sbspro.2009.01.277

Chang, H., & Beilock, S. L. (2016). The math anxiety-math performance link and its relation to individual and environmental factors: a review of current behavioral and psychophysiological research. *Current Opinion in Behavioral Sciences, 10*(C), 33-38. doi:10.1016/j.cobeha.2016.04.011

Charalambous, C. Y., Philippou, G. N., & Kyriakides, L. (2008). Tracing the development of preservice teachers' efficacy beliefs in teaching mathematics during fieldwork. *Educational Studies in Mathematics, 67*(2), 125-142. doi:10.1007/s10649-007-9084-2

Charney, D. (1996). Empiricism is not a four-letter word. *College Composition and Communication, 47*(4), 567-593. doi:10.2307/358602

Chionh, Y. H., & Fraser, B. J. (2009). Classroom environment, achievement, attitudes and self-esteem in geography and mathematics in Singapore. *International Research in Geographical and Environmental Education, 18*(1), 29-44. doi:10.1080/10382040802591530

Cohen, L., Manion, L., & Morrison, K. (2011). *Research methods in education* (7th ed.). New York, NY: Routledge.

Coladarci, T. (1992). Teachers' sense of efficacy and commitment to teaching. *The Journal of Experimental Education, 60*(4), 323-337. doi:10.1080/00220973.1992.9943869

Coleman, G. (2001). *Issues in education: View from the other side of the room*. Westport, CT: Bergin & Garvey.

Cooper, M. M. (1997). Distinguishing critical and post-positivist research. *College Composition and Communication, 48*(4), 556-561. doi:10.2307/358458

Cornell, C. (1999). "I hate math! I couldn't learn it, and I can't teach it!". *Childhood Education, 75*(4), 225. doi:10.1080/00094056.1999.10522022

Creswell, J. W. (2012). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research* (4th, International ed.). Boston, MA: Pearson.

Cronbach, L. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika, 16*(3), 297-334. doi:10.1007/BF02310555

Davidson, C. M. (2008). From traditional to formal education in the lower Arabian Gulf, 1820 - 1971. *History of education, 37*(5), 633-643. doi:10.1080/00467600701430020

Davidson, C. M. (2010). *The higher education sector in the Gulf: History, pathologies, and progress*. Dubai, UAE: Gulf Research Center.

Deieso, D., & Fraser, B. J. (2018). Learning environment, attitudes and anxiety across the transition from primary to secondary school mathematics. *Learning Environments Research*. doi:10.1007/s10984-018-9261-5

Devine, A., Fawcett, K., Szűcs, D., & Dowker, A. (2012). Gender differences in mathematics anxiety and the relation to mathematics performance while controlling for test anxiety. *Behavioral and Brain Functions*, *8*, 1-9. doi:10.1186/1744-9081-8-33

Dickson, M., Kadbey, H., & McMinn, M. (2015). Comparing reported classroom practice in public and private schools in the United Arab Emirates. *Procedia - Social and Behavioral Sciences, 186,* 209-215. doi:10.1016/j.sbspro.2015.04.079

Dickson, M., Kadbey, H., & McMinn, M. (2016). Correlating beliefs and classroom practices of public school science teachers in Abu Dhabi, U.A.E. *Journal of Turkish Science Education, 13*(3), 161-172.

Dickson, M., McMinn, M., & Kadbey, H. (2017). Science anxiety levels in Emirati student teachers. *Learning and Teaching in Higher Education: Gulf Perspectives, 14*(1). doi:10.18538/lthe.v14.n1.250

Diener, E., & Crandall, R. (1978). *Ethics in social and behavioral research*. Chicago, IL: University of Chicago.

Dorman, J. (2002). Classroom environment research: Progress and possibilities *Queensland Journal of Educational Research*, *18*(2), 112-140.

Dossey, J. A. (1992). The nature of mathematics: Its role and its influence. In D. A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 39-48). New York, NY: MacMillan.

Dreger, R. M., & Aiken, L. R. (1957). The identification of number anxiety in a college population. *Journal of Educational Psychology, 48*(6), 344-351. doi:10.1037/h0045894

Duffin, L. C., French, B. F., & Patrick, H. (2012). The Teachers' Sense of Efficacy Scale: Confirming the factor structure with beginning pre-service teachers. *Teaching and Teacher Education, 28*(6), 827-834. doi:10.1016/j.tate.2012.03.004

Durmus, S., & Bicak, B. (2006). *A scale for mathematics and mathematical values of pre-service teachers*. Paper presented at the Third International Conference on the Teaching of Mathematics, Istanbul, Turkey. https://files.eric.ed.gov/fulltext/ED495503.pdf

Encyclopædia Britannica. (2018). Abu Dhabi. In *Encyclopædia Britannica*.

Encyclopaedia Britannica. (2018). United Arab Emirates. In *Encyclopaedia Britannica*.

Enochs, L. G., Smith, P. L., & Huinker, D. (2000). Establishing factorial validity of the mathematics teaching efficacy beliefs instrument. *School Science and Mathematics, 100*(4), 194-202. doi:10.1111/j.1949-8594.2000.tb17256.x

Erktin, E., & Oner, N. (1990). *Development of a math anxiety scale for Turkish students*. Paper presented at the XI International Conference of the Society for Test Anxiety Research (STAR), Berlin, Germany.

Ernest, P. (1989). The impact of beliefs on the teaching of mathematics. In P. Ernest (Ed.), *Mathematics teaching: The state of the art* (pp. 249–253). New York, NY: Falmer.

Ertekin, E. (2010). Correlations between the mathematics teaching anxieties of pre-service primary education mathematics teachers and their beliefs about mathematics. *Educational Research and Reviews, 5*(8), 446-454.

Ertekin, E., Dilmac, B., & Yazici, E. (2009). The relationship between mathematics anxiety and learning styles of preservice mathematics teachers. *Social Behavior and Personality: An International Journal, 37*(9), 1187-1195. doi:10.2224/sbp.2009.37.9.1187

Ertekin, E., Dilmac, B., Yazici, E., & Peker, M. (2010). The relationship between epistemological beliefs and teaching anxiety in mathematics. *Educational Research and Reviews, 5*(10), 631-636.

Faust, M. (1992). *Analysis of physiological reactivity in mathematics anxiety* (Doctoral dissertation), Bowling Green State University, Bowling Green, OH.

Fennema, E., & Sherman, J. A. (1976). Fennema-Sherman Mathematics Attitudes Scales: Instruments designed to measure attitudes toward the learning of mathematics by females and males. *Journal for Research in Mathematics Education*, *7*(5), 324-326. doi:10.2307/748467

Field, A. P. (2013). *Discovering statistics using IBM SPSS: and sex and drugs and rock'n'roll* (4th ed.). London: SAGE.

Fraser, B. J. (1998). Classroom environment instruments: Development, validity and applications. *Learning Environments Research, 1*(1), 7-34. doi:10.1023/A:1009932514731

Fraser, B. J. (2001). Twenty thousand hours: Editor' introduction. *Learning Environments Research, 4*(1), 1-5. doi:10.1023/A:1011406709483

Fraser, B. J. (2007). Classroom learning environments. In S. K. L. Abell, N. G. (Ed.), *Handbook of research on science education* (pp. 103–124). Mahwah, NJ: Lawrence Erlbaum.

Fraser, B. J. (2012). Classroom learning environments: Retrospect, context and prospect. In B. a. T. Fraser, K.G. and McRobbie, C.J. (Ed.), *Second international handbook of science education* (pp. 1191-1239). Dordrecht: Springer.

Fraser, B. J., & Fisher, D. L. (1982). Effects of classroom psychosocial environment on student learning. *British Journal of Educational Psychology, 52*(3), 374-377. doi:10.1111/j.2044-8279.1982.tb02525.x

Fraser, B. J., & Kahle, J. B. (2007). Classroom, home and peer environment influences on student outcomes in science and mathematics: An analysis of systemic reform data. *International Journal of Science Education, 29*(15), 1891-1909. doi:10.1080/09500690601167178

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

Frenzel, A. C., Pekrun, R., & Goetz, T. (2007). Perceived learning environment and students' emotional experiences: A multilevel analysis of mathematics classrooms. *Learning and Instruction, 17*(5), 478-493. doi:10.1016/j.learninstruc.2007.09.001

Gardner, L. E., & Leak, G. K. (1994). Characteristics and correlates of teaching anxiety among college psychology teachers. *Teaching of Psychology, 21*(1), 28-32. doi:10.1207/s15328023top2101_5

Gibson, S., & Dembo, M. H. (1984). Teacher efficacy: A construct validation. *Journal of Educational Psychology, 76*(4), 569-582. doi:10.1037/0022-0663.76.4.569

Gilbert, M. C., Musu-Gillette, L. E., Woolley, M. E., Karabenick, S. A., Strutchens, M. E., & Martin, W. G. (2014). Student perceptions of the classroom environment: Relations to motivation and achievement in mathematics.

Learning Environments Research, 17(2), 287-304. doi:10.1007/s10984-013-9151-9

Goetz, T., & Hall, N. C. (2013). Emotion and achievement in the classroom. In J. A. Hattie, E. M. (Ed.), *International guide to student achievement* (pp. 192–195). New York, NY: Routledge.

Goetz, T., Pekrun, R., Hall, N., & Haag, L. (2006). Academic emotions from a social-cognitive perspective: antecedents and domain specificity of students' affect in the context of Latin instruction. *The British Journal of Educational Psychology, 76*(2), 289-308. doi:10.1348/000709905X42860

Goh, S. C., & Fraser, B. J. (1998). Teacher interpersonal behaviour, classroom environment and student outcomes in primary mathematics in Singapore. *Learning Environments Research, 1*(2), 199-229. doi:10.1023/A:1009910017400

Goh, S. C., Young, D. J., & Fraser, B. J. (1995). Psychosocial climate and student outcomes in elementary mathematics classrooms: A multilevel analysis. *The Journal of Experimental Education, 64*(1), 29-40. doi:10.1080/00220973.1995.9943793

Gough, M. F. (1954). Why failures in mathematics? Mathemaphobia: Causes and treatments. *The Clearing House, 28*(5), 290-294. doi:10.1080/00098655.1954.11476830

Gould, J. E. (1955). The applicability of Kurt Lewin's system of psychology to the classroom. *Peabody Journal of Education, 32*(5), 305-312. doi:10.1080/01619565509536587

Gresham, G. (2007). A study of mathematics anxiety in pre-service teachers. *Early Childhood Education Journal, 35*(2), 181-188. doi:10.1007/s10643-007-0174-7

Gresham, G. (2008). Mathematics anxiety and mathematics teacher efficacy in elementary pre-service teachers. *Teaching Education, 19*(3), 171-184. doi:10.1080/10476210802250133

Gresham, G. (2018). Preservice to inservice: Does mathematics anxiety change with teaching experience? *Journal of Teacher Education, 69*(1), 90-107. doi:10.1177/0022487117702580

Gürbüz, R., & Yildirim, K. (2016). An investigation of mathematics anxiety of primary school teachers. *Turkish Journal of Computer and Mathematics Education, 7*(3), 536-536. doi:10.16949/turkbilmat.277870

Güzeller, C. O., & Doğru, M. (2012). Development of Science Anxiety Scale for primary school students. *Social Indicators Research, 109*(2), 189-202. doi:10.1007/s11205-011-9894-6

Haciomeroglu, G. (2013). Mathematics anxiety and mathematical beliefs: What is the relationship in elementary pre-service teachers? *IUMPST: The Journal, 5*, 1-9.

Haciomeroglu, G. (2014). Elementary pre-service teachers' mathematics anxiety and mathematics teaching anxiety. *International Journal for Mathematics Teaching and Learning, 15*(1), 1-10.

Hackett, G., & Betz, N. E. (1989). An exploration of the mathematics self-efficacy/mathematics performance correspondence. *Journal for Research in Mathematics Education, 20*(3), 261-273. doi:10.2307/749515

Hadfield, O. D., & McNeil, K. (1994). The relationship between Myers-Briggs Personality Type and mathematics anxiety among preservice elementary teachers. *Journal of Instructional Psychology, 21*(4), 375-384.

Hadley, K. M., & Dorward, J. (2011). Investigating the relationship between elementary teacher mathematics anxiety, mathematics instructional practices, and student mathematics achievement. *Journal of Curriculum and Instruction, 5*(2), 27-44.

Haertel, G. D., Walberg, H. J., & Haertel, E. H. (1981). Socio-psychological environments and learning: A quantitative synthesis. *British Educational Research Journal*, *7*(1), 27-36. doi:10.1080/0141192810070103

Harper, N. W., & Daane, C. J. (1998). Causes and reduction of math anxiety in preservice elementary teachers. *Action in Teacher Education, 19*(4), 29-38. doi:10.1080/01626620.1998.10462889

Hart, L. C. (2002). Preservice teachers' beliefs and practice after participating in an integrated content/methods course. *School Science and Mathematics*, *102*(1), 4-14. doi:10.1111/j.1949-8594.2002.tb18191.x

Helmke, A. (1983). *Schulische leistungsangst [Scholastic fear of achievement]*. Frankfurt, Germany: Lang Verlag.

Hembree, R. (1988). Correlates, causes, effects, and treatment of test anxiety. *Review of Educational Research, 58*(1), 47-77.

Hembree, R. (1990). The nature, effects, and relief of mathematics anxiety. *Journal for Research in Mathematics Education, 21*(1), 33-46. doi:10.2307/749455

Hemmings, B. C. (2015). Strengthening the teaching self-efficacy of early career academics. *Issues in Educational Research, 25*(1), 1-17.

Herts, J., & Beilock, S. (2017). From Janet T. Spence's Manifest Anxiety Scale to the present day: Exploring math anxiety and its relation to math achievement. *A Journal of Research, 77*(11), 718-724. doi:10.1007/s11199-017-0845-9

Hoy, A. W., & Spero, R. B. (2005). Changes in teacher efficacy during the early years of teaching: A comparison of four measures. *Teaching and Teacher Education*, *21*(4), 343-356. doi:10.1016/j.tate.2005.01.007

Hoy, W. K., & Woolfolk, A. E. (1990). Socialization of student teachers. *American Educational Research Journal, 27*(2), 279-300. doi:10.2307/1163010

Hughes, P. T. (2016). *The relationship of mathematics anxiety, mathematical beliefs, and instructional practices of elementary school teachers.* (Doctoral Dissertation), Georgia State University, Atlanta, GA.

Huinker, D., & Madison, S. K. (1997). Preparing efficacious elementary teachers in science and mathematics: The influence of methods courses. *Journal of Science Teacher Education, 8*(2), 107-126. doi:10.1023/A:1009466323843

Hunt, G. E. (1985). Maths anxiety – where do we go from here? *Focus on Learning Problems in Mathematics, 7*(2), 29-40.

Isiksal-Bostan, M. (2016). A longitudinal study on mathematics teaching efficacy: Which factors (un)support the development? *EURASIA Journal of Mathematics, Science & Technology Education, 12*(8), 2085-2102. doi:10.12973/eurasia.2016.1277a

Isiksal, M. (2010). The relationship among mathematics teaching efficacy, math anxiety, and mathematical self-concept: The case of Turkish pre-service elementary teachers. *The Asia-Pacific Education Researcher, 19*(3), 501-514. doi:10.3860/taper.v19i3.1857

Jackson, E. (2008). Mathematics anxiety in student teachers. *Practitioner Research in Higher Education, 2*(1), 36-42.

Jenßen, L., Dunekacke, S., Eid, M., & Blömeke, S. (2015). The relationship of mathematical competence and mathematics anxiety: An application of latent state-trait theory. *Zeitschrift für Psychologie, 223*(1), 31-38. doi:10.1027/2151-2604/a000197

Johnson, D. D. P., & Fowler, J. H. (2011). The evolution of overconfidence. *Nature, 477*(7364), 317-320. doi:10.1038/nature10384

Jong, C., & Hodges, T. E. (2015). Assessing attitudes toward mathematics across teacher education contexts. *Journal of Mathematics Teacher Education, 18*(5), 407-425. doi:10.1007/s10857-015-9319-6

Jong, C., Pedulla, J. J., Reagan, E. M., Salomon-Fernandez, Y., & Cochran-Smith, M. (2010). Exploring the link between reformed teaching practices and pupil learning in elementary school mathematics: reformed teaching. *School Science and Mathematics, 110*(6), 309-326. doi:10.1111/j.1949-8594.2010.00039.x

Kagan, D. M. (1992). Implications of research on teacher belief. *Educational Psychologist, 27*(1), 65-90.

Kaiser, H. F. (1960). The application of electronic computers to factor analysis. *Educational and Psychological Measurement, 20*(1), 141-151. doi:10.1177/001316446002000116

Kelly, W. P., & Tomhave, W. K. (1985). A study of math anxiety/math avoidance in preservice elementary teachers. *The Arithmetic Teacher, 32*(5), 51-53.

Khine, M. S., Fraser, B. J., Afari, E., Oo, Z., & Kyaw, T. T. (2018). Students' perceptions of the learning environment in tertiary science classrooms in Myanmar. *Learning Environments Research, 21*(1), 135-152. doi:10.1007/s10984-017-9250-0

Klassen, R. M., & Tze, V. M. C. (2014). Teachers' self-efficacy, personality, and teaching effectiveness: A meta-analysis. *Educational Research Review, 12*, 59-76. doi:10.1016/j.edurev.2014.06.001

Klieme, E., Hartig, J., & Rauch, D. (2008). The concept of competence in educational contexts. In J. Hartig, Klieme, E., & Leutner, D. (Ed.), *Assessment of competencies in educational contexts: State of the art and future prospects* (pp. 3-22). Göttingen, Germany: Hogrefe.

Kline, R. B. (2010). *Principles and practices of structural equation modelling* (3rd ed.). New York, NY: Guilford Press.

Knight, S. L., Parker, D., Zimmerman, W., & Ikhlief, A. (2014). Relationship between perceived and observed student-centred learning environments in Qatari elementary mathematics and science classrooms. *Learning Environments Research, 17*(1), 29-47. doi:10.1007/s10984-014-9156-z

Knobloch, N., & Whittington, M. S. (2002). Novice teachers' perceptions of support, teacher preparation quality, and student teaching experience related to teacher efficacy. *Journal of Vocational Education Research, 27*(3), 331-341. doi:10.5328/JVER27.3.331

Kogelman, S. W., J. (1978). *Mind over math*. New York, NY: McGraw Hill.

Krauss, S. E. (2005). Research paradigms and meaning making: A primer. *Qualitative Report, 10*(4), 758-770.

Kuhn, T. S. (1996). *The structure of scientific revolutions* (3rd ed.). Chicago, IL: University of Chicago Press.

Lampert, M. (1990). When the problem is not the question and the solution is not the answer: Mathematical knowing and teaching. *American Educational Research Journal, 27*(1), 29-63. doi:10.2307/1163068

Lang, Q. C., Wong, A. F. L., & Fraser, B. J. (2005). Student perceptions of chemistry laboratory learning environments, student–teacher interactions and attitudes in secondary school gifted education classes in Singapore. *Research in Science Education, 35*(2), 299-321. doi:10.1007/s11165-005-0093-9

Lazarus, M. (1974). Mathophobia: Some personal speculations. *National Elementary Principal, 53*, 16-22.

Leder, G., & Grootenboer, P. (2005). Affect and mathematics education. *Mathematics Education Research Journal, 17*(2), 1-8. doi:10.1007/BF03217413

Leso, T. P., K.L. (1992). Computer anxiety and different types of computer courses. *Journal of Educational Computing Research, 8*(4), 460-478.

Liebert, R. M., & Liebert, L. L. (1998). *Personality strategies and issues*. Pacific Grove, CA: Brooks.

Lynch, G. (1994). *The efficacy of an elementary mathematics methods course in changing preservice elementary teachers' mathematics anxiety.* (Doctoral dissertation), Dalhousie University, Halifax, Nova Scotia.

Ma, X. (1999). A meta-analysis of the relationship between anxiety toward mathematics and achievement in mathematics. *Journal for Research in Mathematics Education, 30*(5), 520-540. doi:10.2307/749772

Ma, X., & Xu, J. (2004). The causal ordering of mathematics anxiety and mathematics achievement: a longitudinal panel analysis. *Journal of Adolescence, 27*(2), 165-179. doi:10.1016/j.adolescence.2003.11.003

MacLeod, C., & Fraser, B. J. (2010). Development, validation and application of a modified Arabic translation of the What Is Happening In this Class? (WIHIC) questionnaire. *Learning Environments Research, 13*(2), 105-125. doi:10.1007/s10984-008-9052-5

Macpherson, R., Kachelhoffer, P., & El Nemr, M. (2007). The radical modernization of school and education system leadership in the United Arab Emirates: Towards indigenized and educative leadership. *International Studies in Educational Administration, 35*(1), 60-77.

Mallow, J. (2006). Science anxiety: Research and action. In W. H. Leonard & J. J. Mintzes (Eds.), *Handbook of college science teaching* (pp. 3-14). Arlington, VA: National Association of Science Teachers.

Manouchehri, A., & Goodman, T. (2000). Implementing Mathematics Reform: The Challenge within. *Educational Studies in Mathematics*, *42*(1), 1-34. doi:10.1023/A:1004011522216

Martin-Dunlop, C., & Fraser, B. J. (2008). Learning environment and attitudes associated with an innovative science course designed for prospective elementary teachers. *International Journal of Science and Mathematics Education, 6*(1), 163-190. doi:10.1007/s10763-007-9070-2

McGee, J. (2012). *Developing and validating a new instrument to measure the self-efficacy of elementary mathematics teachers.* (Doctoral dissertation), University of North Carolina, Charlotte, NC. Retrieved from http://libres.uncg.edu/ir/uncc/f/McGee_uncc_0694D_10291.pdf

McGee, J., & Wang, C. (2014). Validity-supporting evidence of the Self-Efficacy for Teaching Mathematics Instrument. *Journal of Psychoeducational Assessment, 32*(5), 390-403. doi:10.1177/0734282913516280

McGlynn-Stewart, M. (2010). Listening to students, listening to myself: Addressing pre-service teachers' fears of mathematics and teaching mathematics. *Studying Teacher Education, 6*(2), 175-186. doi:10.1080/17425964.2010.495898

McKinnon, M., Barza, L., & Moussa-Inaty, J. (2013). Public versus private education in primary science: The case of Abu Dhabi schools. *International Journal of Educational Research, 62*, 51-61. doi:10.1016/j.ijer.2013.06.007

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

McMinn, M., Dickson, M., & Kadbey, H. (2015). Emirati science teachers’ beliefs, self-confidence, challenges faced and their reported practice. *International Online Journal of Primary Education, 4*(1), 1-9.

McMinn, M., Kadbey, H., & Dickson, M. (2015). The impact of beliefs and challenges faced, on the reported practice of private school science teachers in Abu Dhabi. *Journal of Turkish Science Education, 12*(2), 69-79.

McRobbie, C. J., & Fraser, B. J. (1993). Associations between student outcomes and psychosocial science environment. *The Journal of Educational Research, 87*(2), 78-85. doi:10.1080/00220671.1993.9941170

Miller, L. D., & Mitchell, C. E. (1994). Mathematics anxiety and alternative methods of evaluation. *Journal of Instructional Psychology, 21*(4), 353-358.

Morris, J. (1981). Math anxiety: Teaching to avoid it. *The Mathematics Teacher, 74*(6), 413-417.

Muijs, D., & Reynolds, D. (2015). Teachers' beliefs and behaviors: What really matters? *The Journal of Classroom Interaction, 50*(1), 25-40.

Muis, K. R. (2004). Personal epistemology and mathematics: A critical review and synthesis of research. *Review of Educational Research*, *74*(3), 317-377. doi:10.3102/00346543074003317

Mulholland, J., & Wallace, J. (2001). Teacher induction and elementary science teaching: enhancing self-efficacy. *Teaching and Teacher Education, 17*(2), 243-261. doi:10.1016/S0742-051X(00)00054-8

Munby, H. (1997). Issues of validity in science attitude measurement. *Journal of Research in Science Teaching, 34*(4), 337-341.

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

Nespor, J. (1987). The role of beliefs in the practice of teaching. *Journal of Curriculum Studies*, *19*(4), 317-328. doi:10.1080/0022027870190403

Newton, K. J., Leonard, J., Evans, B. R., & Eastburn, J. A. (2012). Preservice elementary teachers' mathematics content knowledge and teacher efficacy. *School Science and Mathematics, 112*(5), 289-299. doi:10.1111/j.1949-8594.2012.00145.x

Novak, E., & Tassell, J. L. (2017). Studying preservice teacher math anxiety and mathematics performance in geometry, word, and non-word problem solving. *Learning and Individual Differences, 54*, 20-29. doi:10.1016/j.lindif.2017.01.005

Nurlu, Ö. (2015). Investigation of teachers' mathematics teaching self-efficacy. *International Electronic Journal of Elementary Education*, *8*(1), 21-40.

Ogbuehi, P. I., & Fraser, B. J. (2007). Learning environment, attitudes and conceptual development associated with innovative strategies in middle-school mathematics. *Learning Environments Research, 10*(2), 101-114. doi:10.1007/s10984-007-9026-z

Okur, M., & Bahar, H. H. (2010). Learning styles of primary education prospective mathematics teachers; states of trait-anxiety and academic success. *Procedia - Social and Behavioral Sciences, 2*(2), 3632-3637. doi:10.1016/j.sbspro.2010.03.565

Opolot-Okurut, C. (2010). Classroom learning environment and motivation towards mathematics among secondary school students in Uganda. *Learning Environments Research*, *13*(3), 267-277. doi:10.1007/s10984-010-9074-7

Österholm, M. (2009, January). *Beliefs: A theoretically unnecessary construct?* Paper presented at the Congress of the European Society for Research in Mathematics Education 6, Lyon, France.

Oxford, R. L. A., N.J. (1995). A cross-cultural view of learning styles. *Language Teaching*, *28*, 201–215.

Pajares, M. F. (1992). Teachers' beliefs and educational research: Cleaning up a messy construct. *Review of Educational Research, 62*(3), 307-332. doi:10.2307/1170741

Pajares, M. F. (1997). Current directions in self-efficacy research. In M. Maehr, & Pintrich, P.R. (Ed.), *Advances in motivation and achievement* (Vol. 10, pp. 1-49). Greenwich, CT: JAI Press.

Paolucci, C. (2015). Changing perspectives: Examining the potential for advanced mathematical studies to influence pre-service teachers' beliefs about mathematics. *Teaching and Teacher Education, 49*, 97-107. doi:10.1016/j.tate.2015.03.002

Peer, J., & Fraser, B. J. (2015). Sex, grade-level and stream differences in learning environment and attitudes to science in Singapore primary schools. *Learning Environments Research, 18*(1), 143-161. doi:10.1007/s10984-013-9142-x

Peker, M. (2006). Matematik öğretmeye yönelik kaygı ölçeğinin geliştirilmesi. *Eğitim Bilimleri ve Uygulama Dergisi, 9*, 73-92.

Peker, M. (2009a). Pre-service teachers' teaching anxiety about mathematics and their learning styles. *Eurasia Journal of Mathematics, Science and Technology Education*, *5*(4), 335-345. doi:10.12973/ejmste/75284

Peker, M. (2009b). The use of expanded microteaching for reducing pre-service teachers' teaching anxiety about mathematics. *Scientific Research and Essays, 4*(9), 872-880.

Peker, M. (2016). Mathematics teaching anxiety and self-efficacy beliefs toward mathematics teaching: A path analysis. *Educational Research and Reviews, 11*(3), 97-104. doi:10.5897/ERR2015.2552

Peker, M., & Ertekin, E. (2011). The relationship between mathematics teaching anxiety and mathematics anxiety. *The New Educational Review, 23*(1), 213-226.

Peker, M., & Ulu, M. (2018). The effect of pre-service mathematics teachers' beliefs about mathematics teaching-learning on their mathematics teaching anxiety.

International Journal of Instruction, 11(3), 249-264. doi:10.12973/iji.2018.11318a

Pituch, K., & Stevens, J. (2016). *Applied multivariate statistics for the social sciences*. New York: Routledge.

Plake, B. S., & Parker, C. S. (1982). The development and validation of a revised version of the Mathematics Anxiety Rating Scale. *Educational and Psychological Measurement, 42*(2), 551-557. doi:10.1177/001316448204200218

Poulou, M. (2007). Personal teaching efficacy and its sources: Student teachers' perceptions. *Educational Psychology, 27*(2), 191-218. doi:10.1080/01443410601066693

Price, P. C., & Jhangiani, R. (2013). *Research methods in psychology: Core concepts and skills*. BCcampus, CA: BCcampus.

Puchner, L. D., & Taylor, A. R. (2006). Lesson study, collaboration and teacher efficacy: Stories from two school-based math lesson study groups. *Teaching and Teacher Education, 22*(7), 922-934. doi:10.1016/j.tate.2006.04.011

Purnomo, Y. W., Suryadi, D., & Darwis, S. (2016). Examining pre-service elementary school teacher beliefs and instructional practices in mathematics class. *International Electronic Journal of Elementary Education, 8*(4), 629-642.

Ramirez, G., Chang, H., Maloney, E. A., Levine, S. C., & Beilock, S. L. (2016). On the relationship between math anxiety and math achievement in early elementary school: The role of problem solving strategies. *Journal of Experimental Child Psychology, 141*(C), 83-100. doi:10.1016/j.jecp.2015.07.014

Ramirez, G., Gunderson, E. A., Levine, S. C., & Beilock, S. L. (2013). Math anxiety, working memory, and math achievement in early elementary school. *Journal* *of Cognition and Development, 14*(2), 187-202. doi:10.1080/15248372.2012.664593

Raymond, A. M. (1997). Inconsistency between a beginning elementary school teacher's mathematics beliefs and teaching practice. *Journal for Research in Mathematics Education, 28*(5), 550-576. doi:10.2307/749691

Richardson, F. C., & Suinn, R. M. (1972). The Mathematics Anxiety Rating Scale: Psychometric data. *Journal of Counseling Psychology, 19*(6), 551-554. doi:10.1037/h0033456

Richardson, V. (2003). Pre-service teachers' beliefs. In J. M. Raths, A.C. (Ed.), *Teacher beliefs and classroom performance: The impact of teacher education. Advances in teacher education* (Vol. 6, pp. 1-22). Greenwich, CT: Information Age Publishing.

Ridge, N. (2009). *Privileged and penalized: The education of boys in the United Arab Emirates.* (Doctoral dissertation), Columbia University, New York, NY. Retrieved from http://gateway.proquest.com/openurl?url_ver=Z39.88-2004&rft_val_fmt=info:ofi/fmt:kev:mtx:dissertation&res_dat=xri:pqdiss&rft_dat=xri:pqdiss:3348361

Ridge, N. (2014). *Education and the reverse gender divide in the Gulf States: Embracing the global, ignoring the local*. New York, NY: Teachers College Press.

Ridge, N., Kippels, S., & ElAsad, S. (2015). *Education in Ras Al Khaimah and the United Arab Emirates*. UAE: Sheikh Saud bin Saqr Al Qasimi Foundation for Policy Research.

Riggs, I. M., & Enochs, L. G. (1990). Toward the development of an elementary teacher's science teaching efficacy belief instrument. *Science Education, 74*(6), 625-637. doi:10.1002/sce.3730740605

Romeo, F. (1987). Understanding student teacher anxieties: A descriptive survey. *Journal of Human Behavior and Learning, 4*, 43-47.

Roos, A. L., Bieg, M., Goetz, T., Frenzel, A. C., Taxer, J., & Zeidner, M. (2015). Experiencing more mathematics anxiety than expected? Contrasting trait and state anxiety in high achieving students. *High Ability Studies, 26*(2), 245-258. doi:10.1080/13598139.2015.1095078

Roscoe, M. (2011). *Informal mathematics activities and the beliefs of elementary teacher candidates.* (Doctoral dissertation), The University of Montana, Missoula, MT. Retrieved from http://scholarworks.umt.edu/etd

Rounds, J. B., & Hendel, D. D. (1980). Measurement and dimensionality of mathematics anxiety. *Journal of Counseling Psychology, 27*(2), 138-149. doi:10.1037/0022-0167.27.2.138

Sandman, R. S. (1980). The Mathematics Attitude Inventory: Instrument and user's manual. *Journal for Research in Mathematics Education, 11*(2), 148-149. doi:10.2307/748906

Schmidt, W. H., & Buchmann, M. (1983). Six teachers' beliefs and attitudes and their curricular time allocations. *The Elementary School Journal, 84*(2), 162-171. doi:10.1086/461353

Schoenfeld, A. H. (2016). Learning to Think Mathematically: Problem Solving, Metacognition, and Sense Making in Mathematics (Reprint). *Journal of Education, 196*(2), 1-38. doi:10.1177/002205741619600202

Sharif, T., Hossan, C., & McMinn, M. (2014). Motivation and determination of intention to become teacher: A case of B.Ed. students in UAE. *International Journal of Business and Management, 9*(5), 60-73. doi:10.5539/ijbm.v9n5p60

Shaw, K. E., Badri, A. A. M. A., & Hukul, A. (1995). Management concerns in United Arab Emirates state schools. *International Journal of Educational Management, 9*(4), 8-13. doi:10.1108/09513549510088381

Sloan, T. (2010). A quantitative and qualitative study of math anxiety among preservice teachers. *The Educational Forum, 74*(3), 242-256. doi:10.1080/00131725.2010.483909

Sloan, T., Daane, C. J., & Giesen, J. (2002). Mathematics anxiety and learning styles: What is the relationship in elementary preservice teachers? *School Science and Mathematics, 102*(2), 84-87. doi:10.1111/j.1949-8594.2002.tb17897.x

Smith, D. L., & Lovat, T. J. (2003). *Curriculum: action on reflection* (4th ed.). Tuggerah, NSW: Social Science Press.

Smith, J. P. (1996). Efficacy and teaching mathematics by telling: A challenge for reform. *Journal for Research in Mathematics Education, 27*(4), 387-402. doi:10.2307/749874

Smith, L. J. (2010). *The relationship among mathematics anxiety, mathematical self-efficacy, mathematical teaching self-efficacy, and the instructional practices of elementary school teachers.* (Dissertation/Thesis), The University of Southern Mississippi, Hattiesburg, MS.

Soodak, L. C., & Podell, D. M. (1996). Teacher efficacy: toward the understanding of a multi-faceted construct. *Teaching and Teacher Education*, *12*(4), 401-411. doi:10.1016/0742-051X(95)00047-N

Spicer, J. (2004). Resources to combat math anxiety. *Eisenhower National Clearinghouse Focus, 12*(12), 1-8.

Stern, G. G. (1970). *People in context. Measuring person-environment congruence in education and industry*. New York: Wiley.

Stoehr, K. J. (2017). Mathematics anxiety: one size does not fit all. *Journal of Teacher Education, 68*(1), 69-84. doi:10.1177/0022487116676316

Suinn, R. M., & Winston, E. H. (2003). The Mathematics Anxiety Rating Scale, a brief version: Psychometric data. *Psychological Reports, 92*(1), 167-173. doi:10.2466/pr0.2003.92.1.167

Suliman, O. (2000). *A descriptive study of the educational system in the United Arab Emirates.* (Doctoral dissertation), University of Southern California, Los Angeles, CA.

Suman, O. O., Caglayan, K. Y., & Kartal, A. (2015). Fear of mathematics of pre-service primary school teachers. *H. U. Journal of Education, 30*(2), 69-80.

Swars, S. L., Daane, C. J., & Giesen, J. (2006). Mathematics anxiety and mathematics teacher efficacy: What is the relationship in elementary preservice teachers? *School Science and Mathematics, 106*(7), 306-315. doi:10.1111/j.1949-8594.2006.tb17921.x

Swars, S. L., Hart, L. C., Smith, S. Z., Smith, M. E., & Tolar, T. (2007). A longitudinal study of elementary pre-service teachers' mathematics beliefs and content knowledge. *School Science and Mathematics, 107*(8), 325-335. doi:10.1111/j.1949-8594.2007.tb17797.x

Swars, S. L., Smith, S. Z., Smith, M. E., & Hart, L. C. (2009). A longitudinal study of effects of a developmental teacher preparation program on elementary prospective teachers’ mathematics beliefs. *Journal of Mathematics Teacher Education*, *12*(1), 47-66. doi:10.1007/s10857-008-9092-x

Swetman, B., Munday, R., & Windham, R. (1993). Math-anxious teachers: Breaking the cycle. *College Student Journal, 22*(4), 421-427.

Szydlik, J. E., Szydlik, S. D., & Benson, S. R. (2003). Exploring changes in pre-service elementary teachers' mathematical beliefs. *Journal of Mathematics Teacher Education*, *6*(3), 253-279. doi:10.1023/A:1025155328511

Tabachnick, B. G., & Fidell, L. S. (2013). *Using multivariate statistics* (6th ed.). Boston: Pearson.

Taylor, L. & Brooks, K. (1986). Building math confidence by overcoming math anxiety. From theory to practice. *Adult Literacy and Basic Education, 10*(1), 2-5.

Taylor, B. A., & Fraser, B. J. (2013). Relationships between learning environment and mathematics anxiety. *Learning Environments Research, 16*(2), 297-313. doi:10.1007/s10984-013-9134-x

Taylor, P. C., Fraser, B. J., & Fisher, D. L. (1997). Monitoring constructivist classroom learning environments. *International Journal of Educational Research, 27*(4), 293-302. doi:10.1016/S0883-0355(97)90011-2

Teh, G. P. L., & Fraser, B. J. (1995). Associations between student outcomes and geography classroom environment. *International Research in Geographical and Environmental Education, 4*(1), 3-18. doi:10.1080/10382046.1995.9964955

Temiz, T., & Topcu, M. S. (2013). Preservice teachers' teacher efficacy beliefs and constructivist-based teaching practice. *European Journal of Psychology of Education, 28*(4), 1435-1452. doi:10.1007/s10212-013-0174-5

Terre Blanche, M., Durrheim, K., & Painter, D. (Eds.). (2006). *Research in practice: Applied methods for the social sciences (2nd ed.)*. Cape Town: UCT.

The Abu Dhabi Government. (2008). *The Abu Dhabi Economic Vision Report 2030.* Abu Dhabi, UAE: Author.

Thomas, B. (2006). *Composition studies and teaching anxiety: A pilot study of teaching groups and discipline- and program-specific triggers.* (Doctoral dissertation), Bowling Green State University, Bowling Green, OH.

Thompson, A. G. (1984). The relationship of teachers' conceptions of mathematics and mathematics teaching to instructional practice. *Educational Studies in Mathematics, 15*(2), 105-127. doi:10.1007/BF00305892

Thompson, A. G. (1992). Teachers' beliefs and conceptions: A synthesis of the research. In D. A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 127- 146). New York: Macmillan.

Thompson, B. (2001). Significance, effect sizes, stepwise methods and other issues: Strong arguments move the field. . *Journal of Experimental Education, 7*, 80-93.

Thorne, C. (2011). The impact of educational reforms on the work of the school principal in the United Arab Emirates. *Educational Management Administration & Leadership, 39*(2), 172-185. doi:10.1177/1741143210390058

Tobias, S. (1980). *Overcoming math anxiety*. Boston: Houghton Mifflin.

Trickett, E. J., & Moos, R. H. (1973). Social environment of junior high and high school classrooms. *Journal of Educational Psychology, 65*(1), 93-102. doi:10.1037/h0034823

Trochim, W. M. K. (2006). *Positivism & post-positivism*. Retrieved from http://www.socialresearchmethods.net/kb/positvsm.php

Trochim, W. M. K., & Donnelly, J. P. (2008). *Research methods knowledge base* (3rd ed.). Mason, Ohio: Atomic Dog/Cengage Learning.

Trujillo, K. M., & Hadfield, O. D. (1999). Tracing the roots of mathematics anxiety through in-depth interviews with preservice elementary teachers. *College Student Journal, 33*(2), 219-232.

Tschannen-Moran, M., & Woolfolk-Hoy, A. (2001). Teacher efficacy: capturing an elusive construct. *Teaching and Teacher Education, 17*(7), 783-805. doi:10.1016/S0742-051X(01)00036-1

Tschannen-Moran, M., & Woolfolk-Hoy, A. (2007). The differential antecedents of self-efficacy beliefs of novice and experienced teachers. *Teaching and Teacher Education, 23*(6), 944-956. doi:10.1016/j.tate.2006.05.003

Tschannen-Moran, M., Woolfolk-Hoy, A., & Hoy, W. K. (1998). Teacher efficacy: Its meaning and measure. *Review of Educational Research, 68*(2), 202-248. doi:10.2307/1170754

Udo, M. K., Ramsey, G. P., & Mallow, J. V. (2004). Science anxiety and gender in students taking general education science courses. *Journal of Science Education and Technology, 13*(4), 435-446. doi:10.1007/s10956-004-1465-z

United Arab Emirates National Media Council. (2013). *United Arab Emirates Yearbook 2013*. Dubai, UAE: Elite Media.

United Arab Emirates National Qualifications Authority. (2013). *The UAE education system: Overview of performance in education*. Retrieved from Abu Dhabi, UAE:

Ural, A. (2015). The effect of mathematics self-efficacy on anxiety of teaching mathematics. *Kuramsal Eğitimbilim Dergisi, 8*(2), 173-184. doi:10.5578/keg.9075

Uusimaki, L., & Nason, R. (2004, July). *Causes underlying pre-service teachers' negative beliefs and anxieties about mathematics.* Paper presented at the 28th Conference of the International Group for the Psychology of Mathematics Education, Bergen, Norway.

Uysal, F., & Dede, Y. (2016). Mathematics anxiety and beliefs of Turkish pre-service elementary teachers. *EURASIA Journal of Mathematics, Science & Technology Education, 12*(8), 2171-2186. doi:10.12973/eurasia.2016.1418a

Vinson, B. M. (2001). A comparison of preservice teachers' mathematics anxiety before and after a methods class emphasizing manipulatives. *Early Childhood Education Journal, 29*(2), 89-94. doi:10.1023/A:1012568711257

Visit Abu Dhabi. (2018). UAE capital & surrounds. Retrieved from https://visitabudhabi.ae/en/explore/regions/uae.capital.aspx

Von Oppell, M. A., & Aldridge, J. M. (2015). Teacher beliefs and education reform in Abu Dhabi: 21st century skills? *MSKU Journal of Education, 2*(2), 36-60.

Walberg, H. J., & Anderson, G. J. (1968). Classroom climate and individual learning. *Journal of Educational Psychology, 59*(6), 414-419. doi:10.1037/h0026490

Weiss, I. R., Banilower, E. R., McMahon, K. C., & Smith, P. S. (2001). *Report of the 200 National Survey of Science and Mathematics Education*. Chapel Hill, NC: Horizon Research.

Welder, R. M., Hodges, T. E., & Jong, C. (2011, October). *Measuring changes in teachers' beliefs, attitudes, and dispositions related to experiences in mathematics.* Paper presented at the 33rd Annual Meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education, Reno, Nevada

Whyte, J., & Anthony, G. (2012). Maths anxiety: The fear factor in the mathematics classroom. *New Zealand Journal of Teachers' Work, 9*(1), 6-15.

Widmer, C. C., & Chavez, A. (1982). Math anxiety and elementary school teachers. *Education, 102*(3), 272-276.

Willis, J., Jost, M., & Nilakanta, R. (2007). *Foundations of qualitative research: interpretive and critical approaches*. Thousand Oaks, CA: SAGE.

Wilson, S. (2013). Investigating rural pre-service teachers' mathematics anxiety using the Revised Mathematics Anxiety Scale (RMARS). *Australian and International Journal of Rural Education, 23*(3), 1-11.

Wolf, S. J., & Fraser, B. J. (2008). Learning environment, attitudes and achievement among middle-school science students using inquiry-based laboratory activities. *Research in Science Education, 38*(3), 321-341. doi:10.1007/s11165-007-9052-y

Wood, E. F. (1988). Math anxiety and elementary teachers: What does research tell us? *For the Learning of Mathematics*, *8*(1), 8-13.

Woodcock, S. (2011a). A cross sectional study of pre-service teacher efficacy throughout the training years. *Australian Journal of Teacher Education, 36*(10), 23-34. doi:10.14221/ajte.2011v36n12.2

Woodcock, S. (2011b). A cross sectional study of pre-service teacher efficacy throughout the training years. *Australian Journal of Teacher Education (Online), 36*(10), 23-34. doi:10.14221/ajte.2011v36n10.1

Woolfolk-Hoy, A. (2000). Educational psychology in teacher education. *Educational Psychologist, 35*(4), 257-270. doi:10.1207/S15326985EP3504_04

Woolfolk-Hoy, A., & Spero, R. B. (2005). Changes in teacher efficacy during the early years of teaching: A comparison of four measures. *Teaching and Teacher Education*, *21*(4), 343-356. doi:10.1016/j.tate.2005.01.007

Woolfolk, A. E., & Hoy, W. K. (1990). Prospective teachers' sense of efficacy and beliefs about control. *Journal of Educational Psychology, 82*(1), 81-91. doi:10.1037/0022-0663.82.1.81

Woolfolk, A. E., Rosoff, B., & Hoy, W. K. (1990). Teachers' sense of efficacy and their beliefs about managing students. *Teaching and Teacher Education, 6*(2), 137-148. doi:10.1016/0742-051X(90)90031-Y

World Population Review. (2017). Abu Dhabi Population. Retrieved from http://worldpopulationreview.com//

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

Yazici, E., Peker, M., Ertekin, E., & Dilmac, B. (2011). Is there a relationship between pre-service teachers' mathematical values and their teaching anxieties in mathematics? *Electronic Journal of Research in Educational Psychology, 9*(1), 263-282.

APPENDIX 1

PARTICIPANT INFORMATION STATEMENT

HREC Project Number:	HRE2017-0013
Project Title:	*Pre-Service Teachers' Mathematics Anxiety*
Principal Investigator:	Dr. Jill Aldridge Associate Professor | Science and Mathematics Education Centre School of Education
Student researcher:	Melissa McMinn
Version Number:	1
Version Date:	23/11/2016

<u>What is the Project About?</u>

- The background to the research project (what you already know).
- Mathematics anxiety can affect the learning capabilities of students and, at worst, can cause students to avoid or fear mathematics. It has been found that pre-service teachers often feel nervous and unable to concentrate on their teaching due to their high level of mathematics teaching anxiety. However, the link between mathematics anxiety and mathematics teaching anxiety has not yet been conclusively proven. *Teaching* or *teacher* self-efficacy has been defined as a belief in capability to execute teaching-related tasks and Mathematics teaching efficacy, accordingly, is a belief in one's abilities to successfully effect mathematics teaching tasks. A teacher's mathematics teaching self-efficacy may also impact on their mathematics teaching anxiety, as might the teachers beliefs about mathematics and the environment in which they learn mathematics,
- This study will try and find connections, if any, between mathematics anxiety, mathematics teaching anxiety, teaching self-efficacy, beliefs about the nature of mathematics and the mathematics learning environment. We also aim to identify the level of mathematics anxiety experienced by pre-service teachers and their main areas of concern when it comes to teaching the new 'mathematics'.

- If we identify that pre-service teachers are affected by mathematics anxiety and/or mathematics teaching anxiety, it may help to inform college and professional development programmes to address these issues.
- All of the pre-service teachers across two Higher Educational Institutes will be invited to participate.
- This is a pilot project.

Who is doing the Research?

- The project is being conducted by Melissa McMinn
- The results of this research project will be used by Melissa McMinn 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 have been asked to take part because you are a pre-service teacher in Abu Dhabi.
- Your participation will consist of completing an on-line questionnaire.
- Participation in the on-line questionnaire will take place in a classroom at your college and will take approximately one hour.
- We will ask you questions about how you feel and what you believe about learning, doing and teaching mathematics. The survey only needs to be completed once, and will be submitted on-line.

Are there any benefits' to being in the research project?

- There may be no direct benefit to you from participating in this research, however, sometimes, people appreciate the opportunity to discuss their opinions and feelings.
- We hope the results of this research will allow us to:
    - develop education programs for pre-service and in-service teachers
    - add to the knowledge we have about this condition

Are there any risks, side-effects, discomforts or inconveniences from being in the research project?

- There are no foreseeable risks from this 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 non-identifiable (anonymous). This means that we do not need to collect individual names. No one, not even the research team will be able to identify your information. Any information we collect and use during this research will be treated as confidential. 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.
- 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.
- The results will be available in my Ph.D. dissertation and may be presented at conferences or published in professional journals.

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, staff or colleagues.
- If you chose to leave the study we will be unable to destroy your information because it has been collected in an anonymous way.

What happens next and who can I contact about the research?

- To obtain further information or answer questions, please contact Melissa McMinn on +9712 206 2572 or mmcminn@hct.ac.ae OR Dr. Jill Aldridge on +618 9266 3592 J.Aldridge@curtin.edu.au

- At the start of the questionnaire, available via the link provided, there is a checkbox to indicate you have understood the information provided here in the information sheet and that you agree to be in the research project.

Curtin University Human Research Ethics Committee (HREC) has approved this study (HREC number HRE2017-0013). 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 (08) 9266 9223 or the Manager, Research Integrity on (08) 9266 7093 or email hrec@curtin.edu.au.

APPENDIX 2

ANXIETY FOR MATHEMATICS SURVEY (AMS)

Anxiety caused by mathematics learning		*Not at all anxious*	*A little anxious*	*Somewhat anxious*	*Anxious*	*Very anxious*
Over the past year, I have felt anxious when…						
1.	Walking into a mathematics class.	1	2	3	4	5
2.	Sitting in a mathematics class and waiting for the instructor to arrive.	1	2	3	4	5
3.	Raising my hand in a mathematics class to ask a question.	1	2	3	4	5
4.	Realising that I have to take a certain number of mathematics classes to complete my degree.	1	2	3	4	5
5.	Listening to a lecture in a mathematics class.	1	2	3	4	5
6.	Watching a teacher demonstrate an algebraic equation on the blackboard. For example, $x^2 + (12 – 8) = 53$ (What is the value of x?).	1	2	3	4	5
7.	The teacher pulls our class names out of a hat to choose someone to answer a question in mathematics class.	1	2	3	4	5
8.	The teacher pulls my name out of a hat to answer a question in mathematics class.	1	2	3	4	5
9.	Being asked to solve word problems in mathematics class.	1	2	3	4	5
Anxiety caused by mathematics evaluation		*Not at all anxious*	*A little anxious*	*Somewhat anxious*	*Anxious*	*Very anxious*
Over the past year, I have felt anxious when…						
10.	I take an examination (quiz) in a mathematics course.	1	2	3	4	5
11.	I take an examination (final) in a mathematics course.	1	2	3	4	5
12.	I think about a mathematics test that I have in one week.	1	2	3	4	5
13.	I think about a mathematics test that I have in one day.	1	2	3	4	5
14.	I think about a mathematics test that I have in one hour.	1	2	3	4	5
15.	Waiting to get mathematics test results back in which I expect to do well.	1	2	3	4	5
16.	Waiting to get mathematics test results back in which I expect to do badly.	1	2	3	4	5
17.	Taking a "pop" quiz in a math class.	1	2	3	4	5

Anxiety caused by numerical tasks		*Not at all anxious*	*A little anxious*	*Somewhat anxious*	*Anxious*	*Very anxious*
Over the past year, I have felt anxious when…						
18.	I divide a five digit number by a two digit number, in private, with pencil and paper.	1	2	3	4	5
19.	I add up 976 + 777 on paper.	1	2	3	4	5
20.	I am given a set of addition problems to solve.	1	2	3	4	5
21.	I am given a set of division problems to solve.	1	2	3	4	5
22.	I am given a set of subtraction problems to solve.	1	2	3	4	5
23.	I am given a set of multiplication problems to solve.	1	2	3	4	5
24.	I am asked to help a Grade 2 student with their mathematics homework.	1	2	3	4	5
Anxiety caused by mathematics in real-life situations		*Not at all anxious*	*A little anxious*	*Somewhat anxious*	*Anxious*	*Very anxious*
Over the past year, I have felt anxious when…						
25.	Working out how much something will cost me when there is a '25% off' sale.	1	2	3	4	5
26.	Dividing a dinner bill between you and two friends without the use of a calculator.	1	2	3	4	5
27.	Doubling quantities of ingredients in a recipe to make twice as much.	1	2	3	4	5
28.	Working out how many 150g butter packets to buy when you need 375g.	1	2	3	4	5
29.	Working out how much fabric to cut when I need 1 ¼ metres, but only have a measuring tape in millimetres.	1	2	3	4	5
30.	Working out how much I saved when I had a 40% off voucher.	1	2	3	4	5
31.	Working out how many 8-slice pizzas to buy when each child will eat 3 pieces and there are 7 children altogether.	1	2	3	4	5
32.	Working out how many chocolate bars I could buy (at different prices) when I only have AED20.	1	2	3	4	5
Anxiety caused by non-mathematics situations		*Not at all anxious*	*A little anxious*	*Somewhat anxious*	*Anxious*	*Very anxious*
Over the past year, I have felt anxious when…						
Taking an examination (final) in an English course.		1	2	3	4	5
Being given a "pop" quiz in an Arabic class.		1	2	3	4	5
Thinking about an upcoming English test 1 day before.		1	2	3	4	5
Thinking about an upcoming Arabic test 5 minutes before.		1	2	3	4	5
Waiting to get a science test returned in which you expected to do well.		1	2	3	4	5
Having an Arabic assignment due at the end of the week.		1	2	3	4	5
Being given a set of English grammar questions to answer.		1	2	3	4	5
Raising my hand in an Academic Reading and Writing class to ask a question.		1	2	3	4	5

APPENDIX 3

TEACHING ANXIETY FOR MATHEMATICS SURVEY (TAMS)

Anxiety caused by content knowledge	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
I get anxious when I teach number topics.	1	2	3	4	5
I get anxious when I teach patterns and algebra topics.	1	2	3	4	5
I get anxious when I teach measurement and data topics.	1	2	3	4	5
I get anxious when I teach space and geometry topics.	1	2	3	4	5
I only like teaching mathematics topics that I am good at.	1	2	3	4	5
I avoid teaching mathematics topics I don’t understand.	1	2	3	4	5
I get anxious when I can’t always explain how I solved a mathematics problem.	1	2	3	4	5
I get anxious if I don’t practice the mathematics content before I teach a mathematics lesson.	1	2	3	4	5
I would feel better about teaching mathematics if I was better at doing mathematics.	1	2	3	4	5
I feel nervous that I will make a mistake in front of my students.	1	2	3	4	5
Anxiety caused by teaching mathematics	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
Mathematics is my least favourite subject to teach.	1	2	3	4	5
I feel stressed when I have to teach mathematics in my class.	1	2	3	4	5
Thinking about teaching mathematics makes me feel tired.	1	2	3	4	5

Anxiety caused by methodological knowledge	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
I feel anxious when ….					
Thinking about the theories I learned in college when I plan mathematics lessons.	1	2	3	4	5
Planning mathematics lessons.	1	2	3	4	5
Thinking of hands-on mathematics activities for my students.	1	2	3	4	5
Using a variety of mathematics materials in my lessons.	1	2	3	4	5
Thinking about what I want my students to achieve in mathematics and how to get them there.	1	2	3	4	5
When teaching mathematics, I prefer to use teacher-centred methods as this allows me to control the learning.	1	2	3	4	5
Planning ways to differentiate mathematics lessons.	1	2	3	4	5
Planning ways to use real-life examples when teaching mathematics.	1	2	3	4	5
Thinking about how to turn the rules of mathematics into concrete experiences.	1	2	3	4	5

APPENDIX 4

MODIFIED SELF-EFFICACY FOR TEACHING MATHEMATICS INSTRUMENT (M-SETMI)

Efficacy for teaching mathematics	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
When teaching mathematics …					
I can ask students relevant questions related to mathematics.	1	2	3	4	5
I can use a variety of assessment strategies in mathematics.	1	2	3	4	5
I can provide an alternative explanation or example in mathematics when students are confused.	1	2	3	4	5
I can implement different teaching strategies for mathematics in my classroom.	1	2	3	4	5
I can provide effective scaffolding for students learning mathematics.	1	2	3	4	5
I can motivate students who show low interest in mathematics.	1	2	3	4	5
I can help students to understand the importance of learning mathematics.	1	2	3	4	5
I can get my students to believe that they can do well in mathematics.	1	2	3	4	5
I can help students to find links between mathematics and their lives.	1	2	3	4	5
I can help students to love mathematics.	1	2	3	4	5
Self-confidence	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
It is very easy for me to teach mathematics.	1	2	3	4	5
I am a good mathematics teacher.	1	2	3	4	5
I am confident that I can answer most mathematics questions asked by my students.	1	2	3	4	5
I feel comfortable when a peer observes me teaching mathematics.	1	2	3	4	5
In my head, I can hear "I'm good at teaching mathematics".	1	2	3	4	5
I am as good at teaching mathematics as other student-teachers are.	1	2	3	4	5
I am qualified to teach mathematics.	1	2	3	4	5

Efficacy for teaching mathematics content	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
I can teach students to...					
Use partitioning to add two digit numbers.	1	2	3	4	5
Use partitioning to double two digit numbers.	1	2	3	4	5
Change a fraction to a decimal.	1	2	3	4	5
Understand inverse relationships between operations (i.e. +, - and x, ÷).	1	2	3	4	5
Identify the location of objects on a map using grid references.	1	2	3	4	5
Construct bar graphs showing all necessary features.	1	2	3	4	5
Measure area using cm^2.	1	2	3	4	5
Measure the length of objects.	1	2	3	4	5
Draw increasing patterns.	1	2	3	4	5
Complete number sentences that involve more than one operation.	1	2	3	4	5
Classify and explain future real-life events using ‘impossible’, ‘possible’ and ‘certain’.	1	2	3	4	5
Count groups of objects using one to one correspondence.	1	2	3	4	5
Describe cubes, rectangular prisms and cylinders.	1	2	3	4	5
Divide numbers by 10 and 100.	1	2	3	4	5
Read times involving whole and half hours using an analogue clock.	1	2	3	4	5
Explain whether simple statements involving the equals sign are true or false.	1	2	3	4	5
Sort and compare simple 2d shapes.	1	2	3	4	5

APPENDIX 5

BELIEFS ABOUT MATHEMATICS SURVEY (BAMS)

Beliefs about the nature of mathematics	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
Mathematics can be understood only by people who are clever.	1	2	3	4	5
Mathematics is not creative.	1	2	3	4	5
Mathematics requires logic, not intuition.	1	2	3	4	5
Mathematics consists of mostly unrelated topics.	1	2	3	4	5
Beliefs about the usefulness of mathematics	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
Knowing mathematics is important for all professions.	1	2	3	4	5
Mathematics makes everyday life easier.	1	2	3	4	5
Mathematics has a vital role on the development of civilizations.	1	2	3	4	5
Learning problem solving in mathematics prepares people to deal with problems in their daily lives.	1	2	3	4	5
I use mathematics in many ways in my life.	1	2	3	4	5
Beliefs about doing mathematics	Strongly disagree	Disagree	Neither agree nor disagree	Agree	Strongly agree
Some people have a mathematics mind and some don't.	1	2	3	4	5
Mathematics requires a good memory.	1	2	3	4	5
Knowing why an answer is correct in mathematics is as important as getting a correct answer.	1	2	3	4	5
To be good at mathematics, you need a good memory.	1	2	3	4	5
In mathematics teaching, activities should be designed in a way that students are actively involved.	1	2	3	4	5
People learn not only from their correct solutions but also learn from their mistakes.	1	2	3	4	5

APPENDIX 6

WHAT IS HAPPENING IN THIS CLASS? (WIHIC)

Student Cohesiveness	Almost never	Seldom	Sometimes	Often	Almost always
In my college mathematics classes…					
I feel comfortable around members of this class.	1	2	3	4	5
I feel safe when expressing my ideas in front of students in this class.	1	2	3	4	5
I get on well with students in this class.	1	2	3	4	5
Students in this class accept me.	1	2	3	4	5
I feel welcome in this class.	1	2	3	4	5
I work well with other class members.	1	2	3	4	5
In this class, I get help from other students.	1	2	3	4	5
Teacher Support	Almost never	Seldom	Sometimes	Often	Almost always
In my college mathematics classes…					
The teacher is interested in my problems.	1	2	3	4	5
The teacher goes out of his/her way to help me.	1	2	3	4	5
The teacher considers my feelings.	1	2	3	4	5
The teacher helps me when I have trouble with the work.	1	2	3	4	5
The teacher talks with me.	1	2	3	4	5
The teacher takes an interest in my progress.	1	2	3	4	5
The teacher moves about the class to talk with me.	1	2	3	4	5
The teacher's questions help me to understand.	1	2	3	4	5
Involvement	Almost never	Seldom	Sometimes	Often	Almost always
In my college mathematics classes…					
I discuss ideas in class.	1	2	3	4	5
I give my opinions during class discussions.	1	2	3	4	5
I explain my ideas to other students.	1	2	3	4	5
Students discuss with me how to go about solving problems.	1	2	3	4	5
I am asked to explain how I solve problems.	1	2	3	4	5
Cooperation	Almost never	Seldom	Sometimes	Often	Almost always
In my college mathematics classes…					
When I work in groups in this class, there is teamwork.	1	2	3	4	5
I work with other students on projects in this class.	1	2	3	4	5
I learn from other students in this class.	1	2	3	4	5
I work with other students in this class.	1	2	3	4	5
I cooperate with other students on class activities.	1	2	3	4	5
Students work with me to achieve class goals.	1	2	3	4	5

Equity	Almost never	Seldom	Sometimes	Often	Almost always
In my college mathematics classes…					
The teacher gives as much attention to my questions as to other students' questions.	1	2	3	4	5
I get the same amount of help from the teacher as other students do.	1	2	3	4	5
I have the same amount of say in this class as other students.	1	2	3	4	5
I am treated the same as other students in this class.	1	2	3	4	5
I receive the same encouragement from the teacher as other students do.	1	2	3	4	5
I get the same opportunity to contribute to class discussions as other students.	1	2	3	4	5
My work receives as much praise as other students' work.	1	2	3	4	5
I get the same opportunity to answer questions as other students.	1	2	3	4	5
Personal Relevance	Almost never	Seldom	Sometimes	Often	Almost always
In my college mathematics classes…					
I relate what I learn in this class to life outside college.	1	2	3	4	5
I draw on past experiences to help me in this class.	1	2	3	4	5
What I learn in this class is relevant to my everyday life.	1	2	3	4	5
I apply my everyday experiences in this class.	1	2	3	4	5
This class is relevant to my life outside of college.	1	2	3	4	5
I link my class work to my life outside of this class.	1	2	3	4	5
In this class, I get an understanding of life outside college.	1	2	3	4	5
I apply my past experience to the work in this class.	1	2	3	4	5

APPENDIX 7

OVERVIEW OF SOME LEARNING ENVIRONMENT INSTRUMENTS

Instrument	Scales	Description
Learning Environment Inventory (LEI)	Cohesiveness, Friction, Favouritism, Cliqueness, Satisfaction, Apathy, Speed, Difficulty, Competitiveness, Diversity, Formality, Material environment, Goal Direction, Disorganisation, Democracy	Initially developed as part of the Harvard Project Physics, the 15 scales contain seven statements each that are descriptive of typical classrooms. Participants respond using a 4-point Likert scale to indicate their degree of agreement. Original developer: Herbert Walberg, 1968
Classroom Environment Scale (CES)	Involvement, Affiliation, Teacher Support, Task Orientation, Competition, Order and Organisation, Rule clarity, Teacher Control, Innovation	The CES was developed from research concerning a variety of human environments, including psychiatric hospitals, prisons, university residences and workplaces. The nine scales each contains ten true/false items. Original developers: Rudolf Moos and Edison Trickett, 1974
College and University Classroom Environment Inventory (CUCEI)	Personalisation, Involvement, Student Cohesiveness, Satisfaction, Task Orientation, Innovation, Individualisation	To fill a gap in classroom environment research in tertiary classrooms, the CUCEI was development for use in small classes (up to 30 students). Each of the seven scales contains seven items, to which participants respond using a 4-point Likert scale to indicate their degree of agreement. Original developers: Barry Fraser and David Treagust, 1986
Constructivist Learning Environment Survey (CLES)	Personal Relevance, Uncertainty, Critical Voice, Shared Control, Student Negotiation	The CLES was developed to evaluate a classroom's constructivist epistemology, with a view of students as co-constructors of their own knowledge. The original instrument included 30 items across the five scales, to which participants respond using a 5-point frequency scale, although more recently (2011), a 20-item version has been used. Original developers: Peter Taylor, Barry Fraser, and Darrell Fisher, 1997
Constructivist-Oriented Learning Environment Survey (COLES)	Student Cohesiveness, Teacher Support, Involvement, Young Adult Ethos, Personal Relevance, Task Orientation, Cooperation, Equity, Differentiation, Formative Assessment, Assessment Criteria	The COLES was developed to provide feedback as a basis for reflection in teacher action research, and also included aspects related to student assessment, not previously seen in learning environment instruments. The COLES includes 11 scales with eight items in each, to which participants respond using a 5-point frequency scale. Original developers: Jill Aldridge, Barry Fraser, Lisa Bell, and Jeffrey Dorman, 2012
What Is Happening In the Class (WIHIC) - original	Student Cohesiveness, Teacher Support, Involvement, Investigation, Task Orientation, Cooperation, Equity	Designed to bring parsimony to the field, the WIHIC has become the most frequently and widely used learning environment instrument. Original with ten items in each of nine scales, to which participants respond using a 5-point frequency scale, the WIHIC has been modified for use several times. Original developers: Barry Fraser, Darrell Fisher, and Campbell McRobbie, 1996

APPENDIX 8

ETHICS APPROVAL

Curtin University

Office of Research and Development

GPO Box U1987
Perth Western Australia 6845

Telephone +61 8 9266 7863
Facsimile +61 8 9266 3793
Web research.curtin.edu.au

12-Jan-2017

Name: Jill Aldridge
Department/School: Science and Mathematics Education Centre (SMEC)
Email: J.Aldridge@curtin.edu.au

Dear Jill Aldridge

RE: Ethics approval
Approval number: HRE2017-0013

Thank you for submitting your application to the Human Research Ethics Office for the project **Investigating Emirati Pre-Service Teachers' Mathematics Anxiety, Mathematics Teaching Anxiety, Beliefs about Mathematics and Perceptions of the Learning Environment**.

Your application was reviewed through the Curtin University low risk ethics review process.

The review outcome is: **Approved**.

Your proposal meets the requirements described in National Health and Medical Research Council's (NHMRC) *National Statement on Ethical Conduct in Human Research (2007).*

Approval is granted for a period of one year from **12-Jan-2017** to **11-Jan-2018**. Continuation of approval will be granted on an annual basis following submission of an annual report.

Personnel authorised to work on this project:

Name	Role
Aldridge, Jill	Supervisor
McMinn, Melissa	Student

Standard conditions of approval

1. Research must be conducted according to the approved proposal
2. Report in a timely manner anything that might warrant review of ethical approval of the project including:
   - proposed changes to the approved proposal or conduct of the study
   - unanticipated problems that might affect continued ethical acceptability of the project
   - major deviations from the approved proposal and/or regulatory guidelines
   - serious adverse events

1. Amendments to the proposal must be approved by the Human Research Ethics Office before they are implemented (except where an amendment is undertaken to eliminate an immediate risk to participants)
2. An annual progress report must be submitted to the Human Research Ethics Office on or before the anniversary of approval and a completion report submitted on completion of the project
3. Personnel working on this project must be adequately qualified by education, training and experience for their role, or supervised
4. Personnel must disclose any actual or potential conflicts of interest, including any financial or other interest or affiliation, that bears on this project
5. Changes to personnel working on this project must be reported to the Human Research Ethics Office
6. Data and primary materials must be retained and stored in accordance with the Western Australian University Sector Disposal Authority (WAUSDA) and the Curtin University Research Data and Primary Materials policy
7. Where practicable, results of the research should be made available to the research participants in a timely and clear manner
8. Unless prohibited by contractual obligations, results of the research should be disseminated in a manner that will allow public scrutiny; the Human Research Ethics Office must be informed of any constraints on publication
9. Ethics approval is dependent upon ongoing compliance of the research with the Australian Code for the Responsible Conduct of Research, the National Statement on Ethical Conduct in Human Research, applicable legal requirements, and with Curtin University policies, procedures and governance requirements
10. The Human Research Ethics Office may conduct audits on a portion of approved projects.

Special Conditions of Approval

None

This letter constitutes ethical approval only. This project may not proceed until you have met all of the Curtin University research governance requirements.

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 9

RESEARCH APPROVAL FROM THE HIGHER EDUCATION INSTITUTES

كلية الإمارات للتطوير التربوي
Emirates College for Advanced Education

October 21st, 2018

To Whom it May Concern

The ECAE Institutional Review Board reviewed and approved the PI to survey participants from their institution in association with the following study titled: Mathematics anxiety, Mathematics teaching efficacy and Mathematical beliefs of pre-service Emirati teachers.

The Research Office acknowledge that Ms. Mellisa McMinn (Faculty at Higher Colleges of Technology) is the Principal Investigator of the above study.

If you have any questions concerning this study, please contact the ECAE Research Office at:

research@ecae.ac.ae.

P.O. Box: 126662, Abu Dhabi, United Arab Emirates
Tel: +971 2 5099 999, Fax: +971 2 5099 888

www.ecae.ac.ae

10/12/2018

To Whom It May Concern

The Higher Colleges of Technology (HCT) Institutional Review Board reviewed and approved the Principal Investigator, Ms. Melissa McMinn, and employee of HCT, to conduct a research project entitled:

Investigating Pre-Service Teachers' Mathematics Anxiety, Teaching Anxiety, Self-efficacy, Beliefs about Mathematics and Perceptions of the Learning Environment.

It is acknowledged that HCT Education students will be invited to participate in a survey in association with the research project.

If you have any queries, please contact the HCT Research Office

Hanene Benabdallah
Faculty Affairs & Scholar Activities Dean
Faculty Affairs&App'l Research

Email: hbenabdallah@hct.ac.ae

APPENDIX 10

DIFFERENCES IN YEAR LEVEL

Average Item Mean, Average Item Standard Deviation and MANOVA Results for Differences Between Years 1 to 4 in Mathematics Anxiety Using the Individual Student as the Unit of Analysis

Scale	*Average Item Mean*				*Average Item Standard Deviation*				*Difference between Years*
	Year 1	*Year 2*	*Year 3*	*Year 4*	*Year 1*	*Year 2*	*Year 3*	*Year 4*	*F*
Anxiety - Maths learning	2.34	2.47	2.04	2.19	0.90	0,84	0.96	0.98	2.36
Anxiety - Maths evaluation	2.91	3.02	2.77	3.25	0.99	0.96	1.18	1.07	0.98
Anxiety - Numerical tasks	1.95	2.15	1.99	1.96	0.81	0.97	0.92	0.86	0.57
Anxiety - Real-life Situations	2.11	2.38	2.14	2.34	0.87	0.89	0.96	0.81	1.10
Anxiety - Non-maths Situations	2.01	2.52	2.20	2.42	0.74	0.87	0.93	0.95	3.43

**$p<0.01$

N=38 students in Year 1, 79 students in Year 2, 47 students in Year 3, and 12 students in Year 4.

Effect Size and Tukey's HSD Multiple Comparison for Statistical Significance of Difference Between each Pair of Years for Mathematics Anxiety

Scale	*Effect Size & Tukey HSD*					
	Year 1-Year 2	*Year 2-Year 3*	*Year 3-Year 4*	*Year 1-Year 4*	*Year 1 – Year 3*	*Year 2-Year 4*
Anxiety - Maths learning	-0.15	0.00	-0.00	0.16	0.33	0.30
Anxiety - Maths evaluation	0.85	0.24	-0.43	-0.33	0.06	-0.22
Anxiety - Numerical tasks	-0.23	0.17	0.033	-0.02	-0.05	0.21
Anxiety - Real-life Situations	-0.31	0.25	-0.23	-0.28	-0.04	0.04
Anxiety - Non-maths Situations	-0.64	0.36	-0.23	-0.48	-0.22	0.12

$*p<0.05$, $**p<0.01$
N=38 students in Year 1, 79 students in Year 2, 47 students in Year 3, and 12 students in Year 4.

Average Item Mean, Average Item Standard Deviation and MANOVA Results for Differences Between Years 1 to 4 in Teaching Anxiety Using the Individual Student as the Unit of Analysis

Scale	*Average Item Mean*				*Average Item Standard Deviation*				*Difference between Years*
	Year 1	*Year 2*	*Year 3*	*Year 4*	*Year 1*	*Year 2*	*Year 3*	*Year 4*	*F*
Content Knowledge	2.68	3.15	2.95	3.29	0.91	0.85	0.93	1.27	2.55
Methodological Knowledge	3.32	3.51	3.46	3.64	1.00	0.75	0.97	1.28	0.51

$**p<0.01$
N=38 students in Year 1, 72 students in Year 2, 46 students in Year 3, and 11 students in Year 4.

Effect Size and Tukey's HSD Multiple Comparison for Statistical Significance of Difference Between each Pair of Years for Teaching Anxiety

Scale	*Effect Size & Tukey HSD*					
	Year 1- Year 2	*Year 2- Year 3*	*Year 3- Year 4*	*Year 1- Year 4*	*Year 1 – Year 3*	*Year 2- Year 4*
Content Knowledge	0.53	0.22	-0.30	-0.55	-0.29	-0.13
Methodological Knowledge	-0.21	0.058	-0.15	-0.27	-0.14	-0.12

*$p<0.05$, **$p<0.01$
N=38 students in Year 1, 72 students in Year 2, 46 students in Year 3, and 11 students in Year 4.

Average Item Mean, Average Item Standard Deviation and MANOVA Results for Differences Between Years 1 to 4 in Beliefs About Mathematics Using the Individual Student as the Unit of Analysis

Scale	*Average Item Mean*				*Average Item Standard Deviation*				*Difference between Years*
	Year 1	*Year 2*	*Year 3*	*Year 4*	*Year 1*	*Year 2*	*Year 3*	*Year 4*	*F*
Beliefs about the nature of mathematics	3.09	3.05	2.79	2.76	0.88	0.81	1.08	1.15	
Beliefs about the usefulness of mathematics	3.43	3.48	3.45	3.74	0.93	0.74	0.99	1.51	
Beliefs about doing mathematics	3.48	3.52	3.63	3.57	0.91	0.69	0.82	1.31	

**$p<0.01$

N=38 students in Year 1, 70 students in Year 2, 42 students in Year 3, and 10 students in Year 4.

Effect Size and Tukey's HSD Multiple Comparison for Statistical Significance of Difference Between each Pair of Years for Beliefs about Mathematics

Scale	*Effect Size & Tukey HSD*					
	Year 1-Year 2	*Year 2-Year 3*	*Year 3-Year 4*	*Year 1-Year 4*	*Year 1 – Year 3*	*Year 2-Year 4*
Beliefs about the nature of mathematics	0.05	0.27	0.01	0.30	0.30	0.27
Beliefs about the usefulness of mathematics	-0.06	0.04	-0.23	-0.25	-0.02	-0.22
Beliefs about doing mathematics	-0.05	-0.14	0.06	-0.08	-0.17	-0.05

$^{*}p<0.05$, $^{**}p<0.01$

N=38 students in Year 1, 70 students in Year 2, 42 students in Year 3, and 10 students in Year 4.