

ULRR

Exploring mathematics anxiety and potential associated environmental antecedents amongst a group of adult learners

Item Type	Thesis
Authors	O'Hanlon, Adrian
Download date	2026-06-06 17:09:37
Item License	https://creativecommons.org/licenses/by-nc-sa/4.0/
Link to Item	https://doi.org/10.34961/researchrepository-ul.24081321



**UNIVERSITY OF
LIMERICK**
OLLSCOIL LUIMNIGH

*Exploring mathematics anxiety and potential associated environmental antecedents
amongst a group of adult learners.*

Name: Adrian O Hanlon

Supervisors: Dr Raymond Lynch and Dr Orla McCormack

Word Count: 38,319

Submitted to the University of Limerick, March 2023

Declaration of Originality

This thesis is presented in fulfilment of the requirements for the Structured Masters in Research with the University of Limerick.

It is entirely my own work and has not been submitted to any other university or higher education institution, or for any other academic award in this university.

Name: Adrian O Hanlon

Signature: _____

Acknowledgements

My mathematics and educational journey has been a long and fulfilling road. This thesis and the completion of the Structured Masters by Research is another juncture in my educational story where I would like to acknowledge all those that have supported me.

- My supervisors Dr Raymond Lynch and Dr Orla McCormack for the continued, time, support and most importantly their empathy throughout the entire process.
- Dr Maria Ryan for her knowledge and expertise on mathematics anxiety and advice, I am very grateful.
- The learners who volunteered their time to take part in the research who provided rich data for future FET learners.
- My colleagues in LCETB for their support including Greg Dillon and Billy Carmody for coordinating volunteers for the study.
- All the staff from the UL Professional Diploma in Mathematics for Teaching course who taught and supported me in becoming a qualified teacher of mathematics.
- The UL Mathematics Learning Centre for their mathematics support when I was an undergraduate many years ago.
- My parents Kieran and Mary who have always encouraged me in my educational endeavours.
- My wife Niamh who has always supported my professional development without hesitation and incredible patience.
- My daughters Ellie and Emma for all your hugs and love.

List of Abbreviations

DEIS Delivering Equality of Opportunity in Schools

DES Department of Education and Skills

ESRI Economic and Social Research Institute

HE Higher Education

HEA The Higher Education Authority

LCETB Limerick and Clare Education and Training Board

MA Mathematics Anxiety

MAS-UK Mathematics Anxiety Scale – U.K.

OECD Organisation for Economic Co-operation and Development

PISA Programme for International Student Assessment

SOLAS *An tSeirbhís Oideachais Leanúnaigh agus Scileanna* (Further Education and Skills Service)

VTOS Vocational Training Opportunities Scheme

Abstract

The Further Education and Training (FET) sector has often been referred to the 'Cinderella' sector of the Irish education system. It is often overlooked and undervalued, mainly due to its fragmented provision, as well as an unclear and diverse identify. Almost €800 million of funding is invested by SOLAS annually in FET, serving around 200,000 unique learners each year.

Mathematics Anxiety affects learners at all levels of the education system including FET. Indeed, the concept of mathematics anxiety is prevalent in research in order to understand the fear and anxiety that learners exhibit in dealing with mathematics. The vast majority of research in mathematics anxiety has focused on primary school, post primary school and higher education, where FET has been ignored to a significant extent.

The study comprised of a sequential mixed method approach, the quantitative element was a MAS UK (Mathematics Anxiety Scale) questionnaire (n=15) and the qualitative element was a mathematics life story interview (n=8). The findings show that mathematics anxiety existed at varying levels among these mature students, and that there are significant environmental antecedents that contribute to the level of anxiety experienced.

Table of Contents

Declaration

Acknowledgements

Table of Contents

List of Appendices

List of Figures/Tables

Abstract

Chapter 1: Introduction	Page
1.0 Introduction	p.1
1.1 Context of Research	p.1
1.2 Further Education and Training sector in Ireland	p.4
1.3 The importance of Mathematics skills for the Irish society and economy	p.5
1.4 Mathematics anxiety within Further Education and Training	p.6
1.5 Researchers Positioning	p.7
1.6 Rational for the Study	p.8
1.7 Researchers Positioning and Questions	p.9
1.8 Structure of the Thesis	p.9
Chapter 2: Literature Review	
2.1 Mathematics Anxiety Introduction	p.12
2.2 Adult Education, Further Education & Training and Adult Numeracy policy	p.12
2.2.1 Adult Education, Further Education & Training	p.12
2.2.2 Adult Numeracy policy	p.12
2.3 Mathematics anxiety History	p.14
2.4 Mathematics anxiety Definitions	p.15
2.5 Mathematics Anxiety and Test Anxiety	p.17

2.6 Environmental Antecedents of Mathematics anxiety	p.22
2.7 Environmental Antecedents of Mathematics anxiety	p.22
2.7.1 Environmental Antecedents: Parents	p.23
2.7.2 Environmental Antecedents: Teachers	p.24
2.7.3 Environmental Antecedents: Culture	p.27
2.8 Personal Antecedents of Mathematics anxiety	p.28
2.8.1 Personal Antecedents of Mathematics anxiety: Age	p.28
2.8.2 Personal Antecedents of Mathematics anxiety Gender	p.30
2.8.3 Personal Antecedents of Mathematics anxiety Genetic Disposition	p.30
2.9 Interacting Variables of Mathematics anxiety	p.31
2.9.1 Self-Efficacy	p.32
2.9.2 Motivation	p.33
2.9.3 Prior Knowledge	p.34
2.10.1 Outcomes of Mathematics anxiety: Performance	p.36
2.10.2 Outcomes of Mathematics anxiety: Avoidance	p.37
2.11 Methods to reduce Mathematics Anxiety	P.38

Chapter 3: Methodology

3.0 Introduction	p.41
3.1 Framework of Design	p.41
3.2 Philosophical Worldview	p.41
3.2.1 Postpositivism	p.42
3.2.2 Transformative	p.43
3.2.3 Constructivism	p.43
3.2.4 Pragmatism	p.44
3.2.5 Conclusion of Philosophical Worldview	p.45

3.3 Selected Strategy of Inquiry	p.47
3.4 Mixed Methods Strategies	p.48
3.4.1 Creswell's six most used mixed methods designs	p.48
3.5 Quantitative Data Research Instrument	p.49
3.5.1 Measuring Mathematics Anxiety	p.51
3.5.2 The MAS UK	p.52
3.5.3 Mathematic Anxiety Levels	p.52
3.5.4 MAS UK results from other studies	p.53
3.6 Qualitative Data Instrument	p.54
3.6.1 Consideration of Five Qualitative Approaches	p.55
3.6.2 A Life Story	p.56
3.6.3 A Mathematics Life Story	p.57
3.7 Process of Data Collection	p.58
3.7.1 Participant Selection	p.58
3.7.2 Phase 1 Quantitative Data Process of Research Design	p.58
3.7.3 Phase 2 Qualitative Data	p.59
3.8 Analysis of Quantitative Data	p.59
3.9 Analysis of Qualitative Data	p.60
3.9.1 Thematic Analysis	p.60
3.9.2 Phase 1: Familiarizing yourself with the data	p.62
3.9.3 Phase 2: Generate initial codes	p.62
3.9.4 Phase 3: Searching for themes	p.64
3.9.5 Phase 4: Phasing themes	p.65
3.9.6 Phase 5: Mapping themes	p.66
3.9.7 Phase 6: Producing the report	p.68

3.10 Reliability and Validity	p.68
3.11 Ethical Considerations	p.70
3.12 Limitations	p.71
3.13 Summary	p.72

Chapter 4: Results

4.0 Introduction	p.73
4.1 Addressing Research Question 1:	
<i>What level of mathematics anxiety, if any, exist amongst a cohort of adult learners?</i>	p.73
4.1.1 Data Mean, Median, Range and Standard Deviation	p.73
4.1.2 Tests of Normality	p.74
4.1.3 Mathematics Anxiety Factor Analysis	p.75
4.1.4 MAS UK Results Overview	p.79
4.1.5 Summary in addressing Research Question 1	p.80
4.2 Addressing Research Question 2:	
<i>To investigate what environmental antecedents contribute towards mathematics anxiety across an adult learner's mathematics life story.</i>	p.80
4.2.1 Theme (1): Mathematics Test Anxiety	p.82
4.2.2 Theme (1): The Leaving Certificate	p.83
4.2.3 Theme (1): The Junior Certificate	p.83
4.2.4 Theme (1): Other Assessments (Assessments from other jurisdictions)	p.84
4.2.5 Theme (1): Non-formal assessment	p.85
4.2.6 Theme (1): Further Analysis of MAS-UK	p.85
4.2.7 Theme (1): Summary of Maths Test Anxiety	p.87
4.3 Theme (2): Influence of Teachers	p.87
4.3.1 Theme (2): Traditional Teaching Methods	p.88

4.3.2 Theme (2): Anger	p.89
4.3.3 Theme (2): Embarrassment	p.89
4.3.4 Theme (2): Punishment	p.92
4.3.5 Summary of Influence of Teacher	p.92
4.4 Themes (3): Influence of Parents	p.92
4.4.1 Lack of Parental Support	p.92
4.4.2 Parental Pressure	p.93
4.4.3 Summary in addressing Research Question 2	p.93
4.5 Addressing Research Question 3: <i>What impact, if any, do environmental antecedents have on students' experiences of mathematics?</i>	p.94
4.5.1 Performance, grades, achievement	p.95
4.5.2 Learning Behaviour including procrastination	p.96
4.5.3 Academic and vocational choices	p.97
4.5.4 Summary in addressing Research Question 3	p.98
Chapter 5 Discussion	
5.0 Introduction	p.99
5.1 The extent of mathematics anxiety among adult learners in a VTOS setting	p.99
5.1.1 Administration of the MAS UK	p.100
5.1.2 Cut off point for mathematics anxiety	p.100
5.1.3 Framework of Mathematics Anxiety	p.101
5.1.4 Role of Teachers	p.104
5.1.5 Teaching Methods	p.104
5.1.6 Teaching Methods: Punishment, Anger & Embarrassment	p.105
5.1.7 Mathematics Support	p.108
5.1.8 Role of Parents	p.110

5.1.9 Mathematics Test Anxiety	p.111
Chapter 6 Conclusion	
6.1 Introduction	p.113
6.2 Implications of this research	p.114
6.2.1 Implications for policy	p.114
6.2.2 Implications for future research	p.115
6.2.3 Implications for future research	p.116
6.3 Recommendation(s)	p.116
6.3.1 Mathematics Test Anxiety	p.116
6.3.2 Influence of teacher	p.118
6.3.3 Influence of parents	p.120
Bibliography	p.121
Appendices	p.133
Appendix 1 Mathematics Anxiety (MA) Intervention Studies	p.139
Appendix 2 Mathematics Anxiety Scale-UK (MAS-UK)	p.145
Appendix 3 Mathematics Life Story Framework	p.146
Appendix 4 Codes from thematic analysis	p.147
Appendix 5 Phase 3: Searching for themes	p.153
Appendix 6 Sample Timeline	p.154
Appendix 7 Research Privacy Notice	p.155
Appendix 8 Recruitment Email	p.160
Appendix 9 Volunteer Information Sheet	p.161

Appendix 10 Research Ethics	p.163
Appendix 11 Sample Timeline	p.166
Appendix 12 Summary of transcribed interviews	p.167

List of Figures

Figure 2.1 Environmental and Social/Contextual Factors	p.19
Figure 2.2 A framework for understanding mathematics anxiety	p.20
Figure 3.1 Creswell’s framework of design	p.41
Figure 3.2 Table Four Worldviews	p.42

List of Tables

Table 3.1 Process of data collection	p. 58
Table 3.2 Example of data extracts	p. 64
Table 4.1 Mean, Standard Deviation and Sample Size	p. 74
Table 4.2 MAS UK scores	p. 74
Table 4.3 Normal Q-Q plot	p. 75
Table 4.4 Tests of Normality	p. 75
Table 4.5 MAS UK Factor 1 statements	p. 76
Table 4.6 MAS UK Factor 2 statements	p. 77
Table 4.7 Factor 3 Mathematics Observation Anxiety	p. 78

Table 4.8 MAS UK scores	p. 79
Table 4.9 Learner background with MAS UK score	p. 81
Table 4.10 Statement 6/Taking a maths exam	p. 86

Chapter 1

1.0 Introduction

Mathematics has a significant ability to produce negative emotions from learners particularly when compared to other subject areas and disciplines (Boaler, 2016). Mathematics Anxiety can be responsible for poor performance in mathematics as well as avoidance of the subject (Ashcraft & Moore, 2009, Dowker et al 2016). Mathematics Anxiety according to Hembree (1990) includes emotional, cognitive, behavioral and physiological components. Mathematics Anxiety affects learners at all levels of the education system (Dowker, Sarkar & Looi, 2016), including Further Education (Betz, 1978; Boaler, 2016). The following section will outline the context of the research.

1.1 Context to the study

Research indicates that mathematics anxiety is an important mitigating factor in a learner's ability to develop their mathematics skills, (Ashcraft, 2002; Ashcraft & Moore, 2009; Geary et al., 2004; Swanson et al., 1999; 2006). The importance of empowering adults to learn mathematics is well recognised, particularly those with prior negative experiences and low academic performance in this subject (Larsen, 2015, p50). Adult Learners who hold negative experiences in mathematics find it very difficult to move past these experiences (Boaler, 2016). Richardson and Suinn (1972) found that 11% of students from a University sample required counselling as a result of 'high levels' of mathematics anxiety illustrating the seriousness of the challenge faced by many. There are also issues with engagement. Negative learning experiences of mathematics that some learners hold can develop into fear and avoidance of the subject (Langpaap, 2005; Wilder, 2013). These negative experiences and avoidance of the subject can have a negative impact on an adult's career. For example, adults who avoid Mathematics, limit the career options available to them particularly in the areas of STEM (Hembree, 1990; Beilock & Maloney, 2015). From an Irish context, there has been a convergence of economic and education policies which have shaped the direction of mathematics and STEM education in Ireland which in turn has impacted adult mathematics education (DES, 2016). Avoiding and giving up on learning mathematics can appear acceptable to those who perceive mathematics as optional but this can be 'deeply

problematic for society' as mathematics can lead to opportunities in the scientific and technological fields (Li & Schoenfeld, 2019, p.1). Indeed, mathematics anxiety and mathematics achievement both have been theorized to be important correlates of educational and career outcomes (Wigfield & Eccles, 2000). This is significant as Further Education and Training has a specific focus on employment pathways for learners. As well as the implications of mathematics anxiety for learners it is also important to consider adult learners returning to education and how to meet their specific learning needs.

Adult learning has a number of approaches, theories, frameworks, and models (Merriam et al., 2007), the most prominent of these is andragogy. Andragogy as a concept was introduced in the 1830's by the German teacher Alexander Kapp which was further developed by Malcom Knowles in the 1960s (Knowles 1975). According to Knowles's (1980) theory of andragogy, adults exhibit different learning styles, for example, adult learners tend to bring life experience to the classroom and prefer self-direction (Knowles, 1980). Knowles (1980) advocated that adult learners should feel respected, supported and that the classroom should be constructed in an 'adult friendly' manner, he also suggested that adults should never be 'talked down to'. Knowles also highlights the need for adults to engage in problem solving learning experiences, particularly real life scenarios (Knowles et al., 2012). These approaches are interesting as many of them align with interventions for mathematics anxiety including real life mathematics problem solving, a student centered approach and active learning.

There were some criticisms of the andragogy model though as it was argued by Tight (2002) that andragogy and pedagogy were not completely distinct from one another. Knowles (1980) warns that many adults lack motivation as a result of fear or anxiety towards maths due to their past experiences and have specific fears of memory loss due to their age profile. Another concept linked with andragogy is that of social capital. It is argued that andragogy and social capital theory provide a mutual perspective for both learning and development within a 'knowledge economy' (Kessels, 2004, p.9).

The origins of Social Capital can be traced back as far as the nineteenth century (Schuller, Baron, and Field 2000). Bourdieu (1997) contends that people intentionally engage in public life to build various forms of

capital (or social powers) and manipulate them to use these to their advantage. Bourdieu (1997) argued that social capital as an ‘invisible’ property of an individual is mainly acquired through ‘networks’. In an Irish context, a report from HEA (The Higher Education Authority, 2016, p.42) reported that learners from “*lower socio-economic groups are less likely to have access to the social and culture capital networks associated with higher education, and ‘by consequence often have a less smooth transition to higher education, when compared to their more affluent peers’*”. For many learners from lower socio-economic areas, FET is a much more attractive and attainable transition, however it is not without its social capital issues.

A 2013 survey revealed the continuing low status of vocational education in Ireland with, for example, large numbers of 15-19 year olds believing that vocational routes are ‘for less able students’, ‘make it less likely [a] job will be highly paid’ and ‘is a low status option’ (Pullen, 2013). The inferior perception of FET as a provision compared to higher education was significant in a number of studies (McIver Consulting, 2003; ESRI, 2014; McGuinness et al., 2019). McGuinness et al. (2019) found that FET courses were poorly connected to labour market needs and often seen as a second-best option in the eyes of both school leavers and parents compared to higher education entry. Moreover, Russell (2017) warns that the social and personal benefits of learning in FET are being ignored as the focus is on the economy and labour market activation (Russell, 2017). There are also barriers to FET for learners (Hearne et al, 2022, p.129). Fleming et al (2017) specify such factors including poverty, socioeconomic class and family responsibilities impact on their participation.

It is argued that when learners do not have the ability or access to forms of social capital that are valued by the dominant social classes, then educational outcomes are limited (Reay et al., 2010). Furthermore, there is a belief that social capital can eradicate poverty, on the belief that is the only resource that the lower socio-economic class have if they are not given basic social services (Fournier, 2002). This is based on the inability of people from lower socio-economic group to form effective networks (Øyen, 2002), as was the case in the HEA (2016) report for disadvantaged students in higher education. Moreover, a recent report by Clavel & Flannery (2022, p.10) found that learners achieved high scores in mathematics that were from “*higher levels*

of economics, social and cultural status, higher levels of parental engagement with school government activities and attending a non-disadvantaged school are associated with higher scores” across each of the three tests”. Conversely, low numeracy levels amongst adults can lead to intergenerational cycles of inequality and disadvantage in families (Carpentieri et al., 2013). Moreover, studies have shown that adults who struggle with numeracy have a greater propensity in having lower incomes, finding employment, and struggle with physical and mental health (Carpentieri et al., 2010; Parsons & Bynner, 2005).

In order to address social capital it is paramount that there is a level playing field where FET learners from disadvantaged socio-economic groups have a level playing field with learners in HE (Higher Education), despite the underlining social capital. However, HE graduates continue to achieve far greater post-graduation outcomes including superior job earnings and general life satisfaction, and the more prestigious the HE institution, the more significant the premium (Frawley et al. 2020; McCoy et al. 2014b). Carroll et al (2022), warns that the longer that this situation continues then our education systems will persist with education inequality. Research has also pointed to the importance of Post-Leaving Certificate courses as an important route to employment and higher rates of pay as well as a channel to higher education (McGuinness et al., 2019, ERSI 2022).

The current study is based in Further Education and Training for Adults, hence the importance of understanding Andragogy and Social Capital. The context of the research is based in a Further Education Campus which comprises of Adult Learnerer in a VTOS setting.

1.2 Further Education and Training sector in Ireland

Mathematics Anxiety impacts learners across all levels of the education system (Dowker, Sarkar & Looi, 2016, Finlayson, 2014), including ‘FET’ (Further Education and Training) (Betz, 1978; Boaler, 2016). According to the Department of Further and Higher Education, Research, Innovation and Science (2020), Further education is “*education and training that happens after second-level schooling, but which is not part of the third-level system*”. In recent years, a great deal of policy, funding and attention has been given to FET in Ireland. In 2020, the newly appointed Minister for Further and Higher Education Simon Harris stated that

FET is “Sometimes overlooked, often undervalued” and it is the “Cinderella” of the Irish education. It is often viewed as a lower status provision compared to higher education which is perceived as having greater prestige (McGuinness et al., 2014). Moreover, the perception of FET being inferior is due to the fragmented provision, diverse nature and not having a clear identify (McGuinness et al., 2014). Almost €800 million of funding is invested by SOLAS annually in FET, serving around 200,000 unique learners each year (FET, 2020). VTOS is part of the Further Education and Training provision in Ireland and is defined as “*a second chance education and training programme offered to adults*” (Department of Education and Skills, 2020). The VTOS programme, where the research was carried out, offers a range of courses to learners including Quality and Qualifications Ireland (QQI) Levels 3, 4 and 5, as well as a Leaving Certificate programme for adults. For many learners within the VTOS Leaving Certificate Programme, they enroll with a view to progressing to third level college as a mature learner. For many learners it’s an opportunity to reengage in mathematics having had negative experiences in post primary school. This is important given the significance of mathematics for future career and quality of life outcomes.

1.3 The importance of Mathematics

The importance of mathematics cannot be underestimated. Indeed the OECD (2013a) recognise that the development of mathematics skills should not cease when a learner leaves school. However, mathematics anxiety can counter the development of such skills through the avoidance of mathematics. Hembree (1990) highlights that the issue of adults avoiding mathematics limits the career options available to them particularly in the areas of science and technology. This can be significant, as economies and society are becoming more reliant on technology there is a growing demand for mathematical skills in adult workers (OECD, 2013a). There are studies showing that learners' positive attitude towards mathematics along with academic success can lead to an increase in economic resources (Chiu and Xihau, 2008; Dinçer and Uysal, 2010; OECD, 2013). Moreover, Mathematics is paramount to the economic success of any society (Lipnevich, MacCann, Krumm, Burrus, & Roberts, 2011). The convergence and integration of economic, education and competitiveness policies has had a profound and significant influence on mathematics and STEM education in Ireland (O

Donoghue, 2018), which as a consequence impacts on adult mathematics education and numeracy (DES, 2016). The Further Education and Training 2014-2019 strategy outlines the importance of STEM and it was anticipated that between the period 2012 to 2020 that there would be “*well above average growth is projected for this occupational growth*” (2014, p.70). Whilst, the importance of mathematics and numeracy is well documented, there are causes for concern. For example, the ‘*adult literacy for life- a 10-year adult literacy, numeracy and digital literacy strategy*’ (2021) outlined a number of objectives including the reduction of the number of adults in Ireland with unmet numeracy needs from 25% to 12%. Indeed, these percentages have stagnated for some time as O Donoghue (2018, p.55) states “*The pool of adults with inadequate numeracy has held stubbornly at 25% of the adult population for two decades*”. Gal et al (2020) suggests on a broader level, that numeracy, in contrast to literacy, has received less focus in research, despite the rhetoric in literature that numeracy has an increasing importance in the workplace. More specifically, the Programme for International Student Assessment (PISA) highlighted further concern, where Ireland stood 19th out of the 24 countries in terms of numeracy. Numeracy in everyday life is also important beyond the career domain, financial literacy is more important than ever for society, as people are required to take responsibility for self-budgeting, online banking and decisions around pensions (Cipora, 2021). As previously suggested, low level of numeracy in adults can sustain a trend from one generation to the next in families (Carpentieri et al., 2013). Therefore, Goos et al (2023) argues the necessity of adult numeracy support as a measure in addressing economic and social disadvantage, and perhaps social capital. Moreover, research shows that mental health and well-being of individuals is negatively correlated in moderation with mathematics achievement (Demedts et al, 2022). The importance of mathematics and numeracy education cannot be underestimated in FET therefore, it is essential we understand how adult learners returning to education view mathematics.

1.4 Mathematics anxiety within Further Education and Training

Mathematics Anxiety exists in Further Education (Betz, 1978; Boaler, 2016). There is extensive research to suggest that learners who exhibit mathematics anxiety in Further Education and avoid studying mathematics limit their career prospects (Ashcraft, 2002; Ashcraft & Kirk, 2001; Ashcraft & Krause, 2007; Hembree,

1990). Attitudes and engagement towards mathematics can worsen in childhood and adolescent years (Wigfield and Meece, 1988; Ma and Kishor, 1997), as a consequence this can have negative implications for adult learner engagement in mathematics' related activities (Dowker et al, 2016). Negative experiences in mathematics is a common occurrence in the early years of education for some adult learners, which can affect the learners' confidence and as a result their mathematics anxiety (Zaslavsky, 1994). Mathematics anxiety in adults, according to Klinger (2011), is formed from negative experiences. Kogelman and Warren's (1979) identify the origin of mathematics anxiety, from an "intense emotional reaction to mathematics based on past experiences" (Kogelman & Warren, 1979, p.910). Jameson (2019) specially suggest that adult learners and female particularly report greater levels of anxiety than their peers. There is also the issue of FET learners returning to education for a prolonged period. Betz (1978) suggests that learners who have not practiced mathematics in an educational setting experience anxiety due to a lack of engagement in the subject. Adult Mathematics' Anxiety is often developed from a learners early years at school (Zaslavsky, 1994). The challenge for Teachers in Adult Education regardless of the level of mathematics is to find an approach to address the anxiety in mathematics and for their students to experience success (Klinger, 2011). This section outlined the importance of mathematics for adults in FET. It highlighted its importance in terms of a learners' career options, the economy, particularly around stem and also Ireland's numeracy ranking in the OECD. It is also worth noting that mathematics skills are important for functioning in everyday life as well as in various jobs (Jansen et al, 2016). Cipora (2011) for example, stresses that financial literacy is more important than ever as people need to take responsibility for self-budgeting, online banking and decisions around pensions.

1.5 Rationale for the Study

There is significant correlation between mathematics anxiety and poor performance and avoidance of mathematics. There is overwhelming research which argues that mathematics anxiety has a negative correlation with learner's performance in mathematics (Barroso et al., 2021; OECD, 2013; Ashcraft & Moore, 2009; Caviola et al., 2021; Hembree, 1990; Namkung et al., 2019; Zhang et al., 2019) and learner's pursuit of further study in mathematics or mathematics related careers. Mathematics anxiety can be construed as a global

phenomenon according to the Organisation for Economic Co-operation and Development (OECD, 2015), as well as a number of mathematics anxiety review papers (e.g., Dowker et al., 2016).

While significant research has been conducted on mathematics anxiety across a broad spectrum of educational setting, there exists a significant dearth in research on mathematics anxiety within the area of further education and training, and particularly within the Irish context. There is extensive research in mathematics anxiety in Higher Education, for example (Alexander & Cobb, 1984; Allen & Allen, 2010; Ashcraft & Moore, 2009; Bessant, 1995; Betz, 1978; Clute, 1984; Hembree, 1990; High, 2000; Hunt, Clark-Carter & Sheffield, 2011; Lyons & Beilock, 2012; Sheffield & Hunt, 2007) whilst it is sparse in Further Education and at times dated (Betz, 1978; Boaler, 2016). More research is also evident in Pre Service Teachers than Further Education and Training (Adeyemi, 2015; Aslan, 2013; Luo, Wang, & Luo, 2009). According to Jameson & Fusco (2014) research in adult's mathematics anxiety is limited. Within an Irish context, there has been two primary papers on mathematics anxiety research in higher education Ryan & Fitzmaurice (2017) and Ryan et al (2019), both of which had a specific focus on mature students and higher education.

The potential of understanding the experience of adult's mathematics anxiety in Further Education holds the potential to benefit FET Practitioners and provide practical findings to better support learners experiencing mathematics anxiety. It is important in terms of the economic, social and wellbeing implications discussed earlier in the chapter. Moreover, the Minister for Higher and Further Education recently conceded that Further Education is on the periphery and is often undervalued (Irish Times, 2020). It is anticipated that this research will serve to enhance the understanding of mathematics anxiety, specifically within Further Education. The following section will explore the research questions and research will provide a framework for this thesis.

1.6 Researchers Questions

The purpose of this study is to explore mathematics anxiety amongst a group of adult learners and the potential associated environmental antecedents. It is envisaged, that the outcomes of this research will inform mathematics and numeracy teachers/tutors in Further Education and Training, the prevalence of mathematics anxiety and the associated environmental antecedents

The aims of this research are:

- To investigate the existence of mathematics anxiety among further education students in a VTOS setting.
- To investigate what environmental antecedents, if any, contribute towards mathematics anxiety across an adult learner's mathematics life story.

Three key research questions will underpin the foundations of the thesis.

- What level of mathematics anxiety, if any, exist amongst a cohort of adult learners?
- What, if any, environmental antecedents contribute towards mathematics anxiety across an adult learner's mathematics life story?
- What impact, if any, do environmental antecedents have on students' experiences of mathematics?

1.7 Structure of the Thesis

The structure of the thesis consists of 6 chapters. The first chapter gives a brief background to mathematics anxiety, Further Education and VTOS, as well as this, the Researcher will discuss the Context of Research, the rationale for the Study and the Researchers Positioning and Questions. Chapter two will discuss existing literature on mathematics anxiety. Chapter 3 will outline the research methodology including the researchers' philosophical worldview, selected strategy of inquiry, quantitative and qualitative instrument, process of research design, analysis of quantitative and qualitative data, summary and ethical implications. Chapter 4 will show the results of the quantitative and qualitative data. Chapter 5 will provide a discussion on the results of chapter 4 and chapter 5 will provide a conclusion including addressing the research question, limitations and implications of the study.

1.8 Researchers Positioning

I have taught mathematics to learners in post primary schools and adult learners in 'FET' (Further Education and Training) over several years. I completed a professional diploma in mathematics education from the University of Limerick and completed research on "*Adult Learners Experiences of a Flipped Mathematics*

Classroom in a VTOS Leaving Certificate Class” in conjunction with the Irish Teaching Council. I have taught in Further Education and Training for over ten years, 3 years in a Community Training Centre with a Youth Service provision and currently in a VTOS provision which is now in the process of being integrated with a College of Further Education. As a teacher, I hold such values as inclusivity, student centered approach, a holistic approach to teaching and a broader mentoring ethos. I hold the view on a broader level, that FET requires greater investment of research and investment, this view is also supported by Minister for Further and Higher Education Simon Harris (Irish Times, 2020). I hold the philosophy of life-long learning in mathematics having initially struggled with the subject. Having struggled with mathematics for my leaving certificate, I returned to education in 2007 at the University of Limerick. I questioned my self-efficacy for third level education and I also held my own mathematics anxiety. Through the use of the ‘Maths Learning Centre’ in the University of Limerick and with one to one support, I was able to regain confidence in mathematics. The centre provide a warm welcoming environment and it had a profound impact on my own mathematics life story. Indeed Gill & O Donoghue (2007), who incidentally would both have taught me and had a positive impact on my mathematics journey, carried out a study on this centre ‘*Justifying the Existence of Mathematics Learning Support Measuring the Effectiveness of a Mathematics Learning Centre*’. The study found extensive positive results including a large enrolment of learners to the course, improvement of learners’ grades and a contributing factor towards learner progression. Perhaps if I were a participant in this study, I would have suggested that the Mathematics Learning Centre in the University of Limerick altered my mathematics life story and would help me in overcoming mathematics anxiety, develop my self-efficacy, become a qualified mathematics teacher and began research in the area of mathematics anxiety. A number of years later, I would gain considerable confidence with the subject having completed a professional diploma in mathematics with the University of Limerick and subsequently teaching mathematics to a high standard including teaching mathematics to students at leaving certificate level. Thus, I hold the view that mathematics is attainable given the correct support and environment and with attainable goals. A final note regarding my research positionality is that my own personal educational journey has influenced how I conceptualise social justice and how I relate to the world. I was taught in a DEIS (Delivering Equality of Opportunity in Schools) primary and post primary

school as well as teaching in Further Education where I teach learners from marginalised parts of society. I believe there is educational equality and that the FET sector should no longer be viewed as a lower status provision compared to higher education (McGuinness et al., 2014). Moreover, it should no longer be the ‘Cinderella’ sector and that it requires a greater focus in terms of investment and research, the latter being a motivating factor for this thesis.

Chapter 2 Literature Review

2.1 Introduction

The aim of this Literature Review is to explore, examine, discuss and evaluate existing literature on mathematics anxiety. Within this chapter, the researcher will discuss a brief historical background to mathematics anxiety, examine the various definitions, and outline the antecedents of mathematics anxiety within the context of Further Education and Training.

2.2 Adult Education, Further Education & Training and Adult Numeracy policy

2.2.1 Adult Education and Further Education & Training

In Ireland, adult education and further education are closely related, and are both overseen by the Department of Further and Higher Education, Research, Innovation and Science (2020). Further education colleges and programmes comprises of YouthReach, Post Leaving Certificate (PLC) programmes, adult literacy/numeracy, Community education, and Vocational Training and Opportunities Schemes (VTOS).

The four key agencies include the state authority responsible for FET in Ireland, (SOLAS), National Adult Literacy Association (NALA), the Adult Literacy Association of Ireland (ALOA) and the main provider of FET including adult literacy services in Ireland, the Education and Training Boards Ireland (ETBI). SOLAS (2019, p17) administers the planning, funding and co-ordination of FET, they also are tasked with producing a strategy for FET to the Minister every five years. The current FET Strategy 2020-2024 sets out a vision for the further education and training system in Ireland, the key priorities of the FET Strategy are ‘access and inclusion’, ‘quality and standards’, ‘lifelong learning’ and ‘employer engagement’. Furthermore, it aims to provide high-quality education and training opportunities to individuals in order to enhance their skills, employability, and social inclusion.

2.2.2 Adult Numeracy policy

Further Education, Adult Education, and adult numeracy policy are developed and implemented by the Department of Further and Higher Education, Research, Innovation and Science (2020). A recent Irish

numeracy report *Towards a New Literacy, Numeracy and Digital literacy Strategy* (2023) stated that one of the crucial challenges in numeracy research is that, unlike literacy, there is no consensus as to what exactly numeracy is. As previously stated, Gal et al (2020) also suggested that numeracy received less focus and research compared to literacy. Goos et al (2023) supports this view and states that “*Adult education in Ireland has historically subsumed numeracy within a broad definition of literacy*”. Gal et al (2020, p378) suggests that numeracy is used broadly to encompass “*a set of diverse skills, knowledge-bases, dispositions and affect, communication abilities, and practices and behaviours, that range from simple to very advanced, relate to mathematics and statistics, and that individuals need or use in order to engage and manage diverse life situations and tasks in the adult world*”.

Tout (2020) suggests that many western countries did not have significant numeracy (or literacy) issues due the access to free education and general prosperity within that country. Despite Ireland’s prosperity, there are still some marginalised groups that numeracy support, including migrants, refugees, long-term unemployed, low-paid workers, persons with disabilities, and ethnic minority groups such as Irish Travellers (Government of Ireland, 2021). Adult numeracy in Ireland, is generally targeted at those who have limited or significant challenges in learning mathematics in a traditional setting (Goos et al, 2023). These challenges typically affect older adults and what have experienced interruptions or dropped out from school (Goos et al, 2023). As previously discussed, Ireland’s inadequate (O Donoghue, 2018) or ‘unmet’ (Government of Ireland, 2023) is around 25%. The Adult Literacy for Life (ALL) Strategy was established to address unmet literacy, numeracy and digital literacy needs for people across Ireland, one specific target was to reduce the number of adults in Ireland with unmet numeracy needs from 25% to 12% (Government of Ireland, 2023).

Low levels of numeracy among adults can have serious consequences often associated with socioeconomic disadvantage, with individuals from disadvantaged backgrounds can lead to intergenerational cycles of low levels of mathematics anxiety (NALA, 2019). This lack of social capital can have negative implications for learners. In Ireland, adult numeracy education typically targets those who have had limited opportunities or significant difficulties in learning mathematics in a formal school environment (Goos et al, 2023). NALA, one

of the key agencies in FET and adult numeracy in Ireland, commissioned ‘A report on adult learner’s understanding and conceptualisation of numeracy in Ireland’ (NALA, 2022). One of the key findings was that dispositions, such as confidence and beliefs were significant, many participants in this study only associated negative dispositions towards the concept, with many indicating that they were in fact suffering from mathematics anxiety (NALA, 2022). Moreover, many participants reported feeling anxious, nervous and confused when engaged with numeracy tasks and felt that their own levels of numeracy restricted the opportunities available to them (NALA, 2022). However, it is also important to highlight that adult learners who hold negative experiences in mathematics find it very difficult to move past these experiences (Boaler, 2016) and in many cases exhibit mathematics anxiety (Byrd, 1982).

2.3 Mathematics Anxiety History

It is important to understand the context, history and various definitions of mathematics anxiety before exploring the construct. The infancy of Mathematics anxiety goes back at least to the sixteenth century, according to Dowker et al (2016, p.2), who referenced the verse from a children’s song “*Multiplication is vexation ... and practice drives me mad*” which illustrates that mathematics anxiety has existed for a long period of time. A more theoretical approach was examined in 1954 where the term ‘mathemaphobia’ emerged. This term was used to explain why some students would fail at mathematics tests, thereby showing a positive relationship between mathematics attainment and mathematics anxiety (Gough, 1954). Gough (1954) referred to the construct as a ‘disease’ and suggested it did not require a definition as it was self-explanatory. This would suggest that mathematics anxiety was very much in its early developments. Three years later, Dreger and Aiken (1957) subsequently developed the concept “number anxiety” where there was also an added focus on mathematical performance. Di Martino et al (2013) contends that it has been widely studied with varying attempts to classify its diverse nature. Equally, it is often misunderstood and in some cases it can be misinterpreted as “*just another name for bad at maths*” (Beilock and Willingham, 2014, p.29) or perhaps even a dislike for mathematics (Vinson, 2001). Dowker et al (2016) contend that over the past 60 years that we now have a much greater understanding of the phenomenon which is mathematics anxiety.

2.4 Mathematics anxiety definitions

There are numerous definitions of mathematics anxiety, however Byrd (1982) provides a broad definition and states, “any situation in which an individual experiences anxiety when confronted with mathematics” (Byrd, 1992, p.38). Kogelman and Warren (1979) describe mathematics anxiety as an experience where there is an “intense emotional reaction to mathematics based on past experiences” (Kogelman & Warren, 1979: p. 9-10). Mathematics anxiety is not limited to experiences and also comprises of both physical and psychological behaviors. Wilder (2013) for example outlines that “*Math anxiety does not have a unique description, but rather it has been described using various definitions*” (Wilder, 2013, p.3). Byrd (1982) provides a general description of mathematics anxiety and suggests any ‘negative experience’ when engaged in mathematics. Hembree (1990) described mathematics anxiety as a wide range of fears including any contact with mathematics, classes, homework, and tests. More specifically, mathematics anxiety can be defined as the “feelings of anxiety, dread, nervousness, and associated bodily symptoms related to doing mathematics” (Fennema and Sherman, 1976, p326). According to Spicer (2004), definitions of mathematics anxiety can also be construed as “*an emotion that blocks a person’s reasoning ability when confronted with a mathematical situation*” (Spicer 2004, p1). There are more extreme descriptions which involve physical reactions to mathematics anxiety. For example, Lyons and Beilock (2012) found that some learners would incur physical pain as a result of the anticipation of mathematics-related activities, whilst Kelly et al (2015) stated that mathematics anxiety can result in a learner exhibiting “*clammy hands, upset stomach, and lightheadedness*” (Kelly, Rice, Wyatt, Ducking, & Denton, 2015, p.174). Tobias and Weissbrod (1980) described mathematics Anxiety as “*the panic, helplessness, paralysis and mental disorganization that arises among some people when they are required to solve a mathematical problem*” (p. 65). According to Richardson and Suinn (1972), it “*involves feelings of tension and anxiety that interfere with manipulation of numbers and the solving of mathematical problems in a wide variety of ordinary life and academic situations*” (p.551).

There is a general acceptance that there is no ubiquitously accepted definition of mathematics anxiety, as well as no defined criteria for high levels of mathematics anxiety which in turn makes it difficult to determine its

prevalence (Dowker et al., 2016). Indeed, there isn't an agreed definition of mathematics anxiety, which can prove problematic in providing a clear picture of mathematics anxiety, which will now be further examined in the following section.

Mathematics Anxiety has been widely studied (Di Martino et al, 2013) and what is often a concern is the misuse of the construct to suggest someone who is bad at mathematics must have mathematics anxiety (Beilock and Willingham, 2014) or even a dislike for mathematics (Vinson, 2001). A further concern is that the various (Dowker et al., 2016) and complex definitions (Atkinson, 1988) of mathematics anxiety can lead to ambiguity. Furthermore, Hunt et al (2011) suggest that the most common definition is that which is described by Richardson and Suinn (1972); "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" (p.551). A concern with this conceptualization is that the definition is over 50 years old and may be outdated. Moreover, Byrd (1982) suggested that the definition proposed by Richardson and Suinn (1972) is too simplistic as it did not incorporate the various factors which give rise to mathematics anxiety. Indeed, recently Westfall (2021) distinguished mathematics anxiety into implicit anxiety and explicitly anxiety, as two separate constructs. According to Schnabel & Asendorpf (2010) a persons' self-concept consists of both explicit and implicit processes that operate independently of each other. Self-concept, according to Baumeister (1999) is "*The individual's belief about himself or herself, including the person's attributes and who and what the self is*". Other studies have also identified anxiety as separate constructs (Egloff & Schmukle, 2002; Gschwendner et al., 2008). Explicit anxiety is formed from a person's past experiences (Greenwald & Banaji,1995), where the learners are often conscious from previous experiences that may lead to explicit anxiety, such as public speaking that did not go well (Ceschi et al., 2009). Conversely, Implicit anxiety can be construed as traces of a person's past experiences that are unidentified which gives rise to negative thoughts or behaviours (Greenwald & Banaji,1995; Weck et al., 2011). The next section, will decide on a definition of mathematics anxiety for the purpose of this thesis.

Devine et al. (2012) and Hunt et al (2011) advocate the use of Richardson and Suinn's (1972) definition as it is used widely in mathematics anxiety research and it gives a pragmatic and clear definition. Furthermore, Hunt et al (2011) adopted Richardson and Suinn's (1972) definition in creating the MAS UK test, which is specifically used to explore mathematics anxiety in adults, of which will be administered in this research as a pre/post instrument. The most important aspect of Richardson and Suinn's (1972) definition is that it enables the researcher with a broad and encapsulating nature of mathematics anxiety. For this purpose, the definition of mathematics anxiety by Richardson and Suinn (1972) will be adopted as a working understanding of mathematics anxiety for the purpose of this current research study. This will provide a useful framework for describing mathematics anxiety. Further clarity is also required around the distinction between mathematics anxiety and test anxiety, for example Dowker et al (2016) warns that many studies treat mathematics anxiety as a single entity which may also contribute to some of the above issues, therefore a focus is required to examine if mathematics anxiety and test anxiety should be viewed as distinct entities.

2.5 Mathematics Test Anxiety

In 1957, Dreger & Aiken found 'number anxiety' distinct from general anxiety. Such an early distinction is useful and provides the ability to distinguish between the two constructs. Initial research into mathematics anxiety can be found from the study of test anxiety where there was a likely combination of "*heightened physiological activity*" and "*self-deprecating ruminations*" according to Sarason (1961, pp. 201–202). Several studies suggest that mathematics anxiety is more closely related to other measures of anxiety, especially test anxiety, than to measures of academic ability and performance (Hembree, 1990; Ashcraft et al., 1998). On the surface there appears to be a relationship between mathematics anxiety and mathematics test anxiety (Zeidner & Matthews, 2011), however many argue that there is evidence to suggest that they are unique constructs in their own right (Dreger & Aiken, 1957; Hembree, 1990; Suarez-Pellicioni, Nunez-Pena, & Colome, 2016). Moreover, Brush (1981) identified in his research that students displayed more anxiety in mathematics test situations than the actual process of carrying out a mathematics task. Moreover, Learners with mathematics anxiety exhibit poor performance in solving mathematics problems (Ashcraft & Moore,

2009; Maloney & Beilock, 2012) as mathematics anxiety obstructs and hinders the cognitive process required for completing said tasks (Petronzi, 2021). According to Boaler (2015), approximately one-third of students across all socioeconomic groups experience severe anxiety during timed mathematics tests. Two prominent deliberations from the study of test anxiety that resonate with the study of mathematics anxiety include the contention that there exists a negative correlation between test anxiety and performance, and that test anxiety develops as a consequence of repeated poor performance (Reyes, 1984; Zan et al., 2006). Mathematics Test Anxiety can also result from the need to memorize mathematics information. With regard to test anxiety, Boaler (2015) claimed that all subject areas require some form of memorization but that mathematics is the only subject which requires memorization quickly to earn high scores which compounds the level of mathematics anxiety.

From an Irish context, there is some literature that has examined the impact of mathematics test anxiety and the leaving certificate particularly, often described as a high stakes exam. The ERSI (Economic and Social Research Institute in Ireland) described high-stakes tests as “*standardized examinations, the results of which have significant consequences for schools and/or students*” (Smyth, Banks and Calvert 2011, p.5). According to Smyth et al (2011) in a ERSI study ‘From Leaving Certificate to Leaving School’ it was suggested that Leaving Certificate was perceived as a very ‘high stakes’ exam where participants exhibited high levels of stress, particularly among females and in some cases learners felt that “*The Leaving Cert exams are more a test of memory than intelligence*” (Smyth et al, 2011, p23).

In a longitudinal study with a specific focus on mathematics, Smyth and Banks (2012) examined the impact of high-stakes examinations (Junior Certificate and Leaving Certificate) on students’ experience. The study found that learners illicit significant stress due to the constant reminders of the leaving certificate examination and the majority of learners complained of the teaching practice in using ‘past examination mathematics papers’ as a teaching strategy. However, Smyth and Banks (2012) also found that students’ opinions changed as they got closer to taking a high-stakes examination. Aysel et al (2020) compared the use of high-stakes mathematics examinations at the end of secondary school in Turkey and Ireland with a focus on learners’ traits

and attitudes within the context of learning and assessment of mathematics. Data was collected from over 1200 students in Ireland and Turkey using the same instrument and the research showed that Turkish students were on average more confident and less anxious about mathematics than Irish students. Mathematics test anxiety can be a source of mathematics anxiety but it is paramount that all aspects of the construct are examined.

Smyth and Banks (2012) carried out a longitudinal study on the impact of two high-stakes examinations (Junior Certificate and Leaving Certificate) in Ireland on students' experience. They found that these examinations have significant objective consequences that influence students' behaviour and attitudes. Students mentioned that they felt stressed as a result of their teachers' constant reminders of the Leaving Certificate examination in their classes, and the majority said that their teachers used the practice of Leaving Certificate examination papers as a teaching method. Students' opinions on what constitutes good teaching changed as they got closer to taking the final high-stakes examination, moving from favouring active learning approaches to valuing exam-oriented methods.

2.6 Antecedents of Mathematics anxiety

This section will outline the factors or antecedents of mathematics anxiety including the role of parents, teachers, peers and working memory. The sources of mathematics anxiety are complex and varied (Jameson, 2010), which may indicate why it is difficult to define mathematics anxiety. However, as stated earlier the definition by Richardson and Suinn (1972, p.551) will be adopted for the purpose of this research i.e. "*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 encapsulates the consequences of mathematics anxiety, but it is also important to examine where it stems from.

Mathematics anxiety according to a number of researchers is not a constant or stable construct, but research argues that it develops during the primary and secondary school years of a learner, plateauing and stabilising in late adolescence (Hembree, 1990; Ramirez et al., 2013; Young et al., 2012). According to Cemen (1987), dispositional, environmental, and situational forces can lead to mathematics anxiety (Buckley et al, 2016).

Buckley et al (2016) explains situational forces that ‘underlie’ the experience of mathematics anxiety as environmental forces are external to the person and are influenced by teachers, parents and society in general in contrast dispositional factors, such as personality, are internal to the individual.

Ramirez et al (2018) contend that significant research effort has been carried out into what are the causes or sources of mathematics anxiety, however research has yet to produce conclusive answers. Jameson (2010) argues that sources of mathematics anxiety are complex and vary with each learner. Possible factors including the learner, the influence teachers, parents, and peers, as well as cultural, societal and environmental influences (Dreger & Aiken, 1961). Ramirez et al (2018) suggest that cotemporary theories required to explain the development of mathematics anxiety generally comprise of one of three categories: (a) poor mathematics skills, (b) genetic predispositions, or (c) socio environmental factors. Aiken (1976) outlines a number of sources that can impact on a learner’s mathematics anxiety, including student-teacher interaction, syllabus, teaching methods, teaching resources and support of parents and peers. Chang and Beilock (2016) conducted a review of current behavioural and psychophysiological research into the link between mathematics anxiety and mathematics performance, and its relation to individual and environmental factors. Their research proposes the below model and identified environmental and social/contextual factors, of which was adapted for the purpose of this thesis.

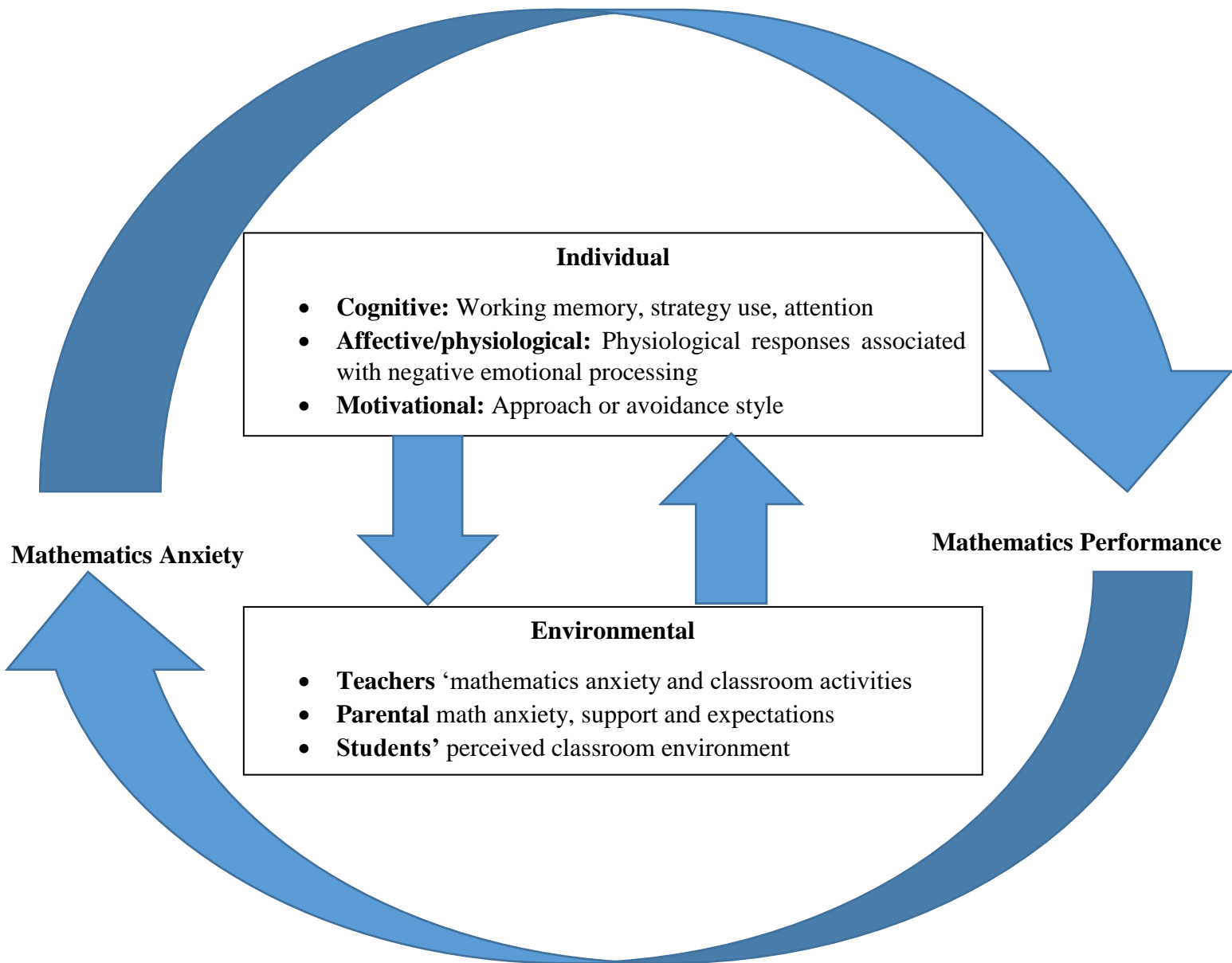


Figure 2.1 Environmental and Social/Contextual Factors (adapted from Chang and Beilock, 2016, p34)

Luttenberger, Wimmer and Paechter (2018, p.313) argue that there isn't a single cause of mathematics anxiety but a range of antecedents which give rise to mathematics anxiety. Luttenberger, Wimmer and Paechter (2018) further explain that mathematics anxiety “*should be regarded as one variable within an ensemble of environment related and person-related variables that interact together*”. This was adopted as the theoretic framework for mathematics anxiety and associated variables for the purpose of this study.

2.7 Environmental Antecedents of Mathematics anxiety

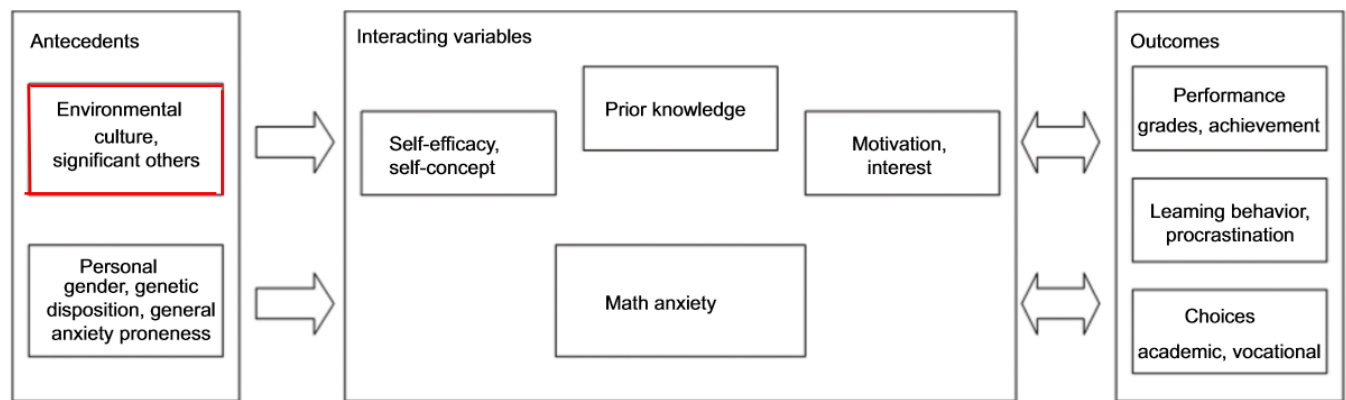


Figure 1 A framework for understanding math anxiety.

Figure 2.2 A framework for understanding math anxiety, (Luttenberger, Wimmer and Paechter, 2018, p.313)

Luttenberger et al (2018, p.311) advocate that environmental factors include the influence of teachers' and parents' attitudes toward their students' and children's ability in mathematics, as well as societal stereotypes (eg, on females' mathematics abilities), or personal factors such as traits or gender. Environmental sources are external factors of mathematics anxiety, which are outside of the learner's control (Baloglu & Kocak, 2006; Cemen, 1987). For example, Baloglu & Kocak, (2006) found that older engineering students experienced mathematics anxiety due to examinations and the perceptions of the engineering course being very difficult. To note, this study had a large sample of 759 volunteer college students from a large south-western state university in the United States, however only 26.7% were male participants, this could be problematic as gender is associated with mathematics anxiety, i.e. female are more likely to suffer from mathematics anxiety than males (Ramirez, Levine and Beilock, 2011). Examples of environmental factors include, the influence of Teachers, Peers and Parents or simply put the environment where a learner finds themselves in. Luttenberger et al (2018, p.311) makes a distinction between personal and environmental characteristics. They suggest that personal (dispositional) antecedents comprise of individual factors such as gender or prior knowledge in mathematics, conversely environmental antecedents include external factors such as educational or cultural

values or the influence of other significant people in their own life. Similarly, Casad, Hale, & Wachs, (2015) suggest environmental factors such as parents, teachers and other peers.

2.7.1 Environmental Antecedents: Parents

There is a growing literature examining the relationship between parents' mathematics anxiety and children's mathematics development (Cosso et al, 2021). There is also evidence in support of the argument that parents can affect their children's attitude and behaviour towards mathematics (Zaslavsky, 1994), particularly mothers (Casad, Hale, & Wachs, 2015). These attitudes and behaviours can manifest into mathematics anxiety. For example, contrary to the thinking that mathematics anxiety stemmed from learners' experiences with teachers and their instruction, some researchers attribute teachers' mathematics anxiety to the learner's parents (Gresham, 2018). Soni and Kamurai (2017) identified parents' mathematics anxiety as a contributing factor towards learner's mathematics anxiety, furthermore they highlighted some significant gender relationships, particularly between mothers and daughters (Casad, Hale & Wachs, 2015).

Support from parents in terms of general education that supports a child's learning can have a positive impact on their development in school (Goodall et al., 2017). Conversely, a lack of support from parents in terms of education and mathematics can lead to the development of mathematics anxiety (Geist, 2010). Parents may also be unfamiliar with up-to-date mathematics teaching methodologies and consequently feel inadequate towards helping their children with homework (Russell, 2009). Furthermore, Goodall et al (2017) suggest that who have a positive influence towards mathematics can particularly impact on their children's performance in school. The parent's belief about their child's capabilities in mathematics can have a significant impact on the learner's mathematical self-efficacy beliefs and performance scores (Eden et al., 2013).

Parents who help their children with mathematics homework have also been found to transmit their own mathematics anxiety from one generation to the next (Retanal et al, 2021). Therefore, it is essential to develop an intervention aimed at enhancing mathematics learning in both the home and classroom environment for both parents and children (Retanal et al, 2021). Morkoyunlu, Konyalioğlu and Gedik (2018) encourage parental support in getting more involved with their children's' mathematics education by developing their

own knowledge of their children's mathematics curriculum through engagement with dedicated mathematics seminars and short courses. This support needs to be carefully considered, as parents' support can create unintended negative consequences. For example, parents' pressure and frustration can be depressing factors for children, and parents who do not value mathematics can also be contributing factors that cause mathematics anxiety (Dossel, 1993; Fraser & Honeyford, 2000).

Parents who have mathematics anxiety also feel that mathematics as a subject, is only attainable by the brightest of learners (Gunderson, Ramirez, Levine & Beilock, 2012), these can have serious implication and can have a damaging effect on a student's self-esteem and self-concept in mathematics (Cemen, 1987; Chinn, 2017). Whilst there is a significant amount of literature to suggest that parents and teachers can influence a learner's mathematics anxiety, it is not established how important it is. For example, Szczygieł (2019, p.1025) suggests that the issues of parents and teachers is "*a significant factor in explaining children's math anxiety and achievement, few studies have been carried out to check these relationships*".

2.7.2 Environmental Antecedents: Teachers

This section will explore literature on how teachers can have an impact on learner's mathematics anxiety. Aiken (1976) identifies contributing factors such as student-teacher interaction, syllabus, teaching methods and resources, support of parents and peers which can lead to mathematics anxiety. The student-teacher interaction is one which can have a significant impact on learners' mathematics anxiety. For example, some adults reported that they developed their mathematics anxiety as a consequence of a teacher reacting angrily when the learner asked for help when they struggled with mathematics (Jackson & Leffingwell, 1999). This negative reaction from a teacher can lead to avoidance of mathematics. A significant issue can be learner embarrassment and fear of getting tasks incorrect in front of teachers and peers. Ashcraft (2002) reports that public embarrassment in mathematics class contributed to learner's mathematics anxiety. Negative experiences in mathematics from earlier stages of education can have consequences such as reduced motivation and unpleasant attitudes toward mathematics during a learner's educational journey (Bekdemir, 2010). Turner et al (2007) speculated that students with teachers who conveyed a high demand of correctness,

may feel “*vulnerable to public displays of incompetence*” (p. 101). Similarly, Mazzocco (2007) suggests that learners can feel nervous or worried about mathematics when they are subject to making mistakes in front of their classmates or receiving negative feedback from teachers. Indeed, learners adopt coping strategies in order to avoid or reduce negative emotions such as anxiety and embarrassment that often arise from a stressful situation i.e. tests, tasks, being asked a question (Friedel et al. 2007; Lazarus 1993). Moreover, tests and assessments in their own right can contribute towards a learner’s mathematics anxiety.

The use of assessment is also a concern, according to a PISA report (OECD, 2015) it was found that the use of formative assessment was associated with lower levels of mathematics anxiety in 39 countries and economies. Moreover, Ding (2016) also advocates the use of formative assessment, specifically for children and argues that formative mathematics assessment in a ‘friendly environment’ could help to reduce children’s mathematics anxiety. It is recognised that how Mathematics is taught in the classroom can be a significant factor in mathematics anxiety (Ashcraft, 2002; Hellum, 2010).

Traditional teaching methods do not work for adult learners who have had negative experiences in mathematics (Klinger, 2011, Mutodi, 2014, Delikta and Stojkovska, 2019). Traditional teaching methods can include an environment where learners passively receive information and do not question the teacher’s authority (Finlayson, 2014). It can also include an emphasis on learners engaging in rote learning where the emphasis is on memorisation rather than active learning (Cates & Rhymer, 2003). According to Finlayson (2014), traditional learning focuses on the transfer of knowledge from curriculum and textbooks where learners work in isolation with an emphasis on correctness whilst disregarding group work and discussion. Mutodi (2014) claimed that the best way to reduce mathematics anxiety is for teachers to include less lecture, student directed classes and more learner collaboration. Turner et al (2007) speculated that students with teachers who conveyed a high demand of correctness, may feel “*vulnerable to public displays of incompetence*” (p. 101). Similarly, Mazzocco (2007) suggests that learners can feel nervous or worried about mathematics when they are subject to making mistakes in front of their classmates or receiving negative feedback from teachers. Indeed, learners adopt coping strategies in order to avoid or reduce negative emotions

such as anxiety and embarrassment that often arise from a stressful situation i.e. tests, tasks, being asked a question (Friedel et al. 2007; Lazarus 1993).

Curtain-Phillips (1999) stated that in order to lessen the development of mathematics anxiety, there should be less teacher-directed input, more student-led classes and general discussions, and mathematics relevant to children's everyday lives. Some of the literature around the influences of the teacher on mathematics anxiety collaborates with the theory of andragogy which is particularly relevant given the nature of this study. For example, mathematics anxiety can be derived from a teachers' anger (Jackson & Leffingwell, 1999), correctness (Finlayson, 2014), public displays of incompetence (Turner et al, 2007) and the embarrassment of the learner (Mazzocco, 2007), whilst Knowles's (1980) theory of andragogy advocated that adult learners should feel respected, supported and that adults should never be 'talked down to'. Traditional teaching methods do not work well for adult learners who have had negative experience in mathematics (Klinger, 2011, Mutodi, 2014, Delikta and Stojkovska, 2019) whilst Knowles et al (2012) advocate the use of non traditional teaching methods such as active learning and the use of real life scenarios (Knowles et al., 2012).

The above evidence illustrates how a Teacher can have an impact on learner's mathematics anxiety through their relationship with learners, how mathematics is taught and the use of assessment, however, there is also a concern that a Teacher can have their own mathematics anxiety and this can be transferred to learners.

Teachers themselves can hold mathematics anxiety, which can be passed onto learners (Beilock, Gunderson, Ramirez, & Levin, 2010). Stoehr (2017), in the study '*Teach Math*', found that three student teachers all had their own unique and distinct fears related to mathematics anxiety. Furthermore, Stoehr (2017) also found that they all had their own separate coping mechanism for dealing with the construct. Teachers who hold mathematics anxiety can lower their expectations for students in mathematics classes (Martinez and Martinez, 2015). Burnett and Wichman (1997) suggest that primary school teachers' and parents' can act as a conduit towards learners. Burton (1979) similarly suggests that teachers (or parents) can 'infect children' with mathematics anxiety. As well as acting as a 'conduit' or 'infecting' children with mathematics anxiety, it is important for a teacher to be aware of the learner's own circumstances which can give rise to mathematics

anxiety. Caglar & Senol (2021) identified a number of factors that lead to learners' mathematic anxiety which comprised of the following:

1. lack of knowledge of students from a previous class, which included
2. dyscalculia,
3. not understanding the logic of the problem,
4. failure to grasp the importance of mathematics in daily life,
5. afraid to answer a question wrong,
6. being bored or afraid of reading long problem sentences,
7. inability to read fluently,
8. lack of concentration,
9. not being in intelligence-enhancing environments

(Caglar,M. & Senol, H., 2021, p.1360).

The above factors need to be considered by mathematics teachers in order to address a learner's mathematics anxiety. Some of the above circumstances are beyond the remit of a teacher, but circumstances such as 'lack of knowledge from a previous class', 'not understanding the logic of the problem', 'failure to grasp the importance of mathematics in daily life', 'afraid to answer a question wrong' and 'being bored or afraid of reading long problem sentences' are all concepts that a teacher can address in a mathematics class.

2.7.3 Environmental Antecedents: Culture

In term of jurisdictional variances, there are differences between countries in term of mathematics performance and attitudes in liking mathematics (Stevenson et al., 1990; Askew et al., 2010). Children in high-achieving countries may have low levels of mathematics anxiety due to their own high level of performance, conversely some children may have high levels of anxiety because some countries having Maths and general education as significantly important. However, Dowker et al (2016), identified that children in high-achieving Asian countries, such as Korea and Japan, tended to demonstrate high mathematics anxiety; while those in high-achieving Western European countries, such as Finland, the Netherlands, Liechtenstein, and Switzerland

tended to demonstrate low mathematics anxiety. Lee (2009) investigated mathematics anxiety scores in a variety of countries and found that the relationship between a country's overall mathematics achievement level, and the average level of mathematics anxiety among children in that country, was not consistent. The above evidence would suggest that the research is inconclusive in terms of a positive correlation between culture/nationality and mathematics anxiety. Luttenbeger et al (2018) provide a rationale for this scenario and argue that Asian students typically set strive towards high grades in mathematics and subsequently evaluate themselves to the highest standards.

2.8 Personal Antecedents

According to Luttenbeger et al (2018, p.315), personal antecedents refer to the “*individual, e.g., prior knowledge, trait anxiety, or gender*”, Cemen (1987, p.18) refer to these as ‘dispositional’ antecedents. Personal antecedents can also include physiological factors such as cortisol secretion (Pletzer et al., 2010; Mattarella-Micke et al., 2011). Dowker et al (2016, p.5) contends that moderate relationships exists between cortisol secretion and mathematics anxiety and that further research is warranted, however they suggest there no evidence that cortisol is a good indicator of mathematics anxiety. The main aspects of personal antecedents are age, gender and genetic disposition and were examined in this order.

2.8.1 Personal Antecedents: Age

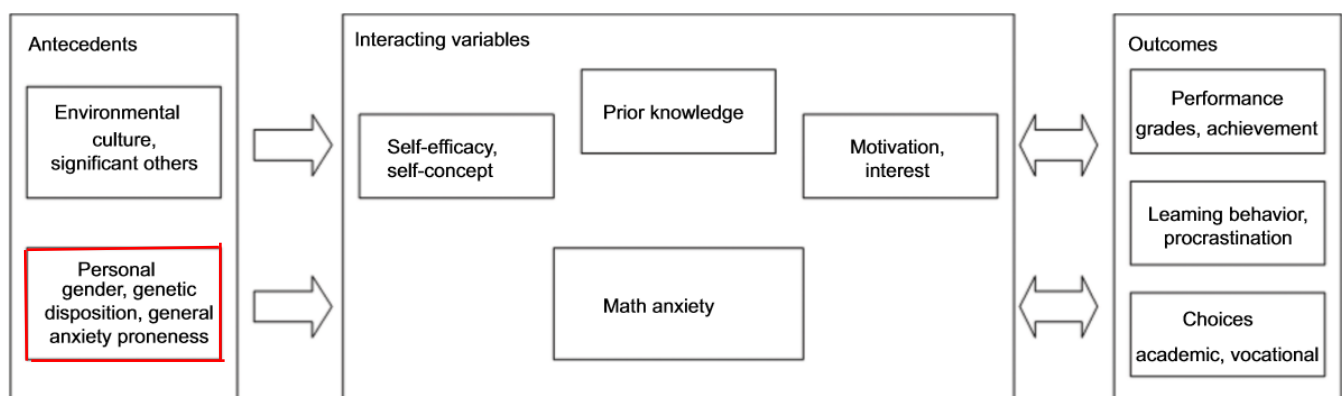


Figure 1 A framework for understanding math anxiety.

One of the issues with mathematics, is that difficulty with learning the subject can increase with age, and thus the mathematics anxiety might also increase with age (Olmez and Ozel, 2012). The vast majority of research

in mathematics anxiety suggests that attitudes towards mathematics deteriorates with age during childhood and adolescence years (Wigfield and Meece, 1988; Ma and Kishor, 1997; Dowker, 2005), which has negative consequences for mathematics development, education and significantly adult engagement in mathematics (Dowker et al, 2016). Mata, Monterio and Peixoto (2012) argue that as age increases so does negative attitudes towards mathematics, and as a consequence, mathematics anxiety increases. This could pose the question, when does mathematics anxiety commence in terms of age. Ramirez et al (2016) contends that it can begin from as young as 6 years of age, this is significant given the nature of this research study. Vukovic et al. (2013) advocates that is paramount to intervene during the early stages of a learner's mathematics learning journey. There is also a requirement to compare mathematics anxiety between mathematic anxious adult and children to better understand the construct (Krinzinger et al., 2009). In terms of this study age, is important given the varying profiles of adult learners. For example, in Limerick City VTOS, adult learners can be a minimum of 18 years, whilst it is not unusual to have learners in their 60's. However, few studies exist which focus on non-traditional adult learners returning to education following a break in their educational journey which focuses on the learners' attitudes towards mathematics examinations (Stacey, 2021). Non-traditional learners in terms of age represent a significant aspect of learners in FET. There is some data from an Irish context but this is within a numeracy context. For example, O Meara et al (2022) published a report that examined adult learners' 'understanding and conceptualisation of numeracy' with the purpose of developing a working definition for numeracy in Ireland. In this report (n=17) many learner's reported mathematics anxiety as a consequence of their mathematics experience in school. It is important to note that this report was within a numeracy context and not a mathematics context, which further highlight the uniqueness of this research and furthermore, the importance for further research in terms of age and more specifically older cohorts of the population. In terms of age, it can be argued that the older the learner, the greater the propensity for mathematics anxiety but this is not straight forward. For example, Dowker et al (2016, p.8) suggests there maybe a number reasons why mathematics anxiety may increase with age which may be a chicken or an egg situation as some reasons maybe "anxiety" whilst others may be more to the "mathematics." It is important to

consider age in terms of personal antecedent, however gender is also a contributing factor in terms of mathematics anxiety.

2.8.2 Personal Antecedents: Gender

It has been argued that gender is a contributing factor of mathematics anxiety (Hopko et al, 2003), which can in turn impact career opportunities. For example Gunderson, Ramirez, Levine and Beilock (2011, p.153 & p.163) identified that girls have a greater propensity to have negative feelings towards mathematics and this “*can lead girls to pursue math-related courses and career paths at lower rates than boys*”. Hopko et al (2003) contends that the majority of mathematic anxiety studies indicate that females experience a greater degree of mathematics anxiety than that of males i.e. (Ashcraft & Faust, 1994; Baloglu & Kocak, 2006; Betz, 1978; Hembree, 1990,). Dowker et al (2016) reports that there is an issue of ‘self-rating’ where research shows that male learners are generally more confident and as a consequence may give themselves higher scores which may be a factor. There are a number of studies that show evidence that female learners are more likely to express their anxiety than that of male learners and that this is related to lower performance in mathematics performance (Devine et al., 2012; Dowker et al., 2016; Hembree, 1990). Conversely, there has been studies which suggest that there is no gender difference when it comes to mathematics anxiety including University students (Ma & Xu, 2004) and secondary school children (Devine et al., 2012, Chinn, 2009) which may indicate that there is no conclusive evidence (Devine et al., 2012). Research demonstrated that countries that provide equal educational opportunity for boys and girls, show little or no difference in mathematics anxiety (Spelke, 2005).

2.8.3 Personal Antecedents: Genetic Disposition

Research comparing monozygotic (Identical) and dizygotic twins suggest that mathematics anxiety has a genetic component too (Luttenbeger et al, 2018) (Wang ey al, 2014). The hereditary contribution to mathematics anxiety can be investigated by comparisons of monozygotic and dizygotic twins. However, Luttenbeger et al (2018) suggest that more research is required in the field of genetic is needed as the role of the genetic influence in comparison to the influence of family and school environment is still unclear.

Malanchini et al (2017) found that 58% of the shared variance between mathematics anxiety and general anxiety is due to shared genetic factors, whilst environmental factors contributes to the remaining 42%. For the purpose of this thesis, there will be a significant focus on environmental antecedents of mathematics anxiety, specifically the way which mathematics is taught.

2.9 Interacting Variables

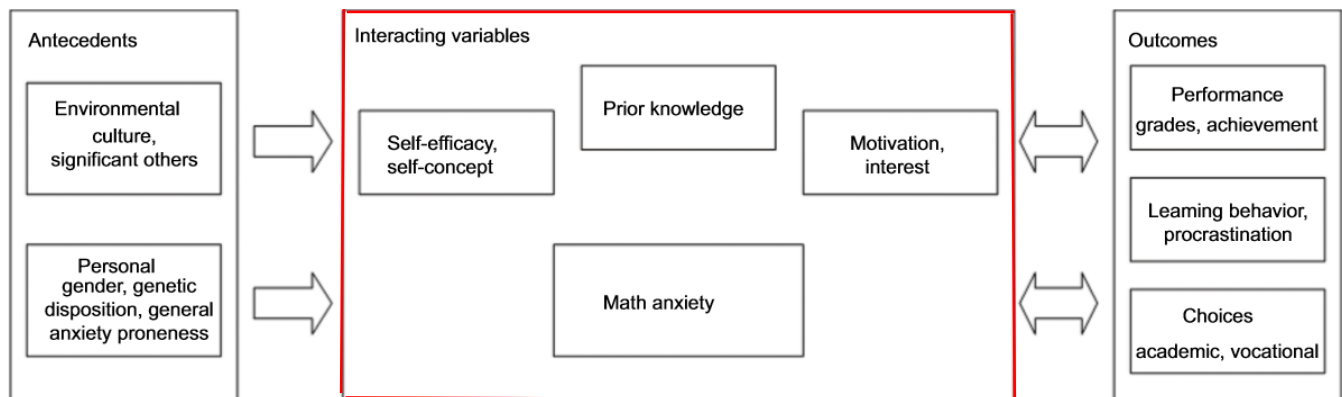


Figure 1 A framework for understanding math anxiety.

Luttenberger et al. (2018) outline a number of interacting variables which mutually interact with mathematics anxiety, examples of these include: self-efficacy, self-concept, prior knowledge and motivation/interest. These variables impact on learners mathematics outcomes which can include exam results, careers, learning behaviors etc. It is also significant that each interacting variable can have an impact on each other which results in compounding the issues with mathematics anxiety. A number of researchers have shown that self-concept and self-efficacy can substantially predict mathematics anxiety (e.g., Hembree, 1990, Meece et al., 1990, Pajares and Miller, 1994). Mathematics self-efficacy within the context of mathematics anxiety will now be explored.

2.9.1 Self-Efficacy

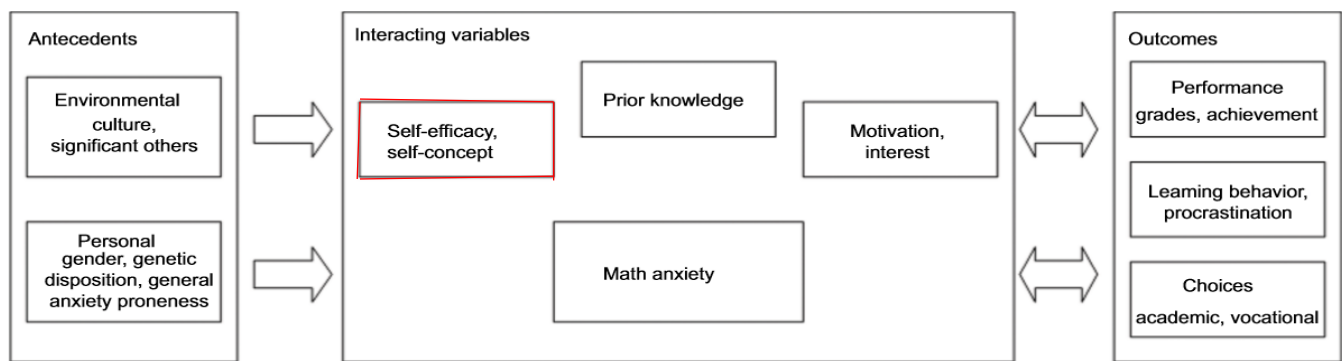


Figure 1 A framework for understanding math anxiety.

The confidence that a person holds in performing a specific task is referred to as self-efficacy (Bandura, 1986), whereas as academic self-efficacy refers to an academic task (Bandura, 1987), mathematics self-efficacy refers to the ability to perform a mathematic related task (Hackett & Betz, 1989). Research has shown that mathematics self-efficacy is a predictor of mathematical success (Ayotola & Adedeji, 2009; Ferrari & Parker, 1992; Lindley & Borgen, 2002). Furthermore, mathematics anxiety has shown negative correlations with mathematics self-efficacy, which suggests that mathematics self-efficacy decreases when mathematics anxiety increases (Akin & Kurbanoglu, 2011; Pajares & Kranzler, 1995; Vinson, 2001). Indeed, mathematics self-efficacy has been found to have a significant positive correlation in terms of performance and a negative correlation in terms of mathematics anxiety (Akin & Kurbanoglu, 2011; Cooper & Robinson, 1989). Indeed, two studies of deaf children found a significant negative relationship between mathematics anxiety and mathematical calculation (Chen & Wang, 2018; Chen & Wang, 2021). There were some limitations with the previous study, including the use of only subtraction and not addition, only the use of nonverbal participants and the inability to make a casual conclusion. What is important for all mathematics researchers and teachers is to note that there is a relationship between self-efficacy and mathematics anxiety (Bandura, 1993; OECD, 2013), i.e. as one goes up the other tends to go down. As well as self-efficacy in mathematics, there is also the issue of self-concept as one of the interacting variables in mathematics anxiety.

Mathematics self-concept, which can be defined as “*student ratings of their skills, ability, enjoyment and interest in mathematics*”, has been identified as an important factor in mathematics education (Erdogana &

Sengulb, 2014, p.1). Admed et al (2012) argue that a low self-concept of mathematics ability is a source of high mathematics anxiety. There is a belief that the relationship between mathematics self-concept and mathematics anxiety is reciprocal (Bandura, 1997, Zeidner, 1998, Pekrun, 2006). Another reciprocal relationship with mathematics anxiety is another interacting variable which is motivation.

2.9.2 Motivation

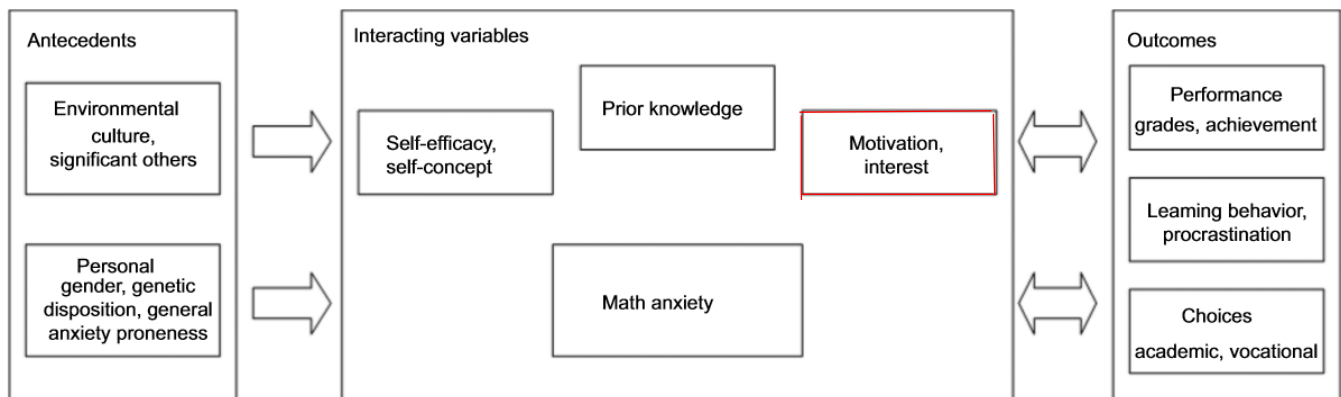


Figure 1 A framework for understanding math anxiety.

According to Ryan & Deci (2000), there are two types of motivation, extrinsic motivation and intrinsic motivation. The latter is an internal force that motivates learners to engage in academic activities, as they are interested in learning and they enjoy the learning process (Schiefele, 1991). Examples of how this can manifest in mathematics can include a lack of enjoyment (e.g. Chiesi & Primi, 2010) and a failure to see the relevance or usefulness of mathematics (e.g. Ashcraft & 35 Moore, 2009). Indeed, there is also a significant negative correlation between intrinsic mathematics motivation and mathematics anxiety (Gottfried, 1990). Extrinsic motivators for a learner include parental expectations, expectations of other influential people and good grades. The positive aspects of Extrinsic motivation is that it produces immediate results and requires less effort compared to intrinsic motivation (Ryan & Deci, 2000), it can however inhibit students from true independent learning (Adamma et al, 2018).

There are other factors that can have negative impacts on learner's motivation in mathematics. For example, Boaler (2016) reports that classroom streaming in terms of learner's ability levels can be damaging as learners in weaker levels can become less motivated and can often resort to bad behaviour. Given the context of

motivation it also important to consider adults motivation, whom are more receptive to internal motivating factors than external motivating factors (Knowles et al., 2005: p.72).

Mathematics anxiety interacts with a number of variables such as self-efficacy or motivation in mathematics, which can intensify or counteract mathematics anxiety (Ashcraft, 2002; Luttenberger et al., 2018; Shields, 2007). Ashcraft & Krause (2007) contends that the higher mathematics anxiety then the lower one’s motivation and mastery learning. Indeed, Zakaria & Nordin (2008) carried out a study on 88 participants and found a negative correlation between motivation and mathematics anxiety. However, it can be the case that learners who worry about the thought of failure in mathematics, may often be motivated to try harder (Evans, 2000; Wigfield & Meece, 1988).

2.9.3 Prior Knowledge

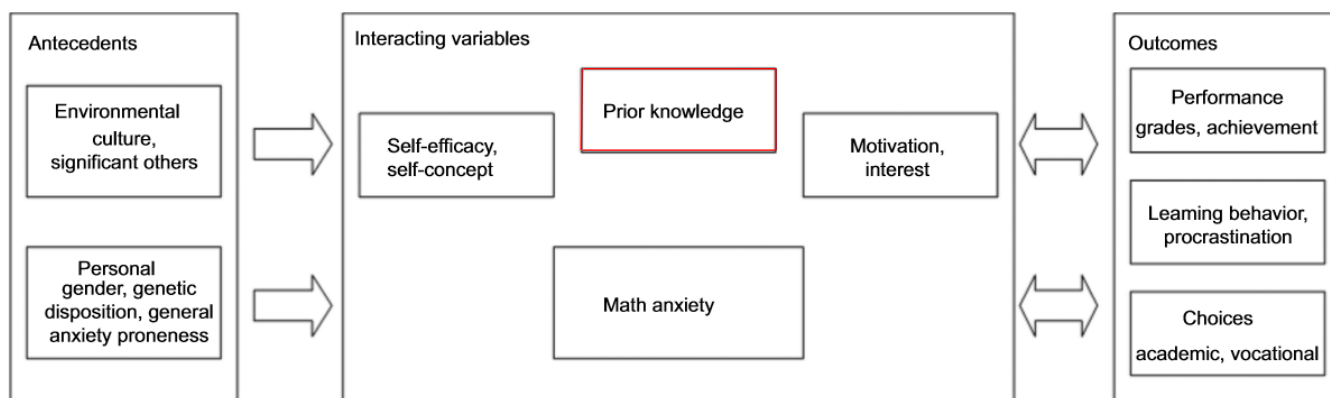


Figure 1 A framework for understanding math anxiety.

The lack of prior knowledge in mathematics or the inability to understand mathematical concepts can contribute to mathematics anxiety (Carey et al, 1987). This can be reciprocated, for example, Luttenberger, Wimmer and Paechter (2018) suggest that mathematics anxiety can have such negative consequences as the prevention of long term knowledge in mathematics, as well as mathematical avoidance. The inability to develop long term knowledge in mathematics is damaging as learner who are afraid of mathematics will not acquire the skills they need to be successful within this area (Mutawah, 2015).

The learner’s disengagement in mathematics or not being able to ‘catch up’ as a result of absenteeism can lead to falling behind and exacerbate further disengagement with mathematics (Cemen, 1987; Chinn, 2017). Tobias

(1986) refers to 'The Deficiency Theory' and argues that mathematics anxiety exists as a result of previous poor mathematical attainment. 'Falling behind' is a concept that is shared by a lot of learners in mathematics. There is a strong consensus that the inability for learners to learn from their mistakes can result in them falling behind and unable to catch up (Ashcraft & Krause, 2007; Boaler, 2016; Maloney, Schaeffer & Beilock, 2013). Mann & Walshaw (2019, p.115) in their study found that mathematics anxiety increased when learners felt they were falling behind others and referred to this as 'social derogation'.

A way to counter this could be the use of mastery learning. As students study for mastery, they compete only with themselves and can work at their own pace (Martinez, 1987). Furthermore, the use of self-pacing means that learners do not move to a new lesson until previous content have been thoroughly learned and that every learner is positively reinforced for learning. Zakaria & Nordin (2008) also advocate this approach in order to reduce mathematics anxiety and recommend teaching mathematics at a slow pace in order for learner's to better comprehend the material being taught in the class. Finlayson (2014, p108) also supports this approach and warns that "*When the pace in the math classroom was too fast, when the focus was on memorization, or knowing or applying the formulae, instead of focusing on understanding the math concepts, participants indicated that math anxiety developed*". It is also vital to note, that in order to move between lessons, it is important to identify the learners' ZPD (zone of proximal development)

ZPD has been defined as: "*the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem-solving under adult guidance, or in collaboration with more capable peers*" (Vygotsky, 1978, p.86). Vygotsky also suggested that teachers should facilitate each student's ZPD through scaffolding (Eun, 2019). Wood et al. (1976, p. 90) define scaffolding as a process "*that enables a child or novice to solve a task or achieve a goal that would be beyond his unassisted efforts.*" Kusmaryono et al (2020) in a study suggested that scaffolding could become an effective teaching strategy to help learners through their ZPD and reported that it can reduce students' mathematics anxiety through the use of active learning within a scaffolding strategy.

2.10.1 Outcomes: Mathematics Performance

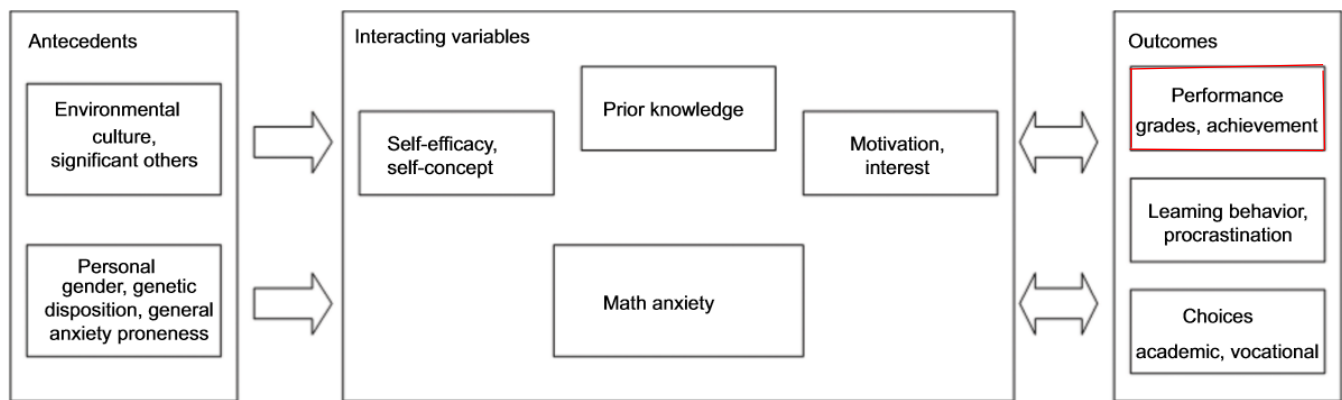


Figure 1 A framework for understanding math anxiety.

Several research studies have identified a negative correlation between mathematics anxiety and performance (Ashcraft & Kirk, 2001; Ashcraft & Krause, 2007; Jameson, 2013). Mathematics Anxiety can result in decreased exposure to mathematics, decreased enjoyment of mathematics, and decreased self-confidence in mathematics (Ashcraft, Kirk, & Hopko, 1998). A 2012 PISA test across the OECD countries showed a positive correlation between mathematics anxiety and lower scores in mathematics (OECD, 2013). The perception of the important of mathematics by the learner can affect a learner's performance and therefore their mathematics anxiety. (Frank et al., 2008). Hembree (1990) was the first to conduct a meta-analysis in the field of mathematics Anxiety and performance. It was found from a sample of 151 studies analysing the relationship between mathematics anxiety and mathematics performance of primary and secondary school students, that mathematics anxiety was negatively associated with mathematical performance. Subsequently, Ma (1999) also carried out a meta-analysis based on 26 studies examining the relationship between anxiety toward mathematics and achievement in mathematics among elementary and secondary students. A correlation of $-.27$ between anxiety about mathematics and achievement in mathematics was found which resulted from the intervention of a computerised mathematics tutoring programs designed to reduce math anxiety and improve math performance in primary and secondary school children. Another negative outcome from mathematics anxiety is avoidance, which can also compound the issue of performance, resulting in a negative cycle in mathematics. It is accepted, that mathematics anxiety can be responsible for poor performance in mathematics

as well as avoidance of mathematics (Ashcraft & Moore, 2009, Dowker et al 2016), which will now be examined as an outcome of mathematics anxiety.

2.10.2 Outcomes: Mathematics Avoidance

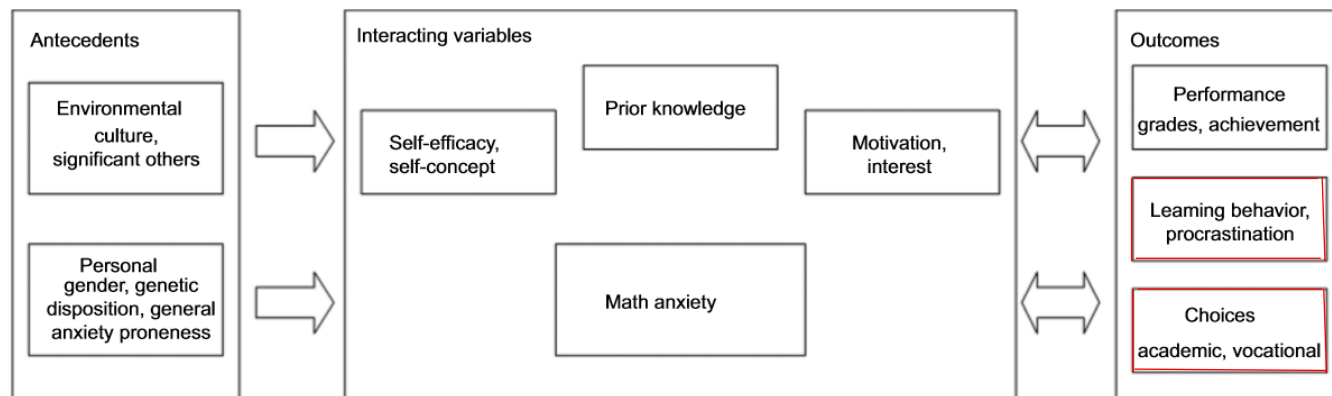


Figure 1 A framework for understanding math anxiety.

Luttenberger, Wimmer and Paechter (2018, p.313) report that educational outcomes including performance, learning behaviours, or choices are influenced by mathematics anxiety. Learners who suffer from mathematics anxiety enrol for fewer mathematics courses and avoid mathematics related activity, as early as secondary school in some cases (Ashcraft & Moore, 2009, Ashcraft & Krause, 2007). Another concept of learners avoiding mathematics is procrastination. Procrastination according to Okoiye et al (2017) can set off a detrimental cycle when learners with mathematics anxiety avoid mathematics, perform below expectations in exams, and as a consequence likely develop even higher levels of mathematics anxiety as a result. Indeed, an overarching concept for choices in academic and vocational, as well as procrastination, can be drawn from mathematics avoidance.

Mathematics avoidance is where learners avoid learning mathematics and mathematical situations that may induce their mathematics anxiety (Ashcraft, 2002). Another issue concerning mathematics avoidance is a tendency for learners to rush through mathematical tasks in order to finish the situation (Kyttälä & Björn, 2010). Rushing through mathematical tasks isn't the only coping mechanism that avoidant mathematical learners engage in. Turner et al. (2002) suggested that learners avoid making eye contact with teachers and disengage in asking for help to avoid embarrassment in front of their peers. Mathematics avoidance is

prevalent across all sectors including primary school (Devine et al., 2012), secondary school (Scarpello, 2007) and further education (Gresham, 2007). Scarpello (2007) warns that learners who hold mathematics anxiety tend not to pursue learning mathematics, which can limit their career choices, equally Hembree (1990) also suggest that adults avoiding mathematics also limits their career options available to them particularly in the areas of science and technology. The outcomes of mathematics anxiety are concerning, however, it is important to note that there are varying levels of mathematics anxiety, which in itself can be problematic to measure.

2.11 Methods to reduce Mathematics Anxiety

In terms of interventions, identifying Mathematics anxiety and subsequent immediate action is paramount (Ramirez et al., 2013). Many students with mathematics anxiety learn to cope by developing strategies to address their levels of mathematics anxiety (Cemen, 1987). Trainee teachers for example who hold mathematics anxiety themselves can pass this fear onto students, Harper & Daane (1998) in there 'Math Methods Courses' helped Teachers to deal with their own mathematics anxiety. A range of studies have attempted to reduce mathematics anxiety in third level undergraduate students through the use of interventions (Thompson et al, 2016). Iossi (2007) categorised each of these interventions under the following headings: curricular, non-instructional and instructional strategies.

Support classes can play a role as a curricular intervention. For example, Gordon & Nicholas (2013) described the concept of the intervention of 'mathematics bridging' which showed some signs of alleviating math anxiety. From an Irish context, the University of Limerick commenced a mathematics bridging course, entitled 'Head Start Maths' where the aim of the course was to revise mathematics fundamentals before the commencement of third-level education so as to lessen the anxiety levels of adult learners towards mathematics (Johnson and O Keefe, 2016). The results did not explicitly state that there was a reduction in the levels of mathematics anxiety. However, it did indicate that rates of learners who dropout of mathematics programmes who attended the bridging course were far less than those that didn't attend it. According to Thompson et al (2016), curriculum interventions at third level institutions is common, the research on the

success of these intervention however remains sparse. However, Hembree (1990), in a meta-analysis of mathematics anxiety interventions found that curriculum interventions were not significantly effective in reducing mathematics anxiety. Curricular changes such as “algorithmic instruction, special classwork in microcomputers, provision of special equipment (for example, calculators), and special techniques for presenting material (tutorial, small-group, and self-paced). Such changes did not seem effective in reducing mathematics anxiety.

Non-instruction interventions include breathing exercises (Brunyé et al., 2013), mindfulness (Neufeld et al., 2018), Yoga (Field, Diego & Hernandez-Reif, 2010) and expressive writing (Park, Ramirez, & Beilock, 2014). Other examples are cognitive treatments such as counselling and cognitive modification (Suinn & Richardson, 1971, Kamour & Altakhayneh, 2021). The importance of mental health in the classroom cannot be underestimated. Neufeld, Paige, Rapke, Karrass and Hall (2018, p.490) stated that “addressing mental health and emotions in mathematics learning has become an integral component of recent initiatives”. Marshall and Mann (2017) explain that the brain of a mathematics-anxious learner shows an activation of emotional areas when confronted with a mathematics problem which is predicated on the level of mathematics anxiety. The consequences of this is that the learner’s working memory is engaged to address the anxiety, rather than allocating its resources to the mathematics problem (Young et al., 2012). Marshall and Mann (2017) illustrate the scenario by describing the student in a ‘state of anxiety’ and as a consequence their brain cannot process mathematical problems effectively. Ashcraft and Kirk (2001) found that for highly mathematics anxious persons, more errors were made when solving mathematics problems due to increased demands on their working memory. There are of course instructional interventions that all mathematics educators should become familiar with in order to minimise mathematics anxiety.

Instructional interventions are those which are initiated by the Teacher (Iossi, 2007). Dossel (1993), reported that giving learners’ successful experiences in mathematics reducing mathematics anxiety, as well as this the importance of effort and understanding of success over achievement was also highlighted. The integration of ICT to facilitate mathematics learning has been used to counteract mathematics anxiety (Furner & Duffy,

2002; Sun & Pyzdrowski, 2009). Segumpan and Tan (2018) found that math anxiety was decreased significantly compared to the traditional classroom, they felt that the asynchronous aspect gave students ample time to prepare outside and before class. Curtain-Phillips (1999) in addressing mathematics anxiety suggested that teaching methods must be re-examined and teaching methods should include less lecture and more student directed classes. Lavasani and Khandan (2011) found learners who were taught in a non-traditional teaching method by use of cooperative learning were found to experience less mathematics anxiety compared with students who were taught in traditional method of learning.

A recent study found that primary school teachers in the UK found that the use of flexible teaching strategies for anxious learners was effective in reducing a learner's mathematics anxiety whilst still been able to teach the mainstream curriculum (Dove, Montague & Hunt, 2021). Another recent study also suggested that another way to support parents would be to provide mathematical examples or to record a short video so that learners can re- watch the example rather than feeling frustrated and fostering negative homework experiences around mathematics (Kiss & Vukovic, 2020). Indeed, this could also benefit parents who may feel more confident in helping their children with their mathematics homework (Kiss & Vukovic, 2020). Another interesting concept was the use of mathematics strategy training which in a study found that not only in improved mathematics abilities, but also in reduced mathematics anxiety through repetition, where children developed a sense of self-control by immersing themselves in mathematical tasks, and reducing their mathematics anxiety (Passolunghi et al, 2020). Petronzi et al (2021) provide a comprehensive table of intervention studies, see appendix (1) for more information. The next chapter will bring the reader through the research design.

Chapter 3 Methodology

3.0 Introduction

Chapter 3 will outline the design of the research study and will identify the philosophical perspective/worldview of the researcher. Fundamental to any research study, is the research design. Cohen et al (2007, p.78) state that, *there is no single blueprint for planning research, research design is governed by the notion of 'fitness for purpose'*. Additionally, the research design must attempt to answer the research aim and questions (Creswell, 2009).

3.1 Framework of Design

The research design will be underpinned by Creswell's framework of design, which consists of three interconnecting concepts: philosophical worldviews, strategies of inquiry, and research methods (Creswell, 2009, p5). See diagram below:

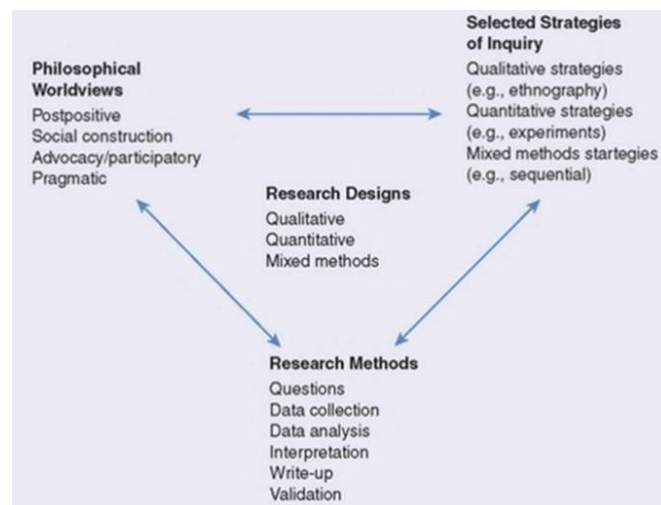


Figure 3.1 Creswell's framework of design (Creswell, 2008, p.5)

3.2 Philosophical Worldview

A philosophical perspective, worldview or paradigm provides the setting for the research design. Philosophical ideas can often be hidden in research (Slife & Williams, 1995), whilst they can also be referred to as paradigms (Lincoln & Guba, 2000; Mertens, 1998); epistemologies & ontologies (Crotty, 1998), and research methodologies (Neuman, 2000). Conversely, Hitchcock and Hughes (1995) argues that ontological

assumptions inform epistemological assumptions, which in turn lead to methodological considerations and which instruments would be the most effective to collect data. Ontology and epistemology can be identified as one element, as Crotty (1998, p.11) proposed that “*ontological issues and epistemological issues tend to emerge together*”. Moreover, Crotty (1998) highlights that a researcher’s ontological and epistemological position are interconnected and that they must compliment and work cohesively together in order to answer a research question and shape a researcher’s inquiry. However, Creswell (2009) warns, that there is ongoing debate about the use of worldviews in terms of inquiry and puts forward that there are four ‘main’ worldviews in literature: postpositivism, constructivism, transformative, and pragmatism.

Postpositivism	Constructivism
<ul style="list-style-type: none"> • Determination 	<ul style="list-style-type: none"> • Understanding
<ul style="list-style-type: none"> • Reductionism 	<ul style="list-style-type: none"> • Multiple participant meanings
<ul style="list-style-type: none"> • Empirical observation and measurement 	<ul style="list-style-type: none"> • Social and historical construction
<ul style="list-style-type: none"> • Theory verification 	<ul style="list-style-type: none"> • Theory generation
Transformative	Pragmatism
<ul style="list-style-type: none"> • Political 	<ul style="list-style-type: none"> • Consequences of actions
<ul style="list-style-type: none"> • Power and justice oriented 	<ul style="list-style-type: none"> • Problem-centered
<ul style="list-style-type: none"> • Collaborative 	<ul style="list-style-type: none"> • Pluralistic
<ul style="list-style-type: none"> • Change-oriented 	<ul style="list-style-type: none"> • Real-world practice oriented

Figure 3.2 Table Four Worldviews, Creswell (2014, p.36)

3.2.1 Postpositivism

Positivism has been widely criticised since the origin of social science (Fox, 2008). Postpositivism challenges positivism and how it seeks to capture the ‘absolute truth of knowledge’ (Phillips & Burbules, 2000). The rejection or critique of positivism can be derived from a belief that you can fully understand (positivism); instead, postpositivism seeks to partially understand. Fox (2008, p.3) puts forward that “*while the pursuit of knowledge remains an aim of social scientific enquiry, the concept of an absolute truth may be seen as an aspiration rather than something that can be discovered once-and-for-all*”.

Wilkinson (2013) gives a very useful example of contrasting between positivism and post positivism. He gives a hypothetical scenario where a scientist hypothesises that all swans are white. Following observation, there was no white swans and the hypothesis was accepted from the inductive reasoning. Subsequently, a different Researcher observed a black swan and from this the null hypothesis is accepted that not all swans are white, (Wilkinson, 2013, p.920). Essentially, postpositivism argues that if some event is reoccurring, it does not necessarily mean that it will happen every time. Moreover, Postpositivism dismisses the positivist philosophy that a researcher can be an independent observer of the social world.

3.2.2 Transformative

In terms of its roots, the transformative worldviews can be drawn from such Philosophers as Marx, Adorno, Marcuse, Habermas, and Freire (Neuman, 2000). Previously, this worldview was referred to as the participatory/advocacy worldview. The transformative worldview developed from the 80's and 90's on the backdrop of scepticism of the postpositivism assumptions, which imposed laws and theories which did not align with marginalised sectors of society.

In terms of research methods, it is generally drawn from a qualitative research approach but it can also draw on quantitative data. A transformative worldview is required to be embedded within a political-change agenda, which in itself, seeks to address social oppression (Mertens, 2010). Even in its broadest level, this research enquiry does not attempt to address social oppression i.e. *“exploring mathematics anxiety amongst a group of adult learners and the potential associated environmental antecedents”*. Moreover, the ontological position of the researcher was that of one reality interpreted differently by participants, but not exclusively to their social position. Whilst it is a single issue, it cuts to the very essence of this worldview, therefore transformative was rejected as a worldview, constructivism was the next worldview to be considered.

3.2.3 Constructivism

The debate between quantitative or qualitative methods is centred on the worldview philosophies of postpositivism and constructivism (Mertens, 2015). Constructivism (often associated with interpretivism, Mertens, 1998) is a worldview and it is typically seen as an approach to qualitative research. Historically,

constructivism can be traced back to the late 18th Century through the work of Immanuel Kant and Husserl. The ontological assumption of constructivism holds that humans create knowledge based on processing their experiences through interaction with external stimuli.

Rather than starting with a theory (postpositivism), where researchers verify a theory, constructivism seeks to make sense of (or interpret) the meanings people hold about the world, this could hold some merit particularly around the antecedents of mathematics anxiety, however Constructivism seeks to be theory generated, similar to postpositivism it ignores the complexity of mathematics anxiety. These constraints allowed the researcher to be flexible in their approach and the system that lends itself best to this method is pragmatism.

3.2.4 Pragmatism

Pragmatism can be identified from the work of Peirce, James, Mead, and Dewey (Cherryholmes, 1992). According to Creswell (2009), pragmatism is not committed to any one system of philosophy and reality, it does however offer flexibility in terms of research methods and techniques, which are most apt for the focus (Creswell, 2009; Mertens, 2015). Pragmatism is a philosophical approach which addresses research questions utilising the various approaches available in understanding and addressing the research question. As Creswell (2009) advocated, “*researchers are free to choose the methods, techniques, and procedures of research that best meet their needs and purposes*” (Creswell, 2009, p.11). It is important to highlight that pragmatism is not flawless or without criticism. For example, Hammond (2013) argues that the flexibility that pragmatism, could be construed as a weakness. McCready (2010) supports this and argues that one of the drawbacks to pragmatism, is that it has been criticised for concentrating on pragmatic results and ignoring philosophy and theory. Hammond (2013) gives a practical example of a pragmatic inquiry which can be utilised to cover experimental testing as well as more inductive approaches to inquiry, which “*leaves a great deal of scope methodologically*”. Other researchers critique pragmatism as it concentrates on the practical aspects of what works, which in turn can ignore the deeper philosophical roots (Hesse-Biber, 2015).

3.2.5 Conclusion

The aims of this research was to “*To investigate the existence of mathematics anxiety among further education students in a VTOS setting*” and “*To investigate what environmental antecedents contribute towards mathematics anxiety*”. The researcher’s axiology is to develop knowledge of mathematics anxiety, particularly within FET, as this sector of education lacks research on a general level and even more so within the context of mathematics anxiety. As Minister for Further and Higher Education Simon Harris stated that FET is “*Sometimes overlooked, often undervalued*” and is the “*Cinderella*” of Irish education (Irish Times, 2020). Therefore, the value in this approach cannot be underestimated. In terms of the researcher’s axiology, pragmatism was deemed most appropriate. The rationale for this approach was committed to any one system of philosophy and it provides flexible research methods and techniques to the researcher (Creswell, 2009).

The three research questions were “*What level of mathematics anxiety, if any, exist amongst a cohort of adult learners*”, “*What, if any, environmental antecedents contribute towards mathematics anxiety across an adult learners’ mathematics life story*” and “*What impact, if any, do environmental antecedents have on students’ experiences of mathematics*”. These were also important to consider when the researcher decided on a worldview paradigm. The learner’s mathematics life story was important in terms of the researcher’s ontology, as each learner would differ in terms of social backgrounds, nationality, age, gender and other variables. In respect of education, each learner would therefore also differ in terms of their interpretation of their mathematical life story. Therefore, each learner would have their own unique interpretation of reality which would align with the worldview of pragmatism.

Whilst considering all four worldviews, it is important to highlight that they are not entirely distinct from each other and there is overlap between them. For example, Mertens (2015, p76) states “*constructivists or proponents of other paradigms and branches can work to advance social justice and human rights; this is not the sole territory of the transformative social justice evaluator*”. Another example is the increasing use of mixed methods in research and the discussion of how each worldwide view attempts to incorporate them into their paradigm (Mertens & Hesse Biber 2013).

In order to design a methodological framework, it was important to first establish the researcher's worldview in terms of ontology and epistemology. Denzin and Lincoln (2000) provide a useful explanation of these assumptions in terms of a research philosophy or worldview and simplify the following to: being (ontology); knowing (epistemology) and acting (axiology).

Having reflected on these worldviews with respect to the researcher's ontological and epistemological worldviews in order to ascertain which methodological framework to utilise. In the first instance, a subjective ontological worldview was decided, as my belief is that reality is constructed by individuals or groups (Beck, 1979). An objectivist ontology was rejected, as it ignores the complexity of learner's mathematics education.

I identified Pragmatism as my philosophical belief, particularly as it is real-world orientated and its 'consequence of action' lens. Furthermore, the most common worldview associated with mixed methods research is pragmatism (Teddlie & Tashakkori, 2009), although clearly not the only one (Feilzer, 2010). However pragmatism does offer an alternative worldview to those of postpositivism and constructivism (Feilzer, 2010) and concentrates on the problem to be researched (Creswell & Plano Clark, 2007, Miller, 2006; Tashakkori & Teddlie, 1998). In terms of mathematics anxiety, my view is that this is a real world construct and the actions or factors of mathematics can lead to consequences of the construct. My philosophical worldview is that education should be focused on experiential and active learning with an aim to solving real world problems, this aligns with Dewey's views of pragmatism (Dewey, 1933). Pragmatism also enabled the researcher not to "*be the prisoner of a particular method or technique*" (Robson, 1993, p. 291), which may not be most appropriate given the research questions and aims. Pragmatism therefore underpins the mixed method design for this current study. Enabling multiple methods and various form of collecting data and research analysis (Creswell, 2014). This applies to mixed methods research in that inquirers draw liberally from both quantitative and qualitative assumptions when they engage in their research (Creswell, 2009), which will be considered in the next stage of the Research Design.

3.3 Selected Strategy of Inquiry

Returning to Creswell’s framework of design, as discussed at the beginning of the chapter, another interconnecting concept is the ‘Strategy of Inquiry’. The previous section focused on the four-worldview philosophies, of which the Researcher identified pragmatism as the most suitable paradigm. This section will explain the different strategies of inquiry, how they interconnect with pragmatism and lastly which methods are chosen for this research study.

A strategy of inquiry allows the researcher to harness their own worldview with the most appropriate methods for collecting and analysing data (Creswell, 2014;Denzin & Lincoln, 2013). The strategy of inquiry enables the researcher to address the research question(s) by utilising the most appropriate methods in the research study (Creswell & Plano Clark, 2011; Kroll & Neri, 2009; Robson, 2011).

According to Creswell (2009), strategies of inquiry are modes of qualitative, quantitative, and mixed methods designs, which enable a clear direction for procedures in the research design. They can also be referred to as ‘approaches to inquiry’ (Creswell, 2007) or research methodologies (Mertens, 1998).

Alternative Strategies of Inquiry		
Quantitative	Qualitative	Mixed Methods
<ul style="list-style-type: none"> • Experimental Design • Non-experimental designs, such as surveys. 	<ul style="list-style-type: none"> • Narrative research • Phenomenology • Grounded theory studies • Case study 	<ul style="list-style-type: none"> • Sequential • Concurrent • Transformative

(Creswell, 2008, p12)

Creswell (2009) argues that researchers can use both quantitative and qualitative data as they work to provide the best answer to a research question(s). It is also useful to draw on values of Pragmatism, which enables the researcher the flexibility in choosing the methods most appropriate in addressing the research questions. The nature of the research questions in this research study, require both quantitative and qualitative data, for this reason it was most appropriate to use a mix method aligned with a Pragmatism philosophical worldview.

3.4 Mixed Methods Strategies

This section further explores the ‘selected strategy of inquiry’ as part of Creswell’s framework of design. Mixed methods has been identified as an ‘interconnecting concept’, however this method is broad in the various methods that are available. The following section will introduce mixed methods and the various approaches available.

A mixed methods design according to Schoonenboom and Johnson (2017) is characterised by the combination of at least one qualitative and one quantitative research component where the overall objective is to enhance a study’s conclusions. In terms of a procedure it can be viewed as collecting, analysing, and “mixing” quantitative and qualitative data at some stage of the research process with the intention of a better understanding of the research problem (Tashakkori and Teddlie 2003; Creswell 2005).

3.4.1 Creswell’s six most used mixed methods designs

There are around forty mixed-methods research designs reported in the literature according to Tashakkori and Teddlie (2003), these include Teddlie and Tashakkori’s (2009) five sets of mixed methods research designs, Morse and Niehaus (2009) eight mixed methods designs, whilst Johnson and Christensen (2017) contains nine designs of which each consist of only one quantitative and one qualitative component.

Creswell et al. (2003) identified the six most often used designs in a study comprising of three concurrent and three sequential designs. More recently, Schoonenboom and Johnson (2017) provide a very useful summary of Creswell and Plano Clark’s (2011) typology of some “commonly used designs”

1. Convergent parallel design (the quantitative and qualitative strands of the research are performed independently, and their results are brought together in the overall interpretation),
2. Explanatory sequential design (a first phase of quantitative data collection and analysis is followed by the collection of qualitative data, which are used to explain the initial quantitative results),

3. Exploratory sequential design (a first phase of qualitative data collection and analysis is followed by the collection of quantitative data to test or generalize the initial qualitative results),
4. Embedded design (in a traditional qualitative or quantitative design, a strand of the other type is added to enhance the overall design),
5. Transformative design (a transformative theoretical framework, e. g. feminism or critical race theory, shapes the interaction, priority, timing and mixing of the qualitative and quantitative strand),
6. Multiphase design (“Mehrphasen-Design”) (more than two phases or both sequential and concurrent strands are combined over a period of time within a program of study addressing an overall program objective)

Source: Schoonenboom and Johnson (2017, p.117)

The research design required the initial measure of mathematics anxiety in students i.e. quantitative data and then qualitative data, which explored various antecedents, it was decided to adopt the mixed-methods sequential explanatory design. Similar research studies in mathematics anxiety used this mixed-methods sequential explanatory design where data of mathematics anxiety was first collected as a quantitative method, followed by a subsequent qualitative method i.e. Öztürk et al (2021), Szczygieł (2020), Delgado & Kassim (2019). Creamer (2017) puts forward the argument that mixed method promote validity and robust findings, this was particularly pertinent given the complexity of the construct of mathematics anxiety. The mixed-methods sequential explanatory design, is highly used and entails collecting and analysing quantitative data initially and then qualitative data in two consecutive phases within one study (Ivankova, Creswell, & Stick, 2006). The next step in the research design was to determine the quantitative and qualitative research instruments to be used as part of the mixed-methods sequential explanatory design.

3.5 Quantitative Data Research Instrument

This section further explores the ‘selected strategy of inquiry’ as part of Creswell’s framework of design. The first research question is “*To measure the initial existence of mathematics anxiety on Further Education Adult Learners*”. It is important to first gauge the level of Mathematics Anxiety before the qualitative research

instrument is used. There are a range of Mathematics Anxiety measurements available, which were outlined within the literature review, however it important to first consider how mathematics anxiety can be measured.

3.5.1 Measuring Mathematics Anxiety

There are a wide range of instruments used to measure mathematics anxiety. These instruments include learners reading a series of statements illustrating mathematical scenarios and expressing the level of anxiety the experience on a Likert-scale (Ryan & Fitzmaurice, 2017). The result from these tests determines the level of mathematics anxiety of the learner. The original mathematics anxiety test was the mathematics anxiety Rating Scale or ‘MARS’ test and this was initially used for learners returning to education (Richardson and Suinn, 1972). The MARS test consisted of a 98-item list of statements (Ryan & Fitzmaurice, 2017) and showed high levels of validity and reliability (Suinn et al., 1988).

The MARS test was adapted to suit primary school students (Suinn et al., 1988) and second level students—Suinn & Edwards, 1982). However, as the test comprised of 98 statements it took a long time to complete and administer and as a result, the test was modified to a 30 statement test ‘the MARS-30 (Suinn & Winston, 2003). These tests were created for learners experiencing mathematics anxiety in the context of American Universities and Schools. The MAS-UK (Mathematics Anxiety Scale U.K) was subsequently developed and it comprised of a list of statements relating to mathematics (Ryan & Fitzmaurice, 2017), which included terminology that was more appropriate towards a British population (Hunt et al., 2011: p. 126). However, there has been questions raised regarding the suitability of these tests as they stem from the field of psychology and not from the lens of mathematics (Zan et al., 2006). Wilder (2013) highlights the lack of high scores available in the MARS test, which would suggest that mathematics anxiety, is not prevalent in colleges despite the anecdotal evidence reported. Wilder states that since that “*many college professionals report anecdotal evidence that students are experiencing significant levels of mathematics anxiety or that they may not encompass all the aspects of what has proven to be a very complex, multidimensional construct* (Wilder, 2013, p15). There are a wide range of mathematics anxiety tests available and MAS-UK was deemed most appropriate for this research study, which is discussed in detail in Chapter 3.

Of course there can be too much focus on quantitative instrument as Arslan et al. (2015), suggests who found that 33 out of 40 research studies in mathematics anxiety meta-analysis were quantitative. Ryan & Fitzmaurice, (2017, p.1) suggest that quantitative tests reveal “*a numerical representation for the level of anxiety felt by the participant, there is limited insight available into the context for such anxiety, thereby limiting understanding of the origin of such feelings*”. Mertens (2015), suggest that drawing on learners experiences can be done so by harnessing a quantitative approach with a qualitative approach where a range of methods can be used to collect the data. Indeed, there are a number of qualitative techniques which can be used in order to obtain rich data from a learner’s environmental antecedents. These include one-to-one interviews (Miller & Mitchell, 1994), Mathematic Life Histories (Drake, 2006; Stoehr, 2015) and Mathematics Autobiographies (McCulloch et al, 2013). Narrative researchers within the mathematics-education research, has drawn on two broad kinds of learner experience narrative, the “well-remembered event” (Carter, 1994) and the “life story” (e.g., Atkinson, 2007; Drake, 2006). (Carter, 1994, p.236) states that a ‘well remember event’ in mathematics as an “*an incident or episode that a student observes in a school situation and considers for his or her reasons as especially salient or memorable*”. McCulloch et al (2013) suggest that mathematics autobiographies, particularly oral autobiographies enable the opportunity to draw on the learners’ attitudes, beliefs, and identities within the context of mathematics (McCulloch et al., 2013). A number of qualitative research method were consider, all of which will be considered in Chapter 3.

To note, there is emerging research which prompts the integration of wearable technology to identify physiological signs of anxiety which could be helpful in measuring anxiety as it occurs in everyday life (Elgendi & Menon, 2019). O Hara et al (2021) suggests such use technology could measure mathematics anxiety in real time during mathematics class including evaluation rather than resorting to self-reporting questionnaires, which can be subject to bias. Other measures of mathematics anxiety including the measure of cortisol secretion (Pletzer et al., 2010; Mattarella-Micke et al., 2011). However, Dowker et al (2016) contends that this is not an accurate indicator of mathematics anxiety. These issues highlight the need for accurate measurements of mathematics anxiety.

3.5.2 The MAS-UK

The MAS-UK questionnaire (Hunt et al, 2011) was used to measure the learner's initial level of mathematics anxiety as outlined in the previous chapter, see (appendix 2) for MAS UK questionnaire template. There were a number of reasons why the Researcher decided to utilize the MAS-UK test. Cipora (2019) for example, outlines an overview of mathematics anxiety measurement techniques, of those, only three different tests were used for adults and adolescents. Moreover, the MAS-UK is the only mathematics anxiety measurement specifically designed for Adults. This is a significant factor as this research study consists exclusively of an adult population. Additionally, the MAS-UK test has demonstrated significant internal reliability (Cronbach's alpha = 0.96) and test-retest reliability ($r = 0.89$) (Hunt, Clark-Carter and Sheffield, 2014). Moreover, the MAS UK provides further analysis as the questionnaire is broken into three section. The three sections comprise of Factor 1 (Mathematics Evaluation Anxiety), Factor 2 (Social/Everyday Mathematics Anxiety), and Factor 3 (Mathematics Observation Anxiety) (Hunt et al, 2011). To date, there is no mathematics anxiety test designed specifically for an Irish population, the MAS-UK was developed for the British population (Hunt, Clark-Carter, & Sheffield, 2011), which in terms of language would be most appropriate for an Irish population. There is also existing literature, where the MAS-UK test was used to measure mathematics anxiety among adult learners in Irish Universities e.g. (Ryan, Fitzmaurice. & Johnson, 2019), (Ryan & Fitzmaurice, 2017) and (Ryan, 2019). The MAS UK questionnaire seemed most appropriate for the participants for this study. However, how to analyse the results required greater research and consideration.

3.5.3 Mathematic Anxiety Levels

A common issue with the use of mathematics anxiety questionnaire related to questions around how prevalent mathematic anxiety may be in the general population. Only recently Cipora (2021, p13) addressed this problem and stated when *“discussing MA (mathematics anxiety) with non-experts, policymakers, or educational practitioners, we often receive the reasonable question about the prevalence of MA. Despite being fundamental, this question still does not have a straightforward and satisfactory answer”*. Hunt (2022), the creator of the MAS-UK, recommended that when using the MAS UK that there should be *“no agreed cut-off*

for such categorization”, furthermore “data should be kept on a continuum where possible”. Cipora et al., (2019) also advocates this approach when using all mathematics anxiety measurements and states that mathematics anxiety “should be considered as a continuous, not a binary trait. One pole of this continuum would represent extreme anxiety towards mathematics. While mathematics anxiety levels gets lower along this continuum, it still exists” (Cipora et al., 2019, p15). The use of a continuum is practical and whilst there should be no ‘agreed cut off’ for categorizations, it is still useful to adopt one ‘pole’ of the continuum, which represents extreme mathematics anxiety. However, it would be useful to review results from other MAS UK tests used in different studies.

3.5.4 MAS UK results from other studies

In examining this issue, the Researcher reviewed a number of articles that used the MAS UK Test as the quantitative research instrument. Ryan and Fitzmaurice (2017) carried out a MAS UK text as part of a mixed method design. Among the 107 respondents, the scores ranged from **23 to 94** out of a potential range of 23 (not at all anxious) to 115 (very anxious). Thus no candidate was coming in as ‘very’ mathematics anxious. Furthermore, Ryan and Fitzmaurice (2017) identify that 10 students (9.3%) were in the range of scores from **82 to 94**, demonstrating ‘**higher levels of mathematics anxiety**’.

Hunt et al (2011) used a greater number of Participants (n=1,153) who were undergraduate students at Staffordshire University, a typical post–1992 university in the Midlands, United Kingdom.

Thomas E. Hunt, David Clark-Carter, & David Sheffield		
Table 1. Means and standard deviations of mathematics anxiety across faculties		
Faculty	M	SD
Arts, media, & design (n = 324)	85.79	27.86
Sciences (n = 335)	82.12	27.12
Computing, engineering, & technology (n = 69)	76.55	22.25
Health (n = 239)	74.14	22.26
Business (n = 155)	65.13	22.44

Cipora et al (2021) gives a practical example of issues with cut offs for mathematic anxiety scales. For example, someone in the “96th percentile might be classified as highly anxious, while individuals who fall, say, in the 94th percentile might not be classified the same way but nevertheless need support” for mathematics anxiety (Cipora et al, 2021 p.13). In acknowledging this issue, Cipora (2021) suggest that future studies should focus on developing better diagnostic/cut-off criteria for mathematics anxiety diagnosis.

There are issues raised that the MAS-UK and other similar tests do not reflect the complexity of mathematics anxiety and its impacts on the research participants (Zan *et al.*, 2006; Wilder, 2013). One issue with researching mathematics anxiety as a quantifiable measurement is that it ignores the complexity of the construct (Sloan, 2010). These issues, coupled with research questions 2 and 3 prompted the exploration of the various qualitative methods as part of the mixed-methods sequential explanatory design.

3.6 Qualitative Data Instrument

This section further explores the ‘selected strategy of inquiry’ as part of Creswell’s framework of design. In terms of selecting the qualitative data instrument, it is necessary to consider the research question(s). The second research question in the study is: *What, if any, environmental antecedents contribute towards mathematics anxiety in an adult learner’s mathematics learning journey?* Additionally, the third research question is: *What impact, if any, do environmental antecedents have on students’ experiences of mathematics?* Considering these questions, the main component of the research design was to examine the ‘environmental antecedents’ and how they influence an adult’s experiences of mathematics in terms of mathematics anxiety and their overall experiences with mathematics. The qualitative instrument was paramount to the research design and critical to the research study.

Qualitative methods are used to understand people’s “*beliefs, experiences, attitudes, behavior, and interactions*” (Papakitso, 2020, p.64). Qualitative research implies a variety of data collection and analysis techniques (Gopaldas, 2016). There is however, a large array of qualitative research methods available (Creswell et al, 2007). Considering these various methods, a useful starting point is Creswell’s ‘main five qualitative approaches’.

3.6.1 Consideration of Five Qualitative Approaches

Creswell (p.78, 2014) identified five main qualitative approaches according including narrative research, phenomenology, grounded theory, ethnography and case study. Each of the five of the main methods will be considered within the context of the research question without any bias. Creswell (2014) strongly recommends that if the researcher is studying a single person, to use the narrative approach or a single case study as ethnography is a much broader representation of the culture. Furthermore, ethnography studies a group that shares the same culture, whereas this study draws on a range of cultures from across the world. For these reasons, ethnography was not considered as a qualitative approach for this study. Another option is 'grounded theory', which is a qualitative research method, that creates a theory of the views of a large number of participants (Strauss & Corbin, 1998). As there will be a small population sample and that a theory is not sought as part of the research questions, general theory was disregarded as a qualitative approach. Case study was also ignored, this approach seeks to focus on an event, program or activity, which would not be relevant to this research study.

The two remaining approaches are narrative research and phenomenology. The term 'focus' in phenomenology and 'life/story' in narrative research contrast between both approaches. The fundamentals of phenomenology is to condense a person's experiences with a 'phenomenon' to a description of an 'essence', where an essence is described as "*the very nature of the thing*" (Van Manen, 1990, p.177). Phenomena according to Moustakas (1994) could be anything such as insomnia, anger, or undergoing coronary artery bypass surgery. Phenomenology then collects data from the individual regarding how they experienced this phenomenon and conveys the experience of the essence including "what" they experienced and "how" (Creswell, 2014).

Narrative research is more than adequate for this research study as it explores stories told by individuals (Polkinghorne, 1995), and this is suitable given the nature of learners' mathematics journey within the research questions. Narrative approach can examine events throughout the learner's mathematics journey. According

to Czarniawska (2004, p.17) narrative approach can be “*spoken or written text giving an account of an event/action or series of events/actions, chronologically connected*”. The chronological aspect is pertinent as it will allow the interviewer to go through all the stages of mathematics education/experience including preschool, primary school, post primary school, further or/and higher education and employment. For this reason, a narrative approach was chosen as one of the interconnecting concepts of the research design.

A narrative research approach can include a variety of approaches, where individuals’ stories are collected and these experiences are ordered chronologically (Creswell, 2013). Narrative researchers within the mathematics-education research, has drawn on two broad kinds of learner experience narrative, the “well-remembered event” (Carter, 1994) and the “life story” (e.g., Atkinson, 2007; Drake, 2006). In terms of a narrative approach, a life story and more specifically a mathematics life story was deemed most appropriate for this research study. The mathematics life story is a very good fit for the research questions, given the focus around a *‘learners’ mathematics learning journey’ (RQ2) and the student’s experiences of mathematics (RQ3. Moreover, the aim of the research has a specific focus on an ‘adult learners’ mathematics life story’*. The following section will provide a rationale for a life story as a research methods, which forms part of Creswell interconnecting concepts.

3.6.2 A Life Story

A life story, through a semi-structured or unstructured interview (Drake, 2006; McAdams, 1993), provides an understanding of a learners’ past experience(s) (Goodson & Sikes, 2001). Exploring a learners’ journey from their past enables the researcher to understand their present (Mertens, 2015). Life Stories have been adapted to Mathematics Life Stories, this was to make it more appropriate towards a learner’s mathematics journey. The purpose of the Mathematics Life Story is to illustrate the narrator’s past and present experiences in mathematics (Ryan, 2019).

3.6.3 A Mathematics Life Story

The rationale underpinning the use of Mathematics Life Story as a research tool is that it ‘give instructors insight into the background of their students’ (LoPresto & Drake, 2004: p. 268). It has evolved from the LifeStory and offers a deep insightful account of a learners experiences in mathematics, this is particularly helpful given the participant’s journey to adult education. As a variation of the life story, the mathematics life story presents the researcher with an individualised account of the narrator’s past and present experiences with mathematics

Furthermore, a mathematics life story can also identify the positive or negative impact that the role of teachers and family can have on a learners’ life story (Ellsworth & Buss, 2000; LoPresto & Drake, 2005). This is particularly relevant given the nature of antecedents in mathematics anxiety. In conjunction with the Mathematics Life Story Framework, a timeline will also be utilised to support the interview. (See page 12 and 13 of appendices for information regarding process of interview).

Ryan (2019) developed the Mathematics Life Story framework as an adaptation to McAdams (2008) interview. Ryans’ (2019) study conducted similar research where the focus was on the existence of Mathematics Anxiety amongst Mature Students in Higher Education. Furthermore, McAdams, (1993) and Plummer (2001) advocate preparing the narrator for the interview and allowing them to record post interview thoughts. A timeline can be used as a focal point for the life story interview (Wellington et al. 2012) and the structure which was used by Ryan (2019) was used in conjunction with the interview (see appendix 11).

The previous sections outlined the philosophical worldview of the researcher, the identification of the most suitable quantitative and qualitative instruments whilst aligning these with the research aim and questions. The following section will show how the process for the data collection.

3.7 Process of Data Collection

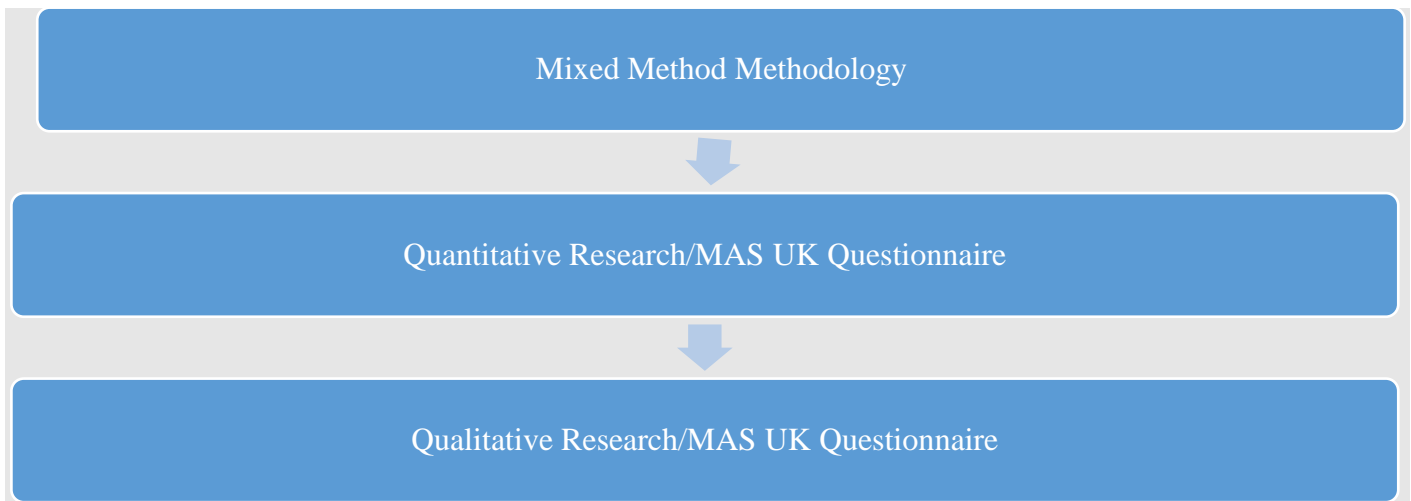


Table 3.1 Process of Data Collection

3.7.1 Participant Selection

Given the small number of available participants due to the complexities of Covid-19, a convenience sampling method was employed. Convenience sampling is a sampling method where members of the target population that meet specific practical criteria, such as easy accessibility, geographical proximity, availability at a certain time, or the willingness to participate are included for the purpose of the study (Dörnyei, 2007). In this study, and similar to Dörnyei (2007), “*captive participants such as students in the researcher’s own institution are main examples of convenience sampling*” (Dörnyei, 2007, p6). An information session was held by the AISS Coordinator where two leaving certificate classes from VTOS in Limerick City were invited. There was a total of 22 between both, 15 participants volunteered for the MAS UK questionnaire and 7 declined. Of those 15 learners, (n=8) volunteered for the Mathematics LifeStory Interview framework and (n=7) declined.

3.7.2 Phase 1: Quantitative Data

As part of this research, quantitative data was used to answer the first research question i.e. what level of mathematics anxiety, if any, exist amongst a cohort of adult learners? As part of a pilot stage, the MAS UK questionnaire was employed which gave the researcher an opportunity to trial the questionnaire. The questionnaire consisted of scores indicating different levels of mathematics anxiety, ranging from ‘not at all’

which would give a score of 1, to ‘much’, which would give a score of 5, with a total of 23 questions. See appendix (2) for more information on MAS UK questionnaire, there were 15 participants that volunteered for MAS UK questionnaire.

3.7.3 Phase 2: Qualitative Data

Qualitative data was used in order to address research question 2 and 3, namely: Q2: What, if any, environmental antecedents contribute towards mathematics anxiety in an adult learners’ mathematics learning journey? And Q3: What impact, if any, do environmental antecedents have on student’s experiences of mathematics? Following the completion of the MAS UK questionnaires (n=15), 8 participants volunteered for the Mathematics Life Story Interview Framework, which was done on a convenience sample. As per the ethics guidelines, participants were emailed with a copy of the Mathematics Life Story Interview Framework to familiarise themselves with the questions as well as an agreed location, time and date. Participants were also informed that the meeting would be recorded with a Dictaphone and Microsoft Teams, and later transcribed. Following on from the interview, participants were emailed a copy of the interview in order to ensure that the content was accurate. Member checking was used and none of the participants requested any changes from the researcher. All participants were thanks for their cooperation.

3.8 Analysis of Quantitative Data

The MAS UK questionnaire was uploaded to Microsoft Forms and learners could access this via a designated channel on Microsoft TEAMS as part of the data collection. Analysis of the questionnaires were facilitated with software SPSS and Microsoft Excel 2016. A starting point for the analysis of the MAS UK results was to identify the Data Mean, Median, Standard Deviation and Range. The next step was to administer a normality test where the Shapiro-Wilk was deemed to be most appropriate. This was supported with a visual inspection of the histograms to check normal Q-Q plots and box plots.

Once the process was completed, the results were examined and they were measured on a continuum (Hunt, 2022) where “*One pole of this continuum would represent extreme anxiety towards math. While mathematics anxiety levels gets lower along this continuum, it still exists*” (Cipora et al., 2019, p.15). This will give a broad

insight into learner's mathematics anxiety, however further analysis was provided by analysing the different 'factors' of the MAS UK questionnaire. The three sections comprise of Factor 1 (Mathematics Evaluation Anxiety), Factor 2 (Social/Everyday Mathematics Anxiety), and Factor 3 (Mathematics Observation Anxiety) (Hunt et al, 2011). These factors gave a more detailed analysis of learners' mathematics anxiety, once completed the next step of the process was to analyse the qualitative data.

3.9 Analysis of Qualitative Data

The following section will outline how the qualitative data from the Mathematics Life Story will be analysed. This will primarily focus on the thematic analysis and inform the reader how the process was followed. The actual thematic analysis of the qualitative data will be covered in Chapter 5.

3.9.1 Thematic Analysis

Thematic Analysis according to Braun & Clarke (2006) is a process for identifying and analysing specific patterns of meaning within a dataset. Nowell, Norris, White and Moules (2017) advise that the lack of focus on rigorous and relevant thematic analysis have consequences in terms of the credibility of the research process. Thematic analysis is not without scrutiny or criticisms, for example, a number of psychologists question if a thematic analysis is an instrument that underpins various different qualitative approaches (Willig, 2013). However, it is well recognised that a thematic analysis is a very effective instrument, particularly for researchers who are not familiar with qualitative methods (Braun & Clarke, 2006; King, 2004). Moreover, a thematic analysis can be easily understood, easily grasped and can be relatively quick to learn as there are few protocols and procedures (Braun & Clarke, 2006; King, 2004).

There are various approaches to thematic analysis (e.g. Alhojailan, 2012; Boyatzis, 1998; Javadi & Zarea, 2016). Peel (2020) gives an overview of the four prominent writers in thematic analysis (1) Braun and Clarke (2006), (2) Creswell (2013), (3) Merriam (2009) and (4) Miles, Huberman and Saldaña (2014). All of these approaches were examined, however, the researcher chose Braun and Clarke (2006) as it was straightforward to follow, providing guidance around potential pitfalls in thematic analysis, it was more comprehensive in terms of its stages and it also enabled reflective practice. The process was very user friendly and provided

detailed steps throughout the thematic analysis. The advice on the potential pitfalls was also beneficial, the writers gave some useful guidance, for example they advocated that the thematic analysis requires the researcher to engage in more interpretive analysis and that interview questions should not be used as themes. The reflective practice was paramount given the nature of the mathematics life-story interview where the process recommended the writer to re-read transcripts, audio- recordings and become very familiar with the data. Indeed a number of prominent researcher advocate the use of Braun and Clarke's six-stage process to thematic analysis within the context of mathematics anxiety research (Thompson et al., 2016; Ryan, 2019; Adeyemi, 2015).

According, to Maguire & Delahunt (2007) it is arguably the most influential approach as it offers such a clear and usable framework for doing thematic analysis. Indeed Byrne (2022) argues "*since the publication of their inaugural paper on the topic in 2006, Braun and Clarke's approach has arguably become one of the most thoroughly delineated methods of conducting thematic analysis*" (Byrne, 2022, p.1). Braun and Clarke (2006) provide a six-step process compared to a five-step process which Creswell (2013), Merriam (2009) and Mills et al (2014) offer. The advantage of this is that it guides the researcher on a step by step basis of which is very clear and comprehensive. Additionally this process enables the researcher to provide rich data, descriptions and social interpretation of the data, which is very apt given the nature of the mathematics-life story interview. The purpose of thematic analysis is to identify themes or patterns of data and match these themes with the research questions i.e.

- RQ1 What level of mathematics anxiety, if any, exist amongst a cohort of adult learners?
- RQ2 What, if any, environmental antecedents contribute towards mathematics anxiety in an adult learner's mathematics learning journey?
- RQ3 What impact, if any, do environmental antecedents have on students' experiences of mathematics?

According to Clarke and Braun (2013) a common mistake can be to confuse the main interview questions as themes. Moreover, it is not just a process where you summarise data, it is important to make 'sense' of the data (Maguire & Delahunt, 2007). Braun & Clarke (2006) identify two opposing levels of themes, these are

referred to as semantic and latent themes. Semantic themes are explicit or surface meanings, whilst in contrast the latent theme attempts to identify the underlying ideas or conceptualisations (Braun & Clarke, 2006). Braun & Clarke (2006) illustrate a six phase thematic analysis below, which enables a systematic approach and a very useful framework for conducting this kind of analysis.

3.9.2 Phase 1: Familiarizing yourself with the data:

Familiarisation is the initial phase, which provides the researcher with an entry point into thematic analysis, gaining insight into what can sometimes appear to be an overwhelming mass of data (Terry et al, 2017). Braun & Clarke (2006) suggest that as you immerse yourself in the data collected, which also involves repeatedly reading the data in an active way. Moreover, Maguire & Delahunt (2007) recommend that it is helpful to make notes and write down early impressions from the data. Braun & Clarke (2006) also recommend that verbal data be transcribed into written form in order to conduct a thematic analysis.

The interviews from the current study were uploaded to Microsoft Word, which also enables a transcription feature, however, the transcription was not entirely accurate, therefore the researcher listened to the interview to ensure that the data was accurate and any errors in the transcript were corrected manually. This approach ensured accuracy of the transcripts and early impressions/notes were inserted as ‘comments’ within the document, as suggested by (Maguire & Delahunt, 2007). Whilst these processes can be mundane or boring, it can be used as an effective way for a researcher to familiarizing themselves with the data (Riessman, 1993). Braun & Clarke (2006) suggest that ‘immersion’ and ‘repeated reading’ in the data is the best method to familiarise yourself with the data.

3.9.3 Phase 2: Generate initial codes

Maguire & Delahunt (2007, p.5) suggest that this step should be adopted in a ‘meaningful and systematic way’, which is the ability to code by reducing ‘*lots of data into small chunks of data*’. Having completed the familiarization process with the Mathematics Life Story Interview, it was found that there were significant chunks of data that were particularly relevant. Moreover, Terry et al (2017, p.15) also highlight the process of chunks or segments of data but raise the importance of the research questions, “*coding is the systematic*

and thorough creation of meaningful labels attached to specific segments of the dataset – segments that have meaning relevant to the research question”. Coding can be carried out manually by the Researcher, or through various software programmes (Kelle, 2004).

It was decided to code the Mathematics Life Story interview transcripts manually, as this was an opportunity to become further familiar with the data (Mertens, 2015). Moreover, Kiger & Varpio (2020, p.4) state that it is “important to note that Clarke and Braun’s thematic analysis is designed to be a recursive, rather than linear, process in which subsequent steps may prompt the researcher to circle back to earlier steps in light of new data or newly emerging themes”. The sample size of this study (n=8) was also a factor.

In terms of thematic analysis, a theme can be formed inductively from the raw data or generated deductively from theory and prior research (Boyatzis, 1998). Braun & Clarke (2006) make a distinction between a top-down/theoretical thematic analysis, which is driven by the research questions and can often be referred to as a deductive analysis (Boyatzis, 1998, Hayes 1997), conversely a bottom-up/inductive one that is more driven by the data itself. As the researcher was concerned with addressing specific research questions, a theoretical (deductive) thematic analysis rather than an inductive was adopted, similar to Maguire & Delahunt (2007). Patton (1990) suggests that qualitative data should not follow rules per se and flexibility will be required to address the research questions.

Any labels, chunks or segments that were familiar to mathematics anxiety or environmental antecedents were highlighted as a ‘Data extract’ and then coded (see examples in the table below – *Give all tables a title and reference number*).

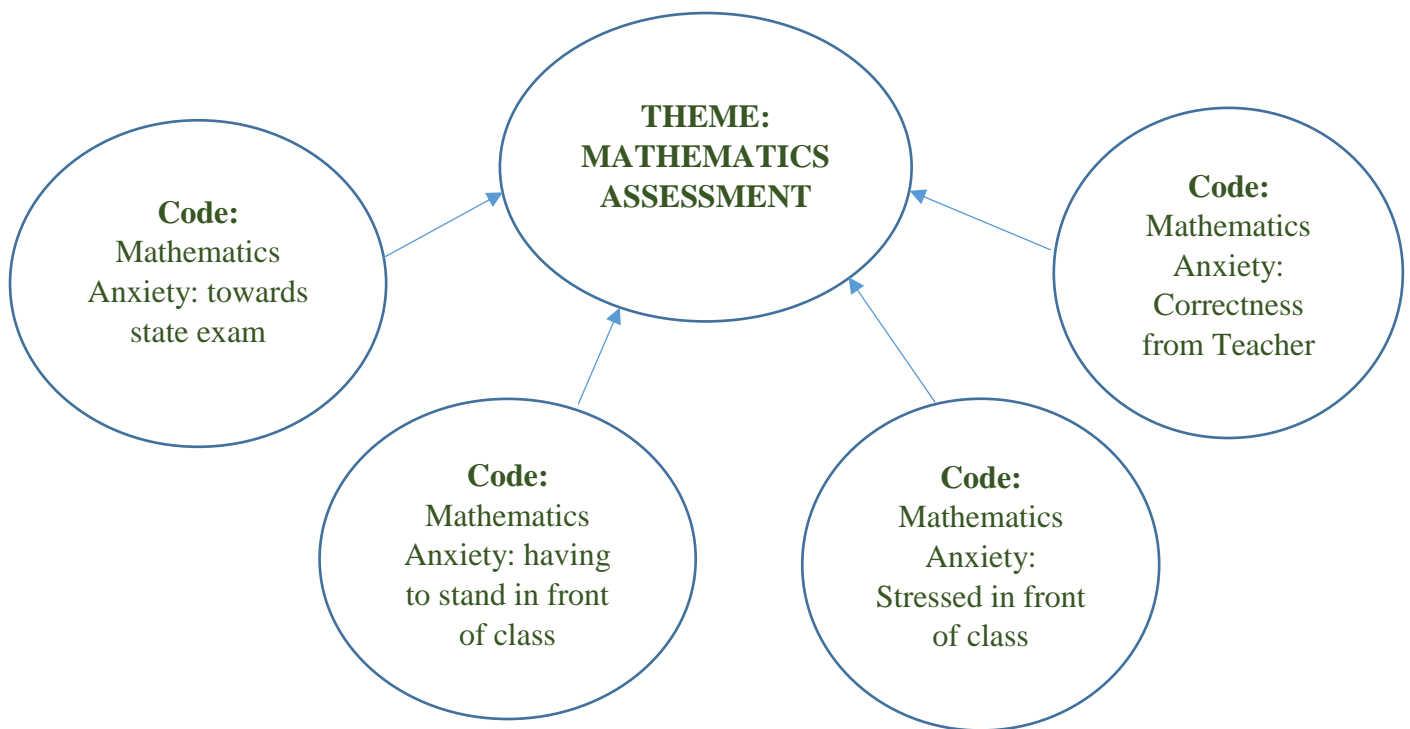
Data extract	Coded for
She wanted you to give the answer quickly, you were really stressed in front of the class and I was scared that I would be called to the board. (Linda)	Stress/Scared Correctness

My father's influence in terms of what he kind of worked as a clerk in in ranks and he worked with accountants. And I think he had visions of me being an accountant. (Stephen)	Influence of Father
Maths in a general sense, doesn't bother me, doing an exam is a different story. Having to have the like complications and understanding of like all the different exam questions. That kind of throws me off because let's looking through the exam paper. I'm going, Nope,Nope,Nope..... (Robert)	Anxiety of State Exams

Table 3.2 Example of data extracts

3.9.4 Phase 3: Searching for themes.

A starting point in terms of ‘searching for themes’ would be to highlight Braun & Clarke’s (2006) approach in that there are no ‘hard and fast’ rules about what makes a theme. Maguire & Delahunt (2007, p6) define a theme as “*a pattern that captures something significant or interesting about the data and/or research question*”. This is particularly important given the common mistake that interview questions can often be used as themes (Clarke & Braun, 2013), as alluded to earlier. As Terry et al (2017) suggest that research question(s) should provide a guide for this, in this context, phase 3 can help determine what is relevant in the data. It is also important to note, that not only are there themes, but relationship between codes, subthemes and different levels of themes including overarching themes (Clarke & Braun, 2006). The theme of ‘Mathematics Assessment’, was identified after having recognised a pattern that captured significant data which was very relevant to the research questions in this study. The below is an example of how the different codes were merged to form the theme of ‘Mathematics Assessment’, see appendix (5) for further examples.



3.9.5 Phase 4: Phasing Themes

This phase provides the opportunity to establish which themes are relevant and have sufficient data to support them, which aren't or which themes can merge into one (Braun & Clarke, 2006). This can be done manually or through specialist software (Bree & Gallagher, 2016), for the purpose of this research it was carried out manually due to the small sample size as referenced in phase two. Maguire & Delahunt (2007, p.7) suggests the following questions should be applied in order:

- Do the themes make sense?
- Does the data support the themes?
- Am I trying to fit too much into a theme?
- If themes overlap, are they really separate themes?
- Are there themes within themes (subthemes)?
- Are there other themes within the data?

On review, it was decided to change the theme names from ‘Mathematics Assessment’ to ‘Mathematics Test Anxiety’ and ‘Learning Culture’ to ‘Learning Environment’ as they were more appropriate to the research questions and the environmental framework. Self-efficacy was eliminated as it was an interacting variable, personal issues & motivation were also eliminated as they were personal antecedents, thus neither were environmental antecedents. See below, table illustrating why self-efficacy was eliminated as it was not construed as an environmental antecedent, rather an interacting variable. Environmental antecedents were examined for the purposes of research questions 2 and 3.

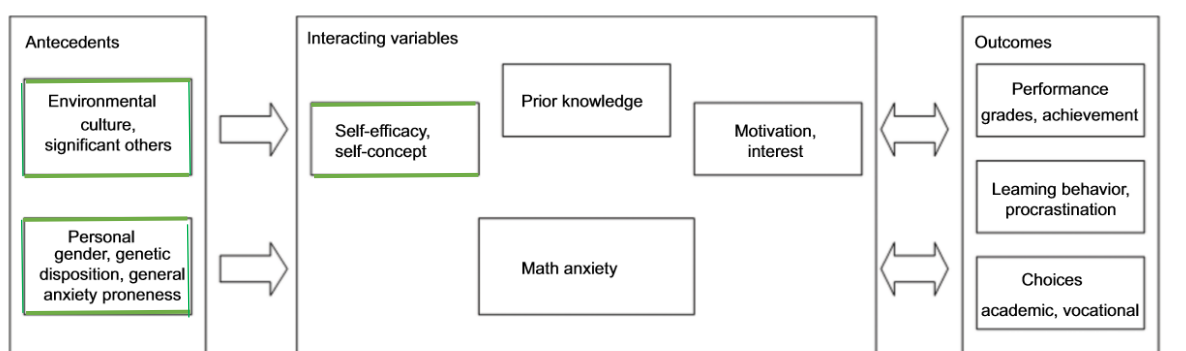


Figure 1 A framework for understanding math anxiety.

~~Theme: Self Efficacy~~

~~Theme: Motivation~~

~~Theme: Personal Issues~~

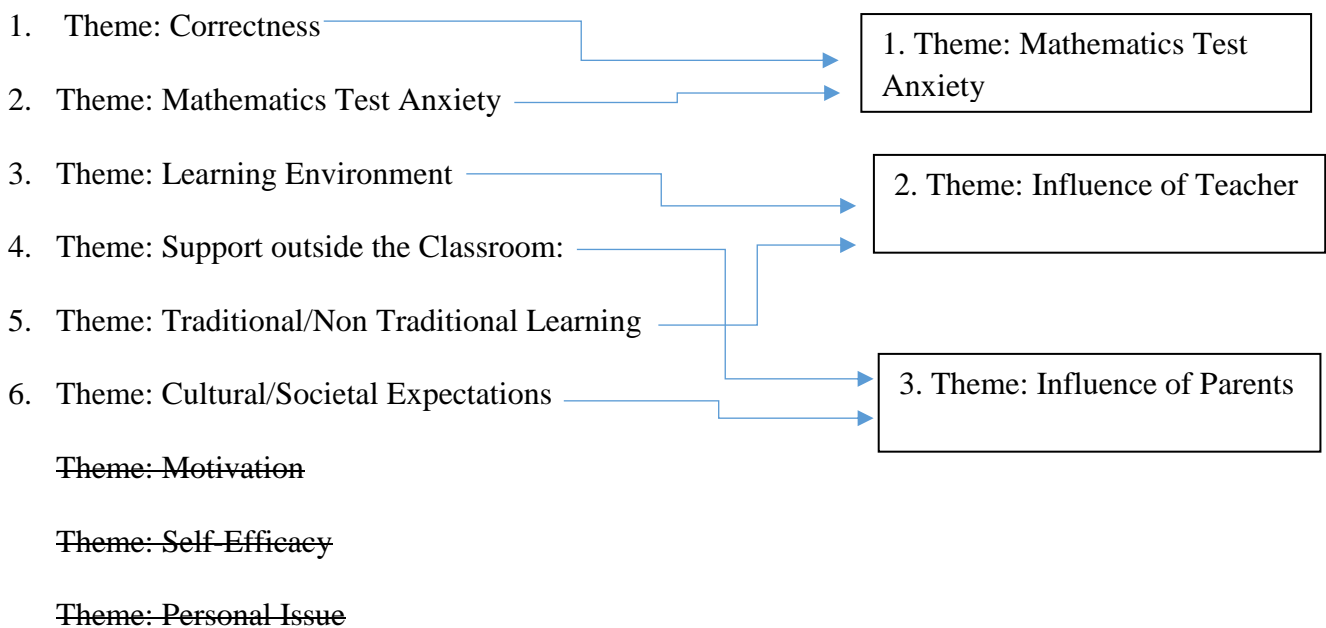
1. Theme: Correctness
2. Theme: ~~Mathematics Assessment~~: Mathematics Test Anxiety
3. Theme: ~~Learning Culture~~: Learning Environment
4. Theme: Support outside Classroom:
5. Theme: Traditional/Non Traditional Learning
6. Theme: Cultural/Societal Expectations

3.9.6 Phase 5: Mapping Themes

At this stage of the process there was an attempt to integrate the themes with the codes, data and the research questions, as suggested by Terry et al (2017). Moreover, phase 5 facilitates the opportunity to review themes,

subthemes and more importantly, how they interact and relate to the main themes (Maguire & Delahunt, 2007). In developing these themes, it is important to ensure that the theme names are “*concise, punchy, and immediately give the reader a sense of what the theme is about*” (Nowell et al, 2017). Phase 5 or the ‘reviewing phase’ according to Terry et al (2017) is like a ‘quality control exercise’, it is used to verify that the themes integrate with the coded data, the dataset, and the research questions. Braun & Clarke (2006) recommend that it is vital not to try and enable a theme to cover too much, diverse or indeed complex. Whilst Luttenberger, Wimmer and Paechter (2018, p.313) argue that there isn’t a single cause of mathematics anxiety but a range of antecedents which give rise to mathematics anxiety, these antecedents were mapped to the various emerging themes where some will synthesised as part of the ‘quality control exercise’ (Terry et al, 2017).

Synthesis of Correctness & Self-Efficacy into Mathematics Test Anxiety



The first theme (see image above), which is prevalent amongst a number of learners, is Mathematics Test Anxiety, which were found in the data set as well as the current literature review. Self-Efficacy and Correctness were merged into Mathematics Test Anxiety as they shared common codes. For example, Self-Efficacy contained such codes as ‘Past negative experience in leaving cert maths’, ‘Low Confidence from negative learning outcomes’ and ‘Disengagement due to negative learning outcomes’. Additionally,

‘Correctness’ comprised of themes such as ‘Giving the right answer’ and ‘Incorrect answer leading to embarrassment towards peers’. The influence of teacher was the next theme to be synthesised

Synthesis of Learning Environment/ Traditional & Non-Traditional Learning to Influence of Teacher

The next theme was the ‘Influence of the Teacher’, which encompassed a number of codes including student/teacher interaction, correctness/embarrassment, traditional teaching methods and corporal punishment. For example, the themes of ‘Learning Environment’ and ‘Traditional/Non Traditional Teaching’ were consolidated into a theme of ‘Influence of Teacher’. Similarly to the previous, there were common codes between these themes which enabled the synthesis as part of phase 5 thematic analysis.

Synthesis of Cultural/Societal expectations to Influence of Parents

In the first instance, upon further review, there was not enough data to support Cultural/Societal expectations as an emerging theme. However, there was some codes, which were common to both Cultural/Societal expectations and influence of parents such as ‘parental expectations’. Moreover, there was sufficient data in Influence of Parents to support it as an emerging theme and furthermore the Synthesis of Cultural/Societal expectations to Influence of Parents

3.9.7 Phase 6: Producing the report

This is the final stage of the thematic analysis where a report is furnished with a final analysis (Braun & Clarke, 2006). The final report should include a clear process where researchers used a logical process to their findings, which is also clear to the reader (Thorne, 2000). Additionally, King (2004) recommends that direct quotes from participants are a crucial component in producing the final report

3.10 Reliability and Validity

Section 3.7 and the preceding sections identified a mixed-methods sequential explanatory design most appropriate for this research study. Creswell & Plano Clark (2018) recommend rigorous procedures for mixed method research in order to maintain validity and reliability of both the quantitative and qualitative research instruments. According to Hesse-Biber (2010, p.85), validity questions if the research instruments applied

actually measures the construct they are supposed to, whilst Teddlie and Tashakkori (2009, p. 209) suggests that reliability focuses on their consistent and accurate representation of this construct. In this research study, the construct was mathematics anxiety and the research instruments were, the mathematics LifeStory (qualitative) and the MAS UK questionnaire (quantitative).

Section 3.8.1 gives a clear argument for the use of the MAS UK questionnaire as part of the mixed method questionnaire for an adult population in a Further Education and Training setting. Moreover, this section outlined the significant internal reliability (Cronbach's $\alpha = 0.96$) and test-retest reliability ($r = 0.89$) (Hunt, Clark-Carter and Sheffield, 2014). Another measure used to increase the validity and reliability of this instrument was to incorporate a pilot stage to trial the questionnaire. According to Cohen et al. (2011), a pilot stage of a questionnaire enhances its validity, reliability, and practicality of the questionnaire. Section 3.10 of this study '*Process of Data Collection*' outlined a pilot stage ($n=6$) of the research process, where the MAS UK questionnaire was used, this gave the researcher an opportunity to trial the research instrument. Some findings from the pilot stage informed the researcher on measures to improve reliability and validity, including the need to increase the number of participants. Indeed, pilot studies are regarded as been a critical aspect of research design, as they increase the likelihood of the study's success and help identify any shortcomings in term of the research execution (Cohen et al., 2018). Another issue which may have impacted on the reliability was that questionnaires tend to fail because participants don't understand them (Boynton, 2004). This was an issue, particularly as English was not the first language for some participants. To address this, the researcher emailed the MAS UK questionnaire to the participants, in advance, and learners were encouraged to ask any questions that required clarification.

Indeed, this approach was also used for the qualitative instrument, as per the ethics guidelines, where participants were emailed with a copy of the Mathematics Life Story Interview Framework to familiarise themselves with the questions. Furthermore, the researcher held a meeting with the creator of the Mathematics LifeStory Interview framework (Ryan, 2019) and simulated a number of interview questions. Ryan (2022) advised the researcher on how best to administer the Mathematics LifeStory Interview, included various

approached to avoiding a number of pitfalls and ensuring an effective approach to the interview process. Examples of these were not to give leading questions, to allow the participant to convey their mathematics life story even if the interview converged on different stages of their mathematics journey and to request the participant to send a sample timeline of their mathematics journey prior to the interview, this would help the participant to illicit memories from their mathematical past.

3.11 Ethical Considerations

The ethical considerations were paramount to the integrity of this research study where a number of ethical concerns were examined. According to Bryman et al (2012, p130), ethics “*bring us into a realm in which the role of values in the research process becomes a topic of concern*”. Cavan (1977, p.810) warns that ethical concerns are “*a matter of principled sensitivity to the rights of others*”. Furthermore, Bryman et al (2012, p.130), expanded on concerns where researchers should be consider how they treat people and what activities they engage as part of the research process. The various concerns and values that were considered by the researcher, were examined, having reflected on the ethical guidelines developed by the University of Limerick. The research was conducted in accordance with the University of Limerick’s ethical guidelines at all times where concerns such as ethics, how participants were treated and how the various research activities were explored. The research received ethics approval from the Education and Health Sciences Research Ethics Committee (2021_04_03_EHS (ER)).

There were ethical concerns that the researcher had to give serious consideration to, namely the potential of bias as participants were taught by the researcher within the VTOS programme. The researcher had to ensure that his position as a teacher within VTOS did not impact on bias through regular discussions with participants, who were also informed that the data would be stored securely and that they could not be identified as they would be given pseudonyms, thus ensuring anonymity. Another ethical consideration that was addressed, was to ensure that participation was completely voluntary. In addressing this, it was decided that the AISS (Activation Inclusion Support Service) officer would send a letter (see appendix 7) inviting learners to

participate where they were informed that participation was completely voluntary and that there would be no implications if they did not partake in the research study. Additionally, learners were informed that even on commencement of the research, they could still decide to withdraw at any stage and they were again advised that this decision would not incur any negative consequences. The researcher also ensured that all participants were comfortable throughout the process and they were offered tea/coffee/water before the interview commenced.

All information gathered is held in the strictest of confidence and pseudonyms were used to ensure anonymity. Mathematics Life Story Interview and Questionnaires were recorded and stored on a secure UL OneDrive folder. The data was held and destroyed after completion of the study in accordance with the UL data retention policy. Participation in the study was completely voluntary and participants could withdraw from the research at any time.

3.12 Limitations

The sample for the study was convenience sampling and it would have been preferable if the sample size was greater, particularly for the quantitative data. The MAS UK was presented in English and it would have been preferable if it were available in a number of languages as for some participants English was not their first language. The mathematics life story, for the most part, focuses on a learner's mathematical journey from the past, and perhaps, lacks a focus on the present. This level of scrutiny could have given a more critical perspective of contemporary teaching methods in Further Education and Training, albeit with a small sample size. There was also the issues of reliability, and it would have been preferable if the MAS UK test was taken twice in hindsight. The sample would have benefited if it had been extended to other sectors of FET including apprenticeships and colleges of further education. Lastly, given the small sample size and convenience sampling approach, it is not possible to generalise these findings more widely but they have highlighted the importance of given adequate attention to and consideration of student's mathematics life stories etc.

3.13 Summary

The purpose of this chapter was to create a research design suitable for the research study including the research questions. Creswell's framework of design was used as a compass in navigating through the various approaches in research design. This prompted the research to identify a philosophical worldview, strategies of inquiry, and research methods (Creswell, 2009).

The researcher identified pragmatism as the most appropriate philosophical worldview, mixed method as a strategy of inquiry, and finally both the MAS UK questionnaire and the Mathematics Life Story framework as the quantitative and qualitative research methods. Additionally, the analysis of how the data was provided including a systematic approach to a thematic analysis for the qualitative data. The reliability, validity and ethical considerations undertaken in the study have been outlined and explained. In the next chapter, the quantitative data will be examined.

Chapter 4 Results

4.0 Introduction

The purpose of this chapter will be to examine the results carried out through both the quantitative data and the qualitative data. The structure of this chapter will commence with research question 1, which will then be followed by research question 2 and finally research question 3.

4.1 Addressing Research Question 1: *What level of mathematics anxiety, if any, exist amongst a cohort of adult learners?*

The rationale for the MAS UK was to collect and analyse the quantitative data to explore the existence of mathematics anxiety and thus addressing research question 1. The MAS UK questionnaire was deemed most appropriate as a quantitative instrument as outlined in the Methodology Chapter 3. Learners were given MAS UK questionnaires following ethical approval from the University of Limerick and participants consent. The chapter will seek to provide a quantitative analysis of the attempting to address research question i.e. *What level of mathematics anxiety, if any, exist amongst a cohort of adult learners?.*

4.1.1 Data Mean, Median, Range and Standard Deviation

There were a total of 23 questions from the MAS UK Questionnaire, where learners their level of anxiety on a scale from 1 to 5 from 'not at all' to 'very much'. This would mean an individual score would range from a minimum of 23 to a maximum of 115. There was a total of 15 questionnaires completed and the mean was 52.33 with a standard deviation of 18.2. Ryan (2019) carried out a MAS UK questionnaire (n=107) on third level adult learners in an Irish university with a mean of 55.2, median 56.5 with a standard deviation of 18.19. This implies that there isn't a significant variation between adult learners' mathematics anxiety and FET learners' mathematics anxiety. It is important to note that these are quantitative findings and the sample size is much greater in Ryan's (2019) study.

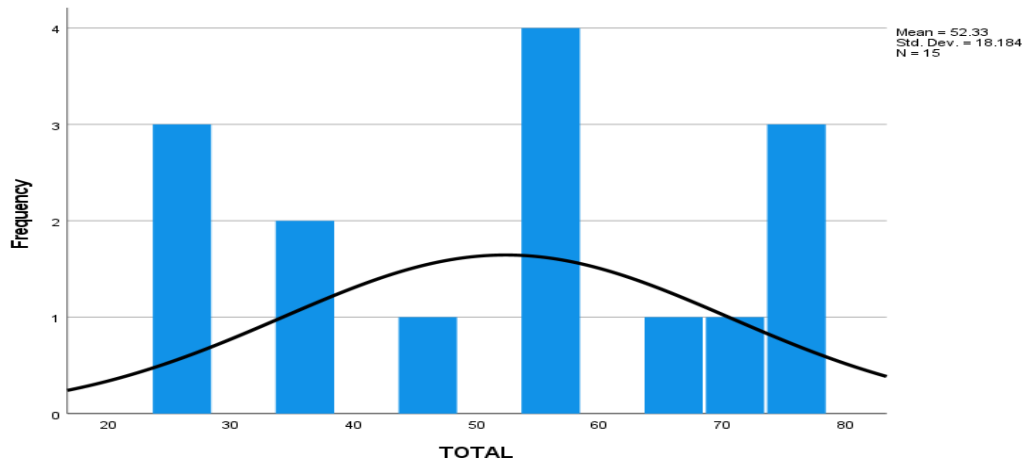


Table 4.1 Mean, Standard Deviation and Sample Size

The below charts illustrates a range between 26 and 76. Ryan and Fitzmaurice (2017) carried out a MAS UK test as part of a mixed method design, among the 107 respondents was from 23 to 94. This has a greater range but this could be due to a more significant sample size (n=107).

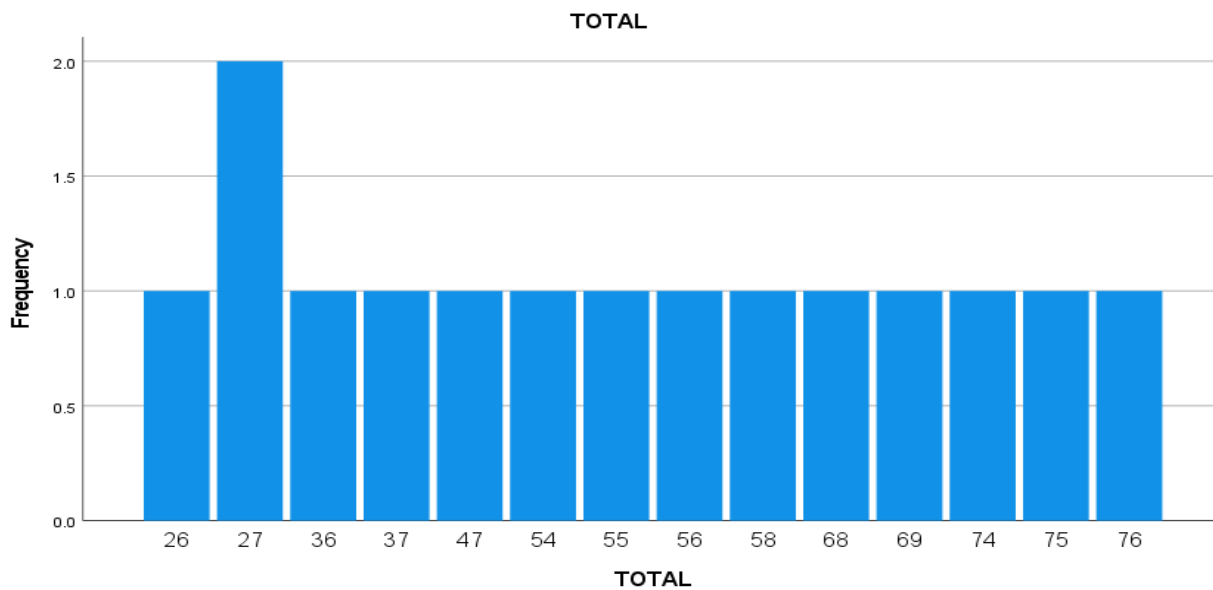


Table 4.2 MAS UK scores

4.1.2 Tests of Normality

Tests of normality were also carried out. Researchers recommend the Shapiro-Wilk test as the best choice for testing the normality of data (Thode, 2012) The Shapiro-Wilk test showed significance of $p = 0.121$, which suggests the data are normally distributed. A visual inspection of the histograms, normal Q-Q plots and box plots also confirm these results.

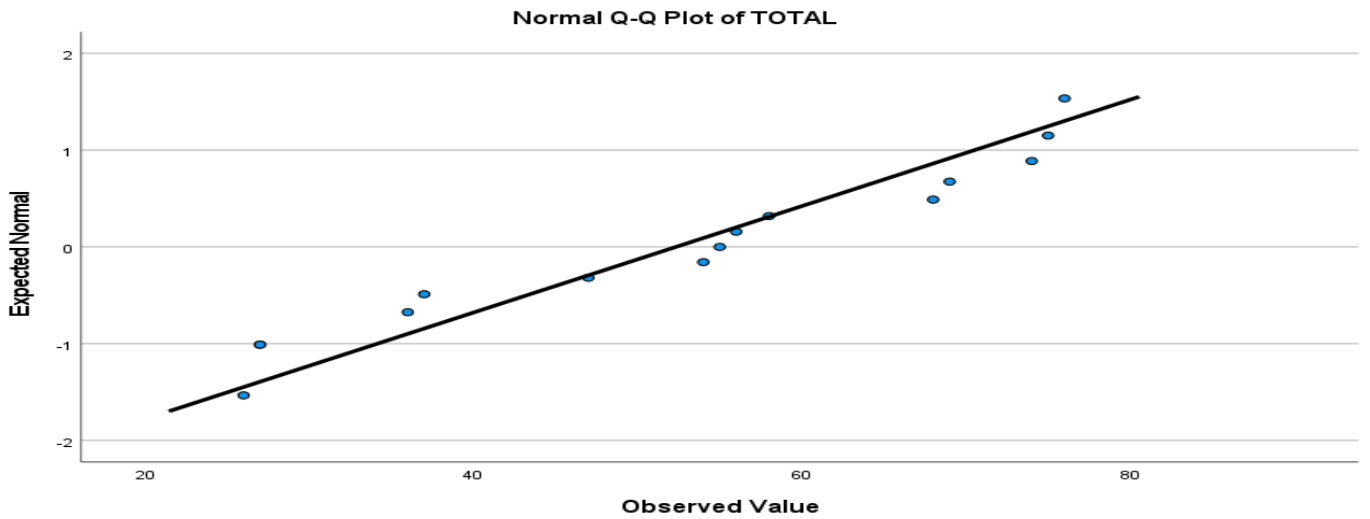


Table 4.3 Normal Q-Q Plot

Tests of Normality

	Kolmogorov-Smirnov ^a			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
TOTAL	.139	15	.200*	.907	15	.121

*. This is a lower bound of the true significance.

a. Lilliefors Significance Correction

Table 4.4 Tests of Normality

4.1.3 Mathematics Anxiety Factor Analysis

The purpose of this section will be to explore the three different factors that make up the 23 questions within the MAS UK Questionnaire. The three sections comprise of Factor 1 (Mathematics Evaluation Anxiety), Factor 2 (Social/Everyday Mathematics Anxiety), and Factor 3 (Mathematics Observation Anxiety) (Hunt et al, 2011). The following table of statements represent Factor 1(Mathematics Evaluation Anxiety)

Factor 1(Mathematics Evaluation Anxiety)

Statement No.	Statement
1	Having someone watch you multiply 12x23 on paper
3	Being asked to write an answer on the board at the front of a maths class
6	Taking a maths exam
7	Being asked to calculate €9.36 divided by 4 in front of several people

10	Calculating a series of multiplication problems on paper
18	Being given a surprise maths test in a class
19	Being asked to memorise a multiplication table
21	Being asked to calculate three fifths as a percentage
23	Being asked a maths question by a teacher/lecturer in front of a class

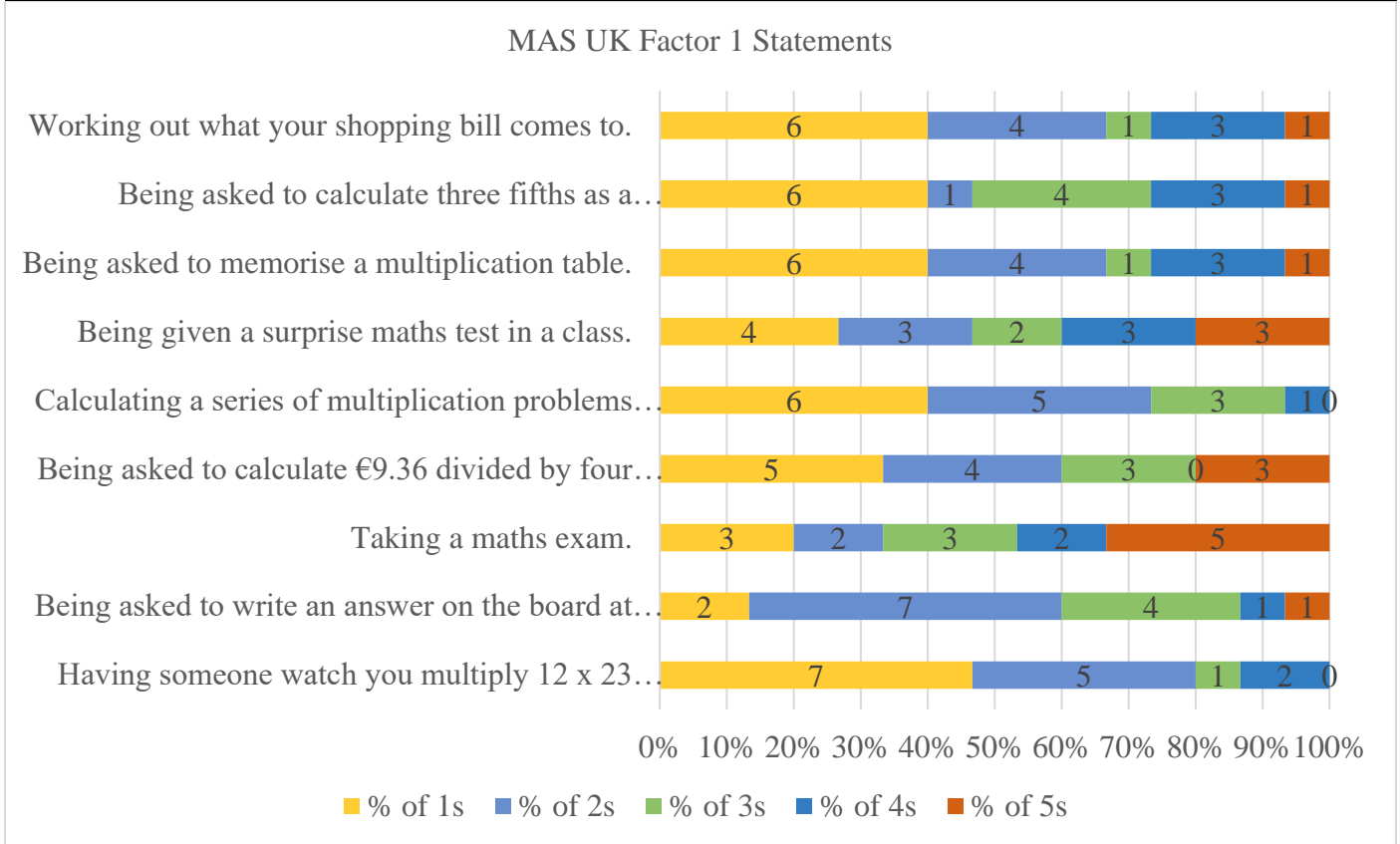


Table 4.5 MAS UK Factor 1 statements

The highest number of 5's was question 6, 7 and 8 with 'taking a maths exam' having a significant value of 33.33%. In terms of the 4's question 18, 19, 21 and 23 all had 20%. If the 4's and 5's are combined then question 6 is still the most prevalent with a 46.67% and question and question 18 'being given a surprise maths test in a class' was 40%.

Factor 2 (Everyday/ Social Mathematics Anxiety)

Everyday/ Social Mathematics Anxiety examines situations where a person is engaged in carrying out a calculation or any social context which involves the use of numbers (Hunt et al., 2011). The following table of statements represents Factor 2 (Everyday/ Social Mathematics Anxiety).

Statement No.	Statement
2	Adding up a pile of change
4	Being asked to add up the number of people in a room
5	Calculating how many days until a person's birthday
8	Being given a telephone number and having to remember it
11	Working out how much time you have left before you set off for work or place of study
13	Working out how much change a cashier should have given you in a shop after buying several items
14	Deciding how much each person should give you after you buy an object that you are all sharing the cost of
22	Working out how much your shopping bill comes to

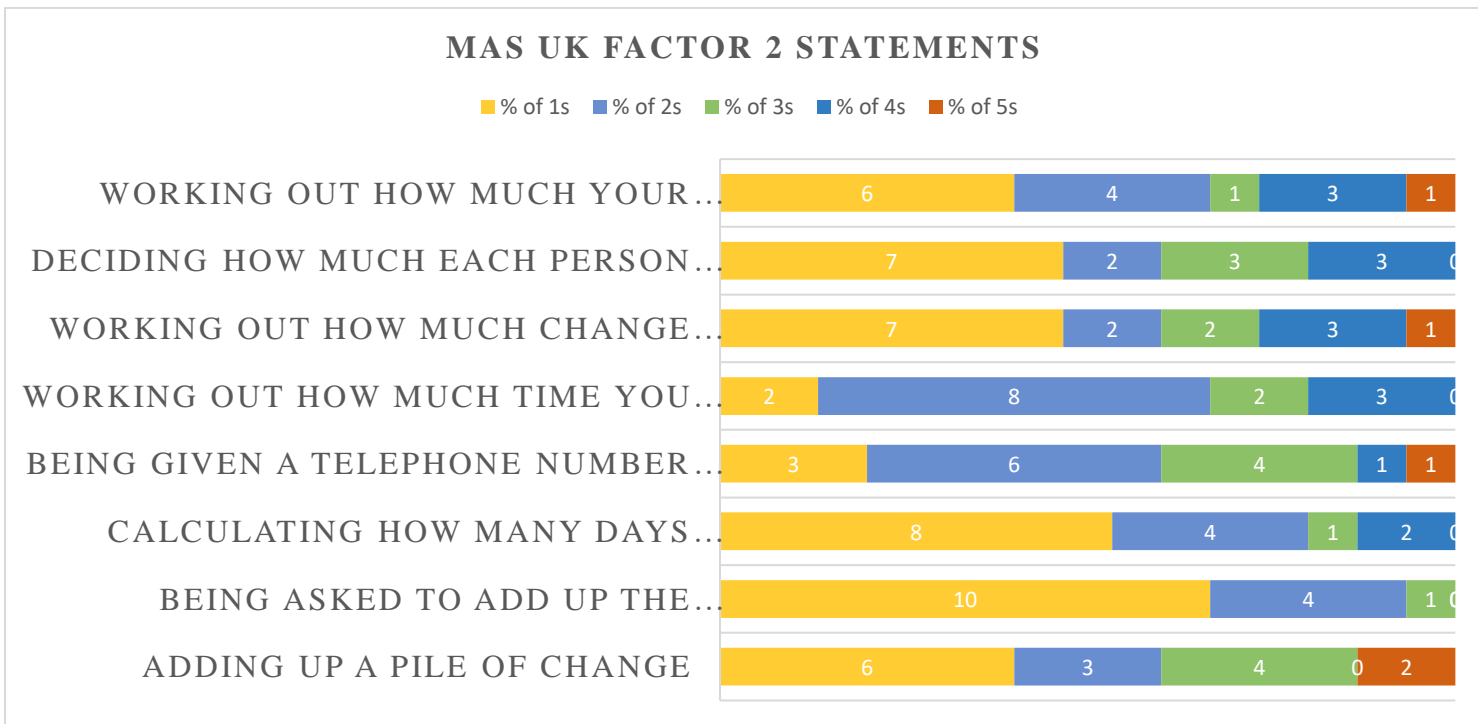


Table 4.6 MAS UK Factor 2 statements

The number of 5's in this data is relatively low compared to MAS UK Factor 1 statements. Question 2 'adding up a pile of change' has 13.33% whilst question 8,13 and 22 only has 6.67%. When adding the 4's and 5's, question 13 'Working out how much change a cashier should have given you in a shop after buying several items' and question 22 'Working out how much your shopping bill comes to' comes to a combined total of 26.67% each.

Factor 3(Mathematics Observation Anxiety)

Factor 3 explores Mathematics Observation Anxiety, this is where the person plays a passive role within the environment and they observe someone else that is immersed in the performance of mathematics (Hunt et al., 2011). The following table of statements represent Factor 3(Mathematics Observation Anxiety).

Statement No.	Statement
9	Reading the word ‘algebra’
12	Listening to someone talk about maths
15	Reading a maths textbook
16	Watching someone work out an algebra problem
17	Sitting in a maths class
20	Watching a teacher/lecturer write equations on the board

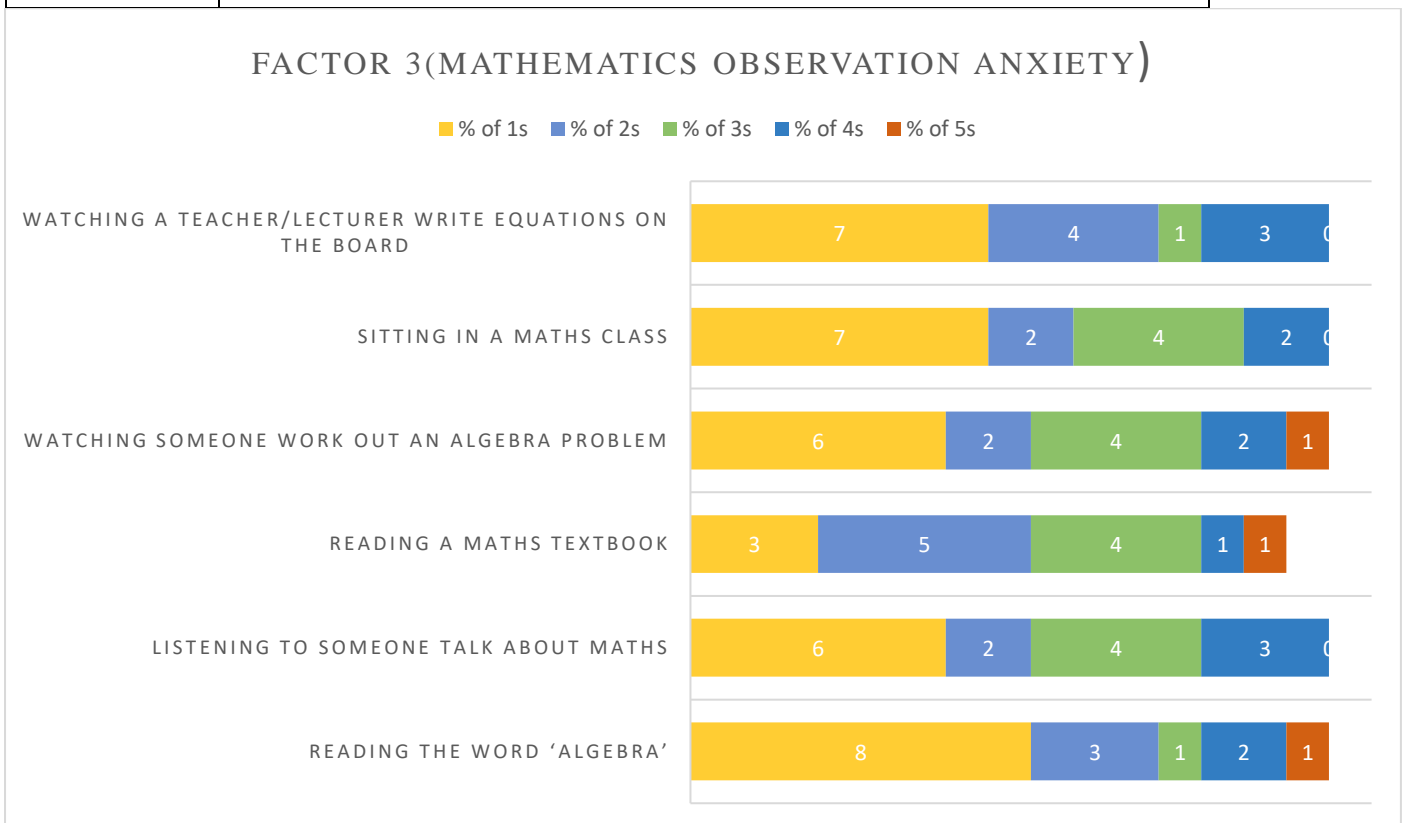


Table 4.7 Factor 3 Mathematics Observation Anxiety

To note one participant didn't answer question 15, therefore only 14 answers for 'reading a maths textbook'. The distribution of the above table shows a significant percentage of 1's indicating that Factor 3 produces the least mathematics anxiety. A total of 53.33% of participants felt that 'Reading the word algebra' produced no anxiety, if included with 1's and 2's then this would be a total of 73.33%. Additionally, 'Watching a teacher/lecturer write equations on the board' produced 73.33% from 1's and 2's, which also suggests that this does not provoke anxiety in learners. There was a very small distribution of 5's, even with 4's and 5's the largest percentage was 20%.

4.1.4 MAS UK Results Overview

The following table gives the results of the MAS UK questionnaire, which gives a snapshot of the levels of anxiety among the participants in the study who volunteered for the second phase of the research process i.e. the mathematics life story interview. It is important to highlight the issue with measuring Mathematics Anxiety before directly answer the first research question.

Name	Mas UK Score	Name	Mas UK Score
Stephen	26	Robert	56
Brendan	27	Thomas	58
Sarah	27	Stacy	75
Linda	36	David	54

Table 4.8 MAS UK scores

Results of large-scale studies shows that the distributions of Mathematics anxiety scores illustrate a normal distribution rather than a bimodal distribution (Cipora et al., 2015). Hunt (2022), the creator of the MAS-UK, recommended that when using the MAS UK that there should be *“no agreed cut-off for such categorization”*, furthermore *“data should be kept on a continuum where possible”*. Cipora et al., (2015) also advocates this approach when using all mathematics anxiety measurements and state that mathematics anxiety *“should be considered as a continuous, not a binary trait. One pole of this continuum would represent extreme anxiety*

towards math. While mathematics anxiety levels gets lower along this continuum, it still exists” (Cipora et al., 2019, p15).

4.1.5 Summary in addressing Research Question 1

The direct answer to the Research Question in the first instance is that mathematics anxiety does exist among a cohort of adult learners, to note, at the point of assessment there existed a variance in levels of mathematics anxiety across the cohort of participants with some holding higher levels of anxiety. The variances in levels of anxiety may be, in part, mediated by antecedent variables, which will be examined in the next section.

A significant amount of research in mathematics anxiety stems from a psychology background with a positivist worldview, where the aim of the research underpins scientific and quantitative outcomes. This is evident in a number of studies. For example, Arslan et al. (2015), found that 33 out of 40 research studies in mathematics anxiety meta-analysis were quantitative. Yanuarto (2016) argues that researching mathematics anxiety from a positivist perspective reducing mathematics anxiety to objective and measurable data which fails to acknowledge the complex nature of the construct. Indeed, Jameson (2010) argues that sources of Mathematics anxiety are complex and vary with each learner, whilst Wilder (2013, p15) states that “*students are experiencing significant levels of math anxiety or that they may not encompass all the aspects of what has proven to be a very complex, multidimensional construct*”. The complexity of the construct is also highlighted by Sloan (2010) who also argues that viewing mathematics anxiety, as a quantifiable measure is problematic as an attempt to understand and improve the research.

4.2 Addressing Research Question 2: To investigate what environmental antecedents contribute towards mathematics anxiety across an adult learner’s mathematics life story.

Qualitative data was required from the Mathematics Life Story interview in order to address both research question 2 and 3. The rationale, which underpins the Mathematics Life Story for the use of qualitative data, is that it ‘gives instructors insight into the background of their students’ (LoPresto & Drake, 2004: p. 268). This is important as it will help the researcher in addressing the research questions, which underpin this study.

Name	Mas UK	Background
Linda	36	Linda is between 30 – 39 years of age and is originally from Eastern Europe. Linda articulated many examples of mathematics anxiety in the interview even though this is not reflected in her MAS UK score. In past events, she experienced stress/anxiety due to Teachers who were anxious, conversely, she appears to relax and open her mind when the Teacher is also relaxed.
Brendan	27	Brendan is between 20 – 29 years of age and is from Ireland. As a young Irish student in his mid-20s, he expressed a very low level of mathematics anxiety as reflected in his MAS UK score. He stressed that he benefited from being in a school that had strong mathematics supports and also had support from his brother and private tuition.
Stephen	26	Stephen is between 50 – 59 years of age and is from Ireland. He returned to education and during the interview illustrated high levels of anxiety particularly towards examinations in mathematics, specifically the mathematics-leaving certificate state exam, even though he had a relatively low MAS UK test result.
David	54	David is between 20 – 29 years of age and is from South Asia. Initially, David had low confidence levels in maths but moved to Ireland and confidence grew due to lower societal expectations and the support of private tuition.
Thomas	58	Thomas is between 50 – 59 years of age and is from Central Asia. Thomas came from a family with low levels of education. He had moderate to high level of maths anxiety based on a score of 58 from his MAS UK questionnaire as well as displaying math anxiety in his mathematics life story interview. He also has a history of mathematics avoidance due to getting questions wrongs in front of peers and corporal punishment. He is very reflective on the importance of maths and he wants to be able to help his kids with their mathematics education.
Stacy	75	Stacy is between 20 – 29 years of age and is from Ireland. Stacy struggled in mainstream education due to a lack of support from both teachers and large classroom sizes. However, she regained her confidence in YouthReach. Stacy had very high levels of mathematics anxiety as reflected in MAS UK score.
Robert	56	Robert is between 20 – 29 years of age and is from Ireland. Robert expressed specific mathematics test anxiety with respect to examinations. Repeatedly refers to his anxiety towards the leaving cert examination and suggests that he had no support outside the classroom.
Sarah	27	Sarah is between 30 – 39 years of age and is from the middle east. She had varying degrees of mathematics anxiety throughout her education. Discipline had a negative impact on her engagement and confidence in maths. Sarah finds tests very stressful and prospers when teachers are flexible and promote an environment where learners can ask questions.

Table 4.9 Learner background with MAS UK score

Appendix (3) shows the question used in the interview and the table above gives a background to each learner. The following table provides a background to each student that agreed to volunteer and participate in each of the interviews. The names are pseudonyms provided to protect the identity of each participant, the MAS UK score is also given as well as a background on each learner.

As the focus of research questions 2 and 3 was on environmental antecedents, it was decided to present them as emerging themes from the thematic analysis. The framework for this was drawn from the Luttenberger, Wimmer and Paechter (2018) framework of mathematics anxiety and the findings from the mathematics life story interviews.

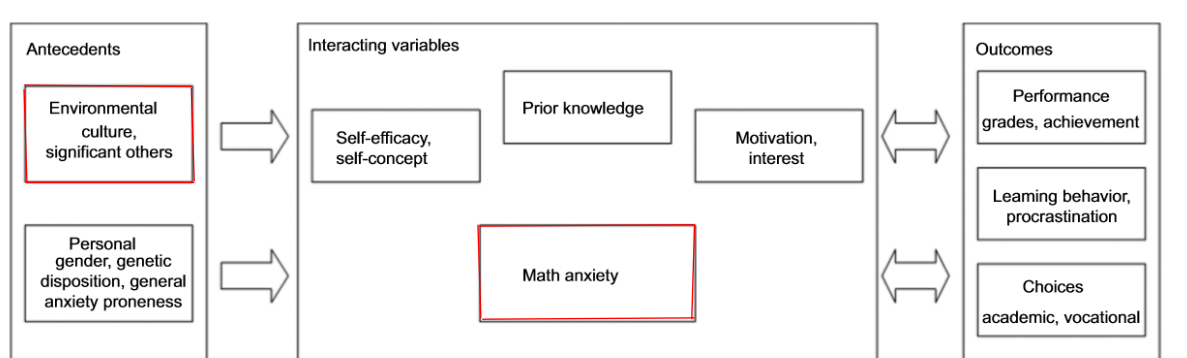


Figure 1 A framework for understanding math anxiety.

Source: (Luttenberger, Wimmer and Paechter, 2018, p.313)

4.2.1 Theme (1): Mathematics Test Anxiety

The Mathematics Test Anxiety derived from a combination of maths tests and various assessments including the state national examinations: the Junior Certificate and Leaving Certificate, as well as being asked to ‘go to the board’ in front of peers and reciting multiplications in front of the class. This theme was very prevalent and applied to the majority of participants with the exception of David and Brendan. The following section will go through leaving certificate, general test anxiety, address research question 2 and then the ‘outcomes’ addressing research question 3.

4.2.2 Theme (1): The Leaving Certificate

The Leaving Certificate presented mathematics test anxiety for both Robert, Sarah and Stephen. Stephen displayed high levels of anxiety and was already apprehensive about the exam even though it was not to take place for another 8 months, *“I’m still nervous about the Leaving Cert next year, that I might pass it or not. Or I go into the exam and it’s a completely different language to what I’ve been doing, you know? Yeah, I’m quite apprehensive actually to be honest”*. Robert suggested he has no anxiety towards maths but significantly, he only had anxiety towards the leaving certificate maths exam *“Maths in a general sense, doesn’t bother me, doing an exam is a different story”*. Later in the interview, Robert was asked if he had any anxiety towards maths in the future and he replied, *“Not really, if it’s not to do with the leaving cert grade in math then I wouldn’t have”*. When probed on this issue on why he gets this anxious in maths and no other subjects he stated, *“Not really because all the other tests are either down to opinion or personal knowledge kind of thing, mathematics you need to have the definitive answer to get the marks”*. He added that he was *“a little bit scared, cause I’ll be looking through the book...how the hell am I going to sit an exam trying to figure this out”*. The leaving certificate is a sixth year and final examination for post primary students, another state exam is the junior certificate which is given to third year post primary students.

4.2.3 Theme (1): The Junior Certificate

Stacy was asked how she felt going into exams and reflected on her experience in the Junior Certificate *“Oh, very, very anxious. And when I get nervous my stomach turns into a washing machine so I remember, I feel sick”*. Indeed, Lyons and Beilock (2012) found in a study that some students would experience physical pain because of the anticipation of math-related activities; similarly, Kelly et al (2015) stated that math anxiety can result in a learners to exhibit an *“upset stomach”* among other symptoms (Kelly, Rice, Wyatt, Ducking, & Denton, 2015, p. 174). The next example with Stephen is very interesting in terms of eliciting mathematics anxiety when reflecting on his ‘intermediate certificate examination’ which was the ‘old’ junior certificate. He drew on an experience when in third year and his usual teacher was out on sick leave, so his class were mixed with a ‘higher level’ class. Stephen referenced the other class and stated *“they were doing stuff in maths*

for the higher level mathematics intermediate certificate, the gulf was huge...that's when the fear kicked in".

The researcher observed Stephen's behaviour, as well as his reference of 'fear' and stated "*I'm watching you put your hands to your face, I can see that anxiety*".

Stephen replied "*Yeah, when you're 14, (and) you see the gulf, I just didn't know what he (teacher) was doing, and then of course my poor father. I think I came home and told him...then he brought me down to 'Grinds' (private tuition school) on a Saturday*".

Stephens seems to highlight the issues around his own self-efficacy compared to the higher level class, the sense of letting down his father, the reference to his fear and lastly his visual sense of anxiety when he put his face to his hand. Research has shown that a parent's belief about their child's capabilities in mathematics can have a significant impact on the learner's mathematical self-efficacy (Eden et al., 2013) whilst fear is associated with mathematics anxiety including classes, homework, and tests Hembree (1990) which can have a significant impact on learner's lack of motivation, the latter having a significant impact on Stephen throughout his mathematical journey. Of course, many learners who present themselves in Further Education and Training would have come from other countries and they too would have had similar experiences to our state examinations as was the case with Sarah.

4.2.4 Theme (1): Other Assessments (Assessments from other jurisdictions)

Sarah also had similar feelings towards an assessment in her own country and recalled, "*I can remember, the night of the final exam for that year, I couldn't sleep that night. I (was) sweating all night and in the morning, even if I know the question, I didn't answer that. I completely paralyzed my mind and my body in that day*".

This statement also resonates with the description of mathematics anxiety by Tobias and Weissbrod (1980) who describe it as the "*the panic, helplessness, paralysis and mental disorganization that arises among some people when they are required to solve a mathematical problem*" (p.65). Of course all mathematical problems do not just manifest in formal examinations and can present themselves in other ways.

David recalled a formal examination from another jurisdiction when he was between 7 and 10 years of age, before moving to Ireland which would have negative consequences had he got less than A's or B's *"It was a private school, a very prestigious school and they had a very high standard and you're expected to get A's and B's. You're not allowed to drop below and (if you did drop below) you would get kicked out of the school."*

4.2.5 Theme (1): Non-formal assessment

Even in the absence of formal assessment, Linda and Thomas were fearful of getting the answer wrong in front of her peers. Linda recalled that *"You were really stressed in front of the class and I was scared that I would be called to the board" ... "I was stressed because when you didn't give the right answer, then you felt like you were kind of stupid... I felt very bad and low"*.

Thomas, who was also from a different jurisdiction outside of Ireland shared a similar experience *"The Maths teacher used to make us stand and come on the board and Just solve the questions in that and I never liked it anyway and that's why I never learned it, so I always hated going down on the board and solving the questions because I knew that I was going to get it wrong and the whole class is going to laugh at me"*.

The significance of mathematics text anxiety cannot be underestimated as there is a significant negative correlation between test anxiety and performance, and that test anxiety manifests because of repeated poor performance (Reyes, 1984; Zan et al., 2006). The issues that arose prompted the researcher to further examine the MAS UK with a specific focus on mathematics test anxiety.

4.2.6 Theme (1): Further Analysis of MAS-UK

The MAS-UK questionnaire comprises of three different scale. Each scale has a different factor, which enables greater analysis of the quantitative data, the three factors are: Mathematics Evaluation Anxiety, Everyday/Social Mathematics anxiety, and Mathematics Observation Anxiety. Relevant to the overall emergent theme of Mathematics Text Anxiety is the 'Mathematics Evaluation Anxiety Factor 1'. This Factor explores

situations where the learner is involved in some form of assessment or being evaluated in a formal or non-formal basis (Hunt et al., 2011). Factor 1 has nine statements, as shown in the below table. Of these, statement 6 displayed interesting results regarding anxiety towards a formal maths exam.

Factor 1(Mathematics Evaluation Anxiety)

Statement No.	Statement
1	Having someone watch you multiply 12x23 on paper
3	Being asked to write an answer on the board at the front of a maths class
6	Taking a maths exam
7	Being asked to calculate €9.36 divided by 4 in front of several people
10	Calculating a series of multiplication problems on paper
18	Being given a surprise maths test in a class
19	Being asked to memorise a multiplication table
21	Being asked to calculate three fifths as a percentage
23	Being asked a maths question by a teacher/lecturer in front of a class

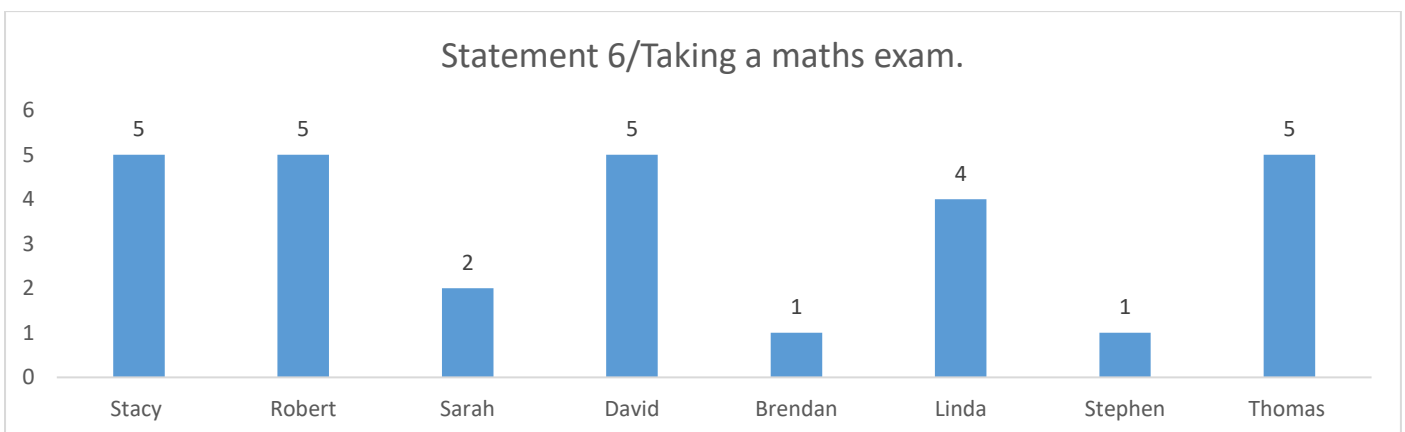


Table 4.10 Statement 6/Taking a maths exam

Closer inspection of the statement below illustrates the significant of mathematics test anxiety where question which prompts the most ‘very much’ is ‘taking a maths exam’ (50%) followed by the second most prevalent

which was 'being given a surprise maths test in a class'. What is even more interesting is that Brendan who reported that he was very anxious regarding the leaving certificate, only scored a '1' indicating that he is not anxious. However, the qualitative data would suggest otherwise.

4.2.7 Theme (1): Summary of Maths Test Anxiety

There was ample evidence of mathematics test anxiety amongst participants in the study. These include both formal and non-formal assessments. Formal assessments including state examinations, with the leaving certificate featuring prominently with learners. Analysis of the MAS UK showed that 50% of participants were 'very anxious' when 'taking a maths exam'. Another theme that was evident within the thematic analysis was the influence of teachers and this was examined in terms of research question 2.

4.3 Theme (2): Influence of Teachers

In terms of the influence of the teacher, there were a number of issues that were raised by the participants. These include impact of traditional teaching methods, anger & embarrassment and punishment from the teacher. It also important to note that there is a crossover between the theme of mathematics test anxiety and the influence for the teacher, for example the teacher can decide on the use of assessment in the class as well as the consequences. Research shows that where punishment is inflicted by the teacher, particularly after failure, evidence has shown a positive correlation with anxiety (Frenzel, Pekrun & Goetz, 2007).

Within Further Education and Training, the age of students can vary greatly as well as their country of origin. Despite this, most learners reported negative experiences with Teachers with the exception of Brendan. Brendan reported positive learning experiences with Teachers and showed very low levels of mathematics anxiety. Brendan stated that he "*started doing maths in primary and the teachers are always very friendly and I have nothing bad to say about my experiences when doing maths in primary school*". The student-teacher interaction has been recognised as a contributing factor to a learner's mathematics anxiety (Ashcraft & Krause, 2007; Dreger & Aiken, 1961; Wigfield & Meece, 1988). The following section will explore the subthemes of traditional teaching methods, anger/correctness and punishment, that all contributed towards a learner's mathematics anxiety.

4.3.1 Theme (2): Traditional Teaching Methods

A number of participants including Linda, Sarah, Stephen, Robert and David raised the issue of traditional teaching. This is important as there is ample evidence which suggests that traditional teaching methods can lead to negative learning experiences including mathematics anxiety (Lavasani and Khandan, 2011). Traditional teaching according to Deliktaş & Stojkovska, (2019) is globally defined as a teacher-centred approach to teaching where the emphasis is on the instruction of information and the learners are receivers of information.

These negative learning experiences can be as a result of didactic and strict teaching practice which doesn't promote questioning, conceptual learning or active learning as was the case with Linda.

Linda had negative feelings towards mathematics due to the traditional learning methods, *"I think mostly it was just teacher sitting by the desk or standing by the board. Explaining and writing and we didn't really had that kind of classes that we could measure something or like in like Maths 'In practice' it was very low in my life"*.

Robert felt that how mathematics was taught didn't relate to the outside world *"I really didn't like it cause it didn't teach anything about the outside world. It was only as I learned before that Maths in school was only useful if you wanted to become a teacher afterwards"*.

Stephen shared didactic experiences to learning where questioning was not tolerated, *"No, he (The Teacher) just went to the board and he just said opened up page 55 yeah. Stephen then asked the Teacher to explain and he was met with aggression "You know he come down to me and then he 'grabbed me'"*. David also shared the issue of questioning, *"Sometimes the teacher would be like come on I'm not going to answer this, you know it says. Come on, you know you're in higher level"*.

There has been a growing demand to change traditional teaching methods to more contemporary approaches, despite this; the former is still commonly used (Earle & Rickard, 2018; Geist, 2010; Geist & King, 2008). Many researchers advocate that traditional teaching methods do not work for Adult Learners who have had

negative experiences in maths (Klinger, 2011, Mutodi, 2014, Delikta and Stojkowska, 2019). Moreover, the incorrect teaching approach can result in mathematics anxiety for learners (Wilbert, 2008 Ashcraft, 2002; Hellum, 2010). Mutodi (2014) claims that the best way to reduce mathematics anxiety is to include less lecture, student directed classes and more collaboration. Another issue with traditional teaching methods, is when Teacher react angrily towards learners as was the case when Stephen was physically grabbed and told '*there's no questions here*'.

4.3.2 Theme (2): Anger

Stephen's experiences with his angry Teacher certainly resonated with Jackson & Leffingwell (1999) who warned that adults developed mathematics anxiety when a teacher reacted angrily with them as they asked for help when they were struggling with mathematics. Sian Beilock and her colleagues have studied people's brains through MRI imaging and found that 'math facts' are held in the working memory section of the brain. But when students are stressed, such as when they are taking math questions under time pressure, the working memory becomes blocked and students cannot access math facts they know (Beilock, 2011; Ramirez, et al, 2013).

This was evident for Linda who was stressed and her working memory appeared to be hampered "*I felt that my head was much more open and relaxed. You know I didn't, I wasn't closing my mind just you know just to survive the lesson the hour I was really kind of listening to the teacher and being involved in everything and I so I'm fully committed and able to do this*".

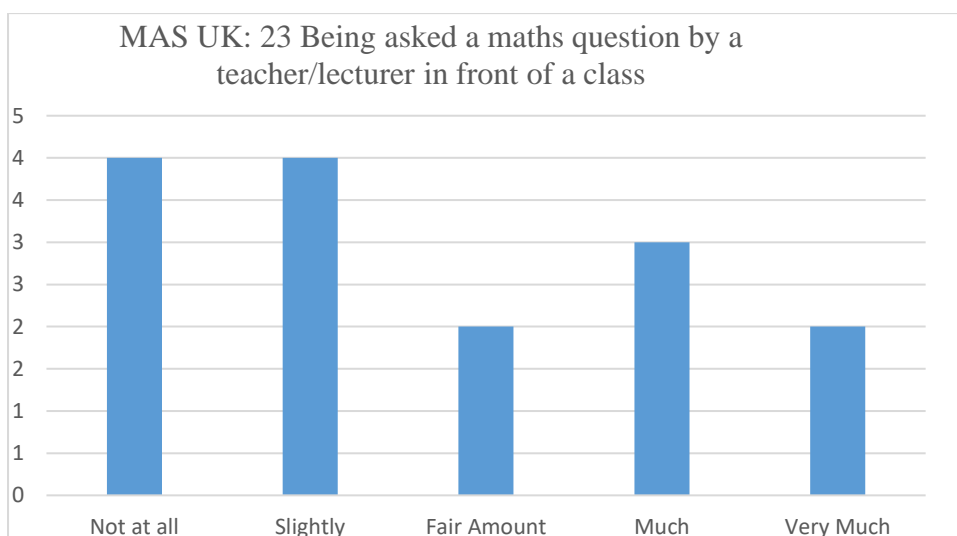
Embarrassment in many cases can be the outcome to an angry teacher or been questioned in front of a learners peers. The following section will give embarrassing situations in terms of mathematics for the learners.

4.3.3 Theme (2): Embarrassment

David "*In (anonymous country)...the teacher, will humiliate you know! I mean, if you have a bad grade, teacher will call out the grade in the front of the whole class if you get something wrong. Or something they make you they don't like it, they just go may say OK, go stand facing the wall with your hands up.*

Stacy shared a similar experience “Kids at that age are kind of ruthless...they were kind of laughing and smirking”. Thomas also feared embarrassed from his peers “I always hated going down on the board and solving out the questions because I knew that I was going to get it wrong and the whole class is going to laugh at me so”.

Indeed, 33.33% described either being anxious or very anxious when being asked a maths question by the teacher in front of the rest of the class indicating that it was a significant factor in mathematics anxiety for participants.



Linda also a sense of embarrassment in front of her peers also shared similar feelings “You were really stressed in front of the class and I was scared that I would be called to the board... I was stressed because when you didn’t give the right answer, then you felt like you were kind of stupid”.

Whilst some of the previous statements didn’t explicitly suggest that the learners induced mathematics anxiety as a consequence, the latter statement by Linda certainly did. She referenced ‘stressed’ twice and the term ‘scared’ from being embarrassed in front of her class mates.

Cemen’s (1987) Model of a Mathematics Anxiety Reaction outlines a number of environmental antecedents to mathematics anxiety including ‘embarrassment and feeling stupid’. Ashcraft (2002) reports that public embarrassment in math class contributed to learner’s mathematics anxiety. Not only can it lead to mathematics anxiety, but it can also mean that the learner is discouraged from engaging in questioning or asking for help

(Ashcraft & Krause, 2007; Fiore, 1999). Embarrassment can induce mathematics anxiety; however, a more severe consequence is that of corporal punishment which also comes under the Teacher Influence Theme.

4.3.4 Theme (2): Punishment

As well as embarrassment, there is also the issue of correctness which can induce mathematics anxiety in learners (Chinn, 2017; Turner, Midgley, Meyer, Gheen, Anderman, Kang & Patrick, 2002). The issue of corporal punishment is significant, as it can have severe consequences for learners. It can manifest itself into mathematics anxiety, mathematics avoidance and poor performance all of which are very relevant to this study.

Thomas who stated, *“In Afghanistan it is different because in the morning the teacher used to come and the mosque there was a few trees there is so. He's used to cut a big stick from one of the trees...end of the day stick (it) would have been to 20 pieces”*.

This was also the case in Ireland where Stephen also learned off his maths tables in fear of being beaten *“It was because I used to watch the others getting sort of beaten for not knowing them so I always was able to sing off the tables”*. There was further evidence when Stephen explained why he performed well in maths at an early age *“I was a very studious student and there was an element of anxiety because of course it was a big stick, you know and so I was quite nervous in CBS”*.

This was also the case in Ireland where Stephen also learned off his maths tables in fear of being beaten *“It was because of the I used to watch the others getting sort of beaten for not knowing them so I always was able to sing off the tables”*. As Thomas warns *“they used to like proper beaten up every children students. So there was this kind of scared from teachers from getting it wrong”*.

Research shows that where punishment is inflicted by the teacher, particularly after failure, evidence has shown a positive correlation with anxiety (Frenzel, Pekrun & Goetz, 2007). Moreover, it is recognised that being insensitive towards learners (Allen, 2016; Boaler, 2010), and instilling fear and dread (Ho et al., 2000)

will increase mathematics anxiety. As well as the influence of the teacher, there was also the influence of the parent that surfaced as an emerging theme.

4.3.5 Summary of Influence of Teacher

Research question 2 examined how the influence of the Teacher can contribute towards a learner mathematics anxiety. Whilst many learners advocated their dislike towards traditional teaching methods, it is inconclusive if this leads to mathematics anxiety. There is however, some evidence that punishment leads to mathematics anxiety, for example, Stephen had a distinct fear of getting questions wrong in mathematics for fear of being beaten. Likewise, embarrassment can cause some degree of mathematics anxiety as was the case with Linda who elicited feelings of anxiety and fear. The influence of parents was also another theme that was evident within the thematic analysis.

4.4 Themes (3): Influence of Parents

The influence of parents was significant and for Robert, Stacy, Linda, Thomas all had negatives influences from their Parents in terms of support. What is particularly striking about this theme was that none of the participants got help from their parents! The reasons for this was the parents were either too busy or that they had such a low level of education that they were unable to help them.

4.4.1 Lack of Parental Support

Linda, Stacy, Robert, Thomas and Brendan did not get any help from her parents in terms of mathematics support, which would be concerning for any learner. Thomas's parents has passed away at a young age whilst Stacys' father had dropped out of school from a young age and was unable to help her with her schoolwork, particularly in mathematics. Interestingly, Stacy found great pride when she was later able to help her brother with his schoolwork. In addition, Thomas used helping his kids with their mathematics homework as a motivating factor in progressing with mathematics as did Stacy with her (future) family.

4.4.2 Parental Pressure

Stephen has high expectations from his father *“My father's influence in terms of what he kind of worked as a clerk in in ranks and he worked with accountants. And that and I think he had visions of me being an accountant”*. Stephen would later recall that he went into a higher-level class and that there was a significant gulf in ability and he perhaps left down his Dad when he told him, *“You're 14, yeah, you see the ‘gulf’, I just didn't know what he (Teacher) was doing, you know? Then of course, my ‘poor father’*. Sarah is very complimentary of her parents who were both Teachers and makes a specific reference to them never putting pressure on her to achieve high grades *“They didn't pressure me about the grades. Even if the society was completely, you know, addicted to their grades, but my parents, even they are teachers”*. Sarah received a very low level of mathematics anxiety (27). Conversely, David felt pressure from his parents and that moving to Ireland from India *“my parents always tell me look everything is easier in Ireland. Why are you performing so bad you know, like even when I'd achieve a good grade, it's like oh come on, it's Ireland you should be getting full straight As”*.

4.4.3 Summary in addressing Research Question 2

The purpose of research question 2 was to investigate what environmental antecedents contribute towards mathematics anxiety across an adult learner's mathematics life story. In terms of mathematics text anxiety as an environmental antecedents, there is sufficient evidence to suggest in the data that it does contribute towards a learner's mathematics anxiety. The quantitative data showed that 50% of learners felt ‘very anxious’ and 12.5% feeling ‘anxious’ in taking an exam. The leaving certificate had a significant impact on learners who came through the Irish education system. Some of the language to describe the thoughts of the leaving certificate exam were: ‘nervous’, ‘apprehensive’, ‘scared’, ‘very very anxious’ and even feeling physically sick.

Another antecedent that was examined was the influence of the teacher. Some learners had a distinct anxiety of getting questions wrong in mathematics for fear of being beaten. Likewise, embarrassment can cause some degree of mathematics anxiety, as was the case with Linda who elicited feelings of anxiety and fear. Therefore,

it is reasonable to say that the influence of the teacher does contribute towards mathematics anxiety across an adult learners' mathematics life story. The last theme that was examined was the influence of the parent.

The data showed that a significant amount of learners experienced a lack of support from parents, however, there appears to be little to no evidence that it resulted in learners' mathematics anxiety. According to Geist (2010), a lack of support from parents in terms of education and mathematics can lead to the development of mathematics anxiety. Moreover, there is some research to suggest that mathematics anxiety can be stemmed from the learner's parents (Gresham, 2018), particularly mother and daughter (Casad, Hale & Wachs, 2015). Indeed gender is a significant factor of mathematics anxiety where females have a greater propensity to mathematics anxiety (Ashcraft & Faust, 1994; Baloglu & Kocak, 2006; Betz, 1978; Hembree, 1990.), however it was not explored as it was a personal antecedent and not an environmental antecedent which was the focus of the research question. This prompted the researcher to examine what environmental antecedents were silent or missing from the data. Given the nature of the adult learner, the environmental factor of parents were historic and not current. There is also a lack of literature exploring a learner's children as an environmental factor, for example, many of the participants elicited helping their kids and siblings with their homework as a motivational factors in mathematics attainment. Perhaps these attainments could enhance the learner's social capital by devolving educational 'networks' as referenced by Bourdieu (1997). Lastly, mathematical support outside of teachers/classes did not feature, this was significant given the nature of the adult learning returning to education.

4.5 Addressing Research Question 3 *What impact, if any, do environmental antecedents have on students' experiences of mathematics?*

The purpose of research question was to examine what impact did any of the emerging themes have on students' experiences of mathematics? Research question 3 section focuses on the consequences of the environmental antecedents derived from the findings of research question 2. It may also be useful to show the framework of understanding mathematics anxiety for the purpose of outcomes, to note Luttenberger, Wimmer

and Paechter (2018, p313) state that the outcomes in the framework are the ‘most important’. The first consequence to be examined is learner’s mathematics avoidance and learner’s mathematics performance.

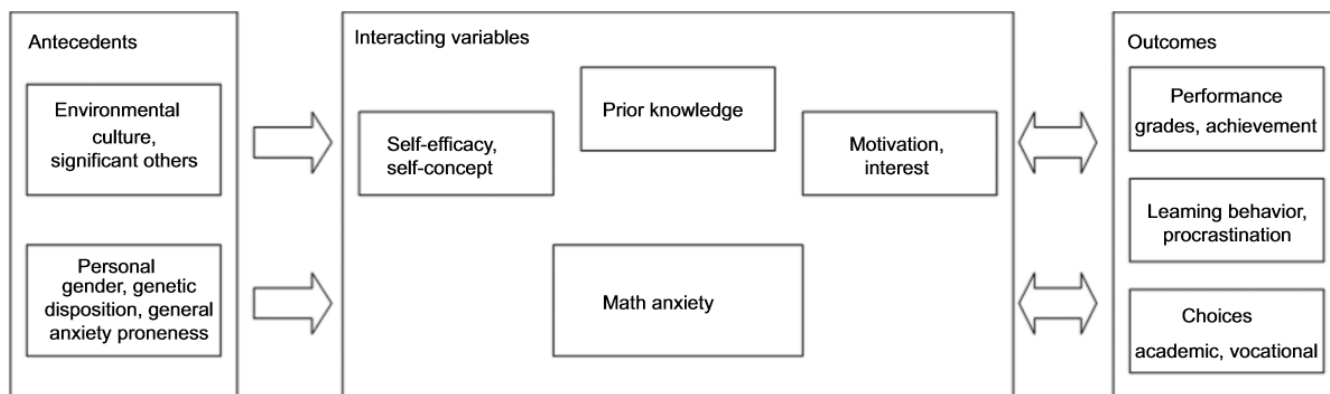


Figure 1 A framework for understanding math anxiety.

4.5.1 Performance, grades, achievement

Linda explained that she developed mathematics anxiety in secondary school as a consequence of inadequate teaching methods and a lack of support, this had a negative impact on her performance and she passed state examinations with the exception of mathematics. Indeed, failing mathematics was a motivation factor in her decision to return to education, she reported that she had significantly improved in her performance due to the support she is given in VTOS. Stephen is currently having issues with his mathematics performance as he still has mathematics anxiety and stated that “*I'm kind of struggling with it, you know that that's why I feel, I have to attend every class because of that nervousness that I might fall behind*”. There is no question of the relationship between mathematics anxiety and performance. For example, Hembree (1990) used a sample of 151 studies of primary and secondary school students and found that mathematics anxiety was negatively associated with mathematical performance. Brendan on the other hand who showed the lowest levels of mathematics anxiety excelled in his mathematical performance and he also benefited from private tuition, support from his brother and a very friendly environment in both his primary and secondary school. The previous examples shows how mathematics anxiety has an impact on performance and grades, as was the case with David who also had low confidence in mathematics.

David reported that *“math's always been one of the hardest subjects for me, so my confidence was very low in doing maths... it made me feel anxious and I would always get many things wrong in maths”*.

Stacy was another learner who resorted to mathematics avoidance and she claimed missed 60% of the school year, she stated that you *“don't get help from anybody in there, so it's like why should I go if I'm screwed. We left last stranded anywhere and in this thing of those will help me in the real world and like so why you want to go to school then”*.

Stacy complained of teachers not helping her with mathematics which led to her avoidance of the subject, poor performance and ultimately leaving mainstream education.

4.5.2 Learning Behaviour including procrastination

In terms of procrastination, there was a number of examples where learner would put off engaging in mathematics. Jenifer et al (2022) hypothesized high-stakes mathematics exams would result in avoidance of mathematics and as a consequence and lower performance. This is very interesting, as Stephen conveyed his fear of high stake mathematics exams i.e. ‘the leaving certificate’ and was worried he wouldn’t pass the exam *“Yeah, of opening up past...Those math papers, you'll get hurt”*, Stephen would then convey his avoidance of the subject and referred to himself as ‘Scrooge’ in terms of the time he would give mathematics compared to other subjects. There was also significant examples of learning behaviour including physical implications for mathematics anxiety.

Stacy was asked how she felt going into exams and warned *“Oh, very, very anxious. And when I get nervous my stomach turns into a washing machine so I remember, I feel sick”*. Lyons and Beilock (2012) found in a study that some students would experience physical pain because of the anticipation of math-related activities; similarly, Kelly et al (2015) stated that math anxiety can result in a learner to exhibit an *“upset stomach”* among other symptoms (Kelly, Rice, Wyatt, Ducking, & Denton, 2015, p.174). Sarah also had similar feelings towards as assessment; she recalled, *“I can remember, the night of the final exam for that year, I couldn't sleep that night. I (was) sweating all night and in the morning, even if I know the question, I didn't answer that. I completely paralyzed my mind and my body in that day”*. This statement also resonates with the description

of math anxiety by Tobias and Weissbrod (1980) who describe it as the “*the panic, helplessness, paralysis and mental disorganization that arises among some people when they are required to solve a mathematical problem*” (p. 65). Physical implications are a serious consequence of mathematics test anxiety, but there are non-physical implications such as embarrassment.

Stacy experienced embarrassment in the form of her peers and she had a negative experience “*Kids at that age are kind of ruthless...they were kind of laughing and smirking*”.

Linda also shared a similar experience of embarrassment in front of her class, “*You were really stressed in front of the class and I was scared that I would be called to the board... I was stressed because when you didn't give the right answer, then you felt like you were kind of stupid*”.

Thomas also feared embarrassment from his peers “*I always hated going down on the board and solving out the questions because I knew that I was going to get it wrong and the whole class is going to laugh at me so*”.

Cemen's (1987) Model of a Mathematics Anxiety Reaction outlines a number of environmental antecedents to mathematics anxiety including ‘embarrassment and feeling stupid’. Ashcraft (2002) reports that public embarrassment in math class contributed to learner's mathematics anxiety. Not only can it lead to mathematics anxiety, but it can also mean that the learner is discouraged from engaging in questioning or asking for help (Ashcraft & Krause, 2007; Fiore, 1999).

4.5.3 Academic and vocational choices

There is significant research which supports the hypothesis that avoiding mathematics can result in a restriction of career choices and vocational opportunities (Ashcraft & Krause, 2007; Betz, 1978; Hopko et al., 2003; Wilder, 2013). This statement is evident in Thomas's case “*I could have got into maths in England and then go get further education and that because of the maths I was just left out*”. He confirms his position of avoidance at the end of his interview “*But yes it's like water and fire me and maths were like, yeah, you see, we're far away from each*”. Linda, through the support in VTOS suggested that her mathematics anxiety decreased from the support she received and was unsure if she would continue studying mathematics in the future “*I've proven to myself that I can do it (mathematics) and it's no problem for me so I can keep the anxiety*”

in the past completely, but I'm still not sure if I if maths is something I can go further with". To note, Linda would later get accepted into a University where she would continue to study mathematics. Similarly Brendan would also go to study at University with a number of mathematics modules.

Mathematics anxiety can be responsible for poor performance in mathematics and mathematics avoidance (Ashcraft & Moore, 2009, Dowker et al 2016). As a consequence of a lack of support in mathematics, subsequent avoidance and poor performance, Stacy decided to leave mainstream education and enrolled with YouthReach. She reported excellent support from the YouthReach programme, however, it is unknown what the implications were in terms of her decision to enter YouthReach and her previous mathematics avoidance. On reflection, it may have been prudent to question the participant on this decision, however, it could be argued that her mathematics avoidance resulted in her having to leave her school, which in itself is a significant implication for the avoidance of mathematics.

4.5.4 Summary in addressing Research Question 3

In considering the three different themes, it has been found that the outcomes of mathematics test anxiety can include both mathematics anxiety, physiological implications, embarrassment, avoidance and career limitations. To conclude, mathematics test anxiety particularly, has an overall negative experience on learners within this study. Some of the implications included negative performance and poor grades where one learner developed mathematics avoidance and chose to leave her post primary school, others developed varying levels of mathematics anxiety. Learning behaviour comprised of embarrassment, confidence, physical implications and procrastination. Learner's choices in terms of academic and vocational opportunities were determined by a number of factors including mathematics anxiety, mathematics avoidance and mathematics confidence.

Chapter 5 Discussion

5.0 Introduction

The purpose of this study is to explore mathematics anxiety amongst a group of adult learners and the potential associated environmental antecedents in a Further Education and Training setting. The research questions were as follows

1. What level of mathematics anxiety, if any, exist amongst a cohort of adult learners?
2. What, if any, environmental antecedents contribute towards mathematics anxiety in an adult learner's mathematics learning journey?
3. What impact, if any, do environmental antecedents have on students' experiences of mathematics?

Having addressed the three research questions in the previous chapter, it is evident that mathematics anxiety does exist, to varying degrees, among further education and training learners. The level of mathematics anxiety ranges from very low levels to high levels of mathematics anxiety.

5.1 The extent of mathematics anxiety among adult learners in a VTOS setting

As stated, it is evident that mathematics anxiety does exist, to varying degrees, amongst the further education and training learners in this study. The level of mathematics anxiety ranged from very low levels to high levels of mathematics anxiety. There was some issues with the quantitative data, which were explored in the next section, despite that the MAS UK questionnaire was the most suitable quantitative research instrument for the study. This study showed, that Further Education and Training did not differ to other sectors such as Higher Education, in terms of the extent of mathematics anxiety for adult learners. What was significant in this study, was the constant theme of mathematics test anxiety, which arose in both formal and non-formal assessment(s).

5.1.1 Administration of the MAS UK

The administration of the MAS UK was very user friendly and the factor analysis was very beneficial and enabled the researcher to identify mathematics test anxiety as a significant aspect of mathematics anxiety for learners within this study. Indeed 5 out of 15 learners were ‘very anxious’ when prompted to taking a maths exam and 2 were ‘anxious’. However, there was one notable inconsistency between the quantitative and qualitative data, for example, Brendan who reported that he was ‘very anxious’ regarding the leaving certificate in the mathematics life story framework interview, only scored a ‘1’ indicating that he is ‘not anxious’ in ‘taking a maths exam’ as part of one of the 23 questions in the MASK UK. There could be a number of reasons for this including an administrative error by this participant. However, Ryan (2019) also shared a similar experience, when she stated “*one student, Jon, had a MAS-UK score of 59, but his account of his anxieties towards mathematics suggested he was more anxious than what his score proposed ...similarly, Lynn’s and Kate’s MAS-UK scores of 57 and 61 respectively were not reflective of their accounts of negative experiences with mathematics in the interview*”. Ryan (2019) suggests that these findings question the validity of the MAS-UK test as a true measure of a learner’s mathematics anxiety. The findings, from this current study, also question the validity of the MAS UK instrument as an accurate measurement of mathematics anxiety.

5.1.2 Cut off point for mathematics anxiety

Attempts to examine the prevalence of mathematics anxiety in this study raised several issues as there is no agreed ‘cut off point’ in determining if a learner does or does not have mathematics anxiety (Cipora, 2021). Hunt (2022), recommends that when using the MAS UK that there should be “*no agreed cut-off for such categorization*”, and that “*data should be kept on a continuum where possible*”. There is certainly an argument for the advancement of a mathematics anxiety questionnaire where ‘an agreed cut off point’ was explicit, along with varying categorisations of mathematics anxiety and perhaps one created specifically for an Irish population. Cipora (2021) supports this and recommends that future research should focus on developing better diagnostic/cut-off criteria for mathematics anxiety diagnosis. It should be noted that this would not be

a straight forward process and that perhaps the use of self-reporting questionnaires for mathematics anxiety will never give an accurate prevalence of the construct.

5.1.3 Framework of Mathematics Anxiety

In terms of the framework of mathematics anxiety, the sources of mathematics anxiety among these learners can be drawn from a number antecedents including personal and environmental. However, for the purpose of this study, the focus was on environmental antecedents, which were derived from a thematic analysis that highlighted a number of significant themes. The model utilised for these themes was adopted from Luttenberger, Wimmer and Paechter (2018, p.313) who state that mathematics anxiety “should be regarded as one variable within an ensemble of environment related and person-related variables that interact together”. One limitation to the below model, is that it does not reference avoidance of mathematics explicitly which would be helpful, particularly in this study.

Learners with mathematics anxiety tend to exhibit mathematics avoidance and more frequently procrastination behaviour (Akinsola et al, 2007). Academic procrastination is where students postpone their engagement with academic tasks such as mathematics homework or preparation for examinations (Luttenberger et al, 2018). Hopper (2005) and Phillips (2000) reported that mathematics is often associated with pain and frustration and for this reason, many learners procrastinate in studying mathematics. Procrastination, therefore, has significant effects, setting off a vicious cycle where learners engage in mathematics avoidance, display poor mathematics performance in examinations, which in turn can lead to higher levels of mathematics anxiety (Hembree, 1990). It is important to note that mathematics avoidance can further exacerbate mathematics anxiety (Frenzel et al., 2007; Tobias, 1993), which could create a reciprocal effect, complicating the construct further.

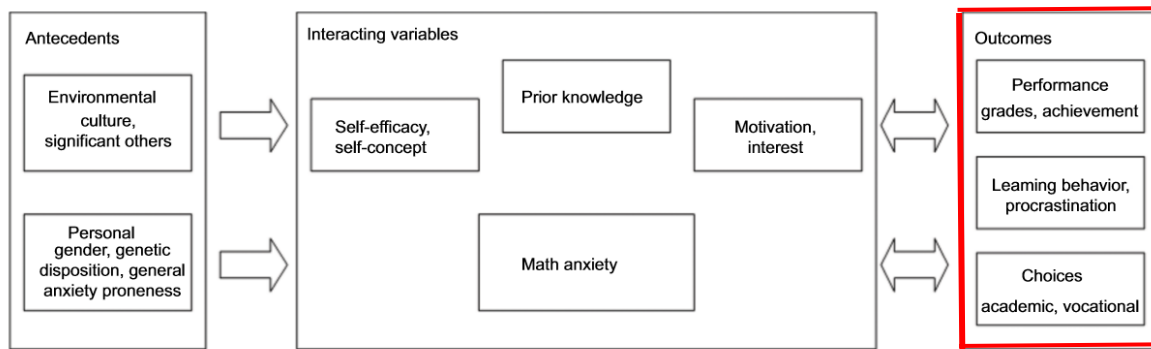


Figure 1 A framework for understanding math anxiety.

Luttenberger, Wimmer and Paechter (2018) with reference to the ‘framework for math anxiety’, suggest that the ‘most important’ outcomes are ‘mathematics anxiety & performance’, ‘mathematics anxiety, performance, and effects on working memory’, ‘Mathematics anxiety and learning behaviours, especially procrastination’ and mathematics anxiety and academic and vocational choices. The latter is pertinent as Luttenberger, Wimmer and Paechter (2018) cite a study by Chipman (1992) where female freshmen college students, investigated the relationship between mathematics anxiety and career interests crucial where mathematics anxiety was crucial when it came to exclusion from a career in science and engineering. It is well documented that mathematics avoidance can limit career options to learners, particularly in the areas of STEM (Hembree, 1990; Beilock & Maloney, 2015). Mathematics as a subject choice is compulsory for many learners particularly in primary and post primary school, however as adult’s progress to higher and further education, they may decide to avoid mathematics due to mathematics anxiety. The negative outcomes of mathematics anxiety can have career implications for learners (Hembree, 1990; Beilock & Maloney, 2015) and society (Li & Schoenfeld, 2019), therefore, it is important that it is explicit within outcomes of a framework of mathematics anxiety.

Another issue with the framework is that ‘age’ is also not explicitly stated. One of the issues with mathematics, is that difficulty with learning the subject can increase with age, and thus mathematics anxiety might also increase with age (Olmez and Ozel, 2012). The vast majority of research in mathematics anxiety suggests that attitudes towards mathematics deteriorates with age during childhood and adolescence years (Wigfield and Meece, 1988; Ma and Kishor, 1997; Dowker, 2005), which has negative consequences for mathematics

development, education and significantly adult engagement in mathematics (Dowker et al, 2016). Mata, Monterio and Peixoto (2012) argue that as age increases so does negative attitudes towards mathematics, and as a consequence, mathematics anxiety increases. This could pose the question, when does mathematics anxiety commence in terms of age. Ramirez et al (2016) contends that it can begin from as young as 6 years of age, this is significant given the nature of this research study. Vukovic et al. (2013) advocates that is paramount to intervene during the early stages of a learner’s mathematics learning journey. There is also a requirement to compare mathematics anxiety between mathematic anxious adult and children to better understand the construct (Krinzinger et al., 2009). It is important to consider age in terms of personal antecedent, however gender is also a contributing factor in terms of mathematics anxiety. The comparison of mathematic anxious between adults and children (Krinzinger et al, 2009) is important and furthermore when you consider the learning needs of adults, it raises an argument if there should be a modified framework for mathematic anxious children and adults (Knowles, 1980). A suggestion which could be explored, would be a framework, for children incorporating pedagogical teaching methods and a framework for adults incorporating andragogical teaching methods, see original framework and proposed framework below.

(Luttenberger, Wimmer and Paechter, 2018, p.313)

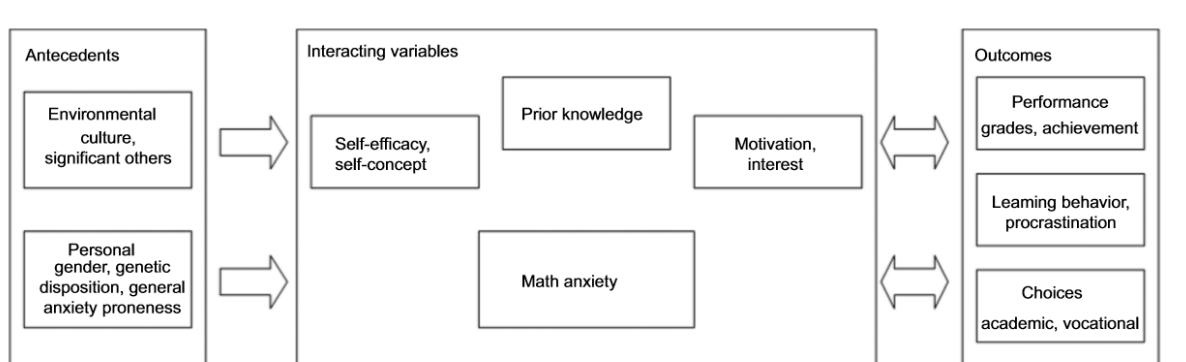
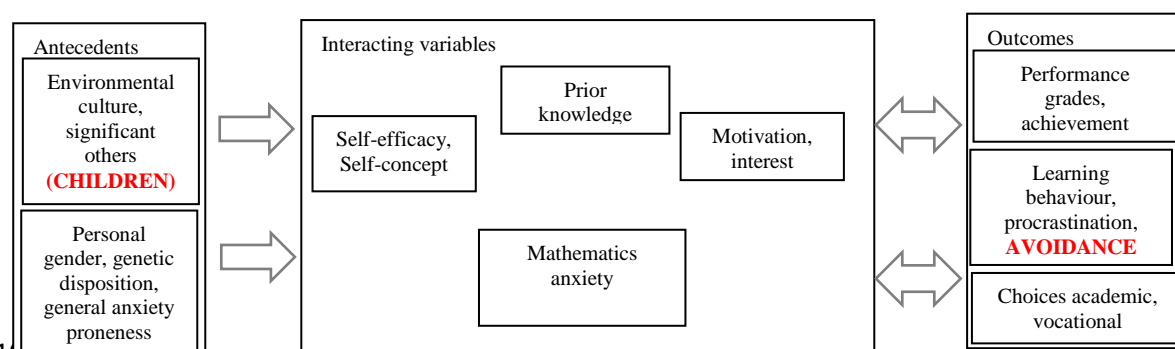


Figure 1 A framework for understanding math anxiety.



5.1.4 Role of Teachers

The role of the teachers in the study was very significant in terms of a learners experiences with mathematics, including mathematics anxiety. Indeed, Klinger (2011) highlight the challenge for all Teachers in Adult Education is to find an effective approach to address mathematics anxiety. However, there was a significant amount of FET learner's in this study who conveyed their dislike to traditional teaching methods, punishment, anger and embarrassment which will was discussed in further detail in the next section. The role of the teacher can be broad, Aiken (1976) identifies a number of sources that lead to mathematics anxiety including student-teacher interaction, syllabus, teaching methods and teaching resources. Within this theme, the dominant factor for learners in Further Education and Training, were teaching methods, anger, embarrassment and punishment.

5.1.5 Teaching Methods

The issue of teaching methods prompts further discussion. There is ample evidence that teaching methods in mathematics can result in mathematics anxiety for learners (Wilbert, 2008 Ashcraft, 2002; Hellum, 2010). Teachers of mathematics in FET need to be aware of these consequences and incorporate alternative approaches to teaching mathematics if mathematics anxiety is to be addressed. Within this study, it was found that teaching methods were a significant environmental antecedent for mathematics anxiety even with the varying ages of adult learners and the jurisdictions where learners were taught including the use of traditional teaching methods.

In terms of teaching methods, the dominant theme that emerged from the thematic analysis, was the use of traditional teaching methods and how this contributed towards learner's mathematics anxiety. It is well reported that traditional teaching methods do not work for adult learners who have had negative experiences in mathematics (Boaler, 2010; Haylock, 2018, Klinger, 2011, Mutodi, 2014, Delikta and Stojkovska, 2019). A number of participants including Linda, Sarah, Stephen, Robert and David raised the issue of traditional teaching. Traditional teaching methods in this study included didactic teaching, punishment, anger and embarrassment. Moreover, a move towards more student-centred, constructivist teaching methods holds the potential to mitigate against the advancement of mathematics anxiety in students

5.1.6 Teaching Methods: Punishment, Anger & Embarrassment

As early as primary school many learners recalled embarrassment and anxiety when been called to the board or having to going through their 'timetables'. This certainly resonates with Bekdemir (2010) who warned that negative experiences in mathematics from earlier stages of education can lead to negatives unpleasant attitudes toward mathematics during a learner's educational journey. This was something which was prevalent across a number of participants, which in many cases led to mathematics avoidance. Ashcraft (2002) reports that public embarrassment in mathematics class contributed to learner's mathematics anxiety. Shields (2005), supports this concern and references unrealistic expectations, intimidation, and insensitive. Embarrassment in front of peers can lead to mathematics anxiety for learners. Moreover, Turner et al (2007, p.101), also suggested that students with teachers who demand correctness may feel "*vulnerable to public displays of incompetence*". Linda's experience of embarrassment supports this statement when she recalls her experience of having to go to the boards in mathematics class and states "*she (the teacher) wanted you give the answer quickly. You were really stressed in front of the class*". Stacy also shared a similar experience when being asked to recite multiplication tables in front of the class and which she displays feelings such as embarrassment and anxiety, particularly in front of her peers "*Kids at that age are kind of ruthless, they were kind of laughing and smirking because I think at that age I should have known them*". The evidence in this study as well as others clearly shows that Teachers need to be aware of how learners are assessed in front of their peers, as it can lead to such negatives unpleasant attitudes in mathematics including anxiety and embarrassment.

Stacy, Linda and Thomas experienced embarrassment in from of her peers, which had a negative impact on their self-esteem. Cemen's (1987) Model of a Mathematics Anxiety Reaction outlines a number of environmental antecedents to mathematics anxiety including 'embarrassment and feeling stupid', whilst Ashcraft (2002) reports that public embarrassment in mathematics class contributed to learner's mathematics anxiety. Not only can it lead to mathematics anxiety, but it can also mean that the learner is discouraged from engaging in questioning or asking for help (Ashcraft & Krause, 2007; Fiore, 1999). Another example of traditional teaching is the use of corporal punishment.

The use of corporal punishment, particularly after failure has shown to have a positive relationship with mathematic anxiety (Frenzel, 22 Pekrun & Goetz, 2007). The use of corporal punishment is not unique within this study, indeed Ryan (2019, p.190) interviewed 'Jon', a learner in higher education who stated, "If you got the slightest thing wrong, you got beat, and one teacher would slap you across the knuckles. Another teacher would beat you, just lose her temper because she felt you were thick, and that's what she would be telling you". What is interesting is that Ryan (2019) reported that the corporal punishment did not prevent the learner from progressing in mathematics but there was a 'regime of terror' that stayed with the learner throughout his mathematics journey. This is somewhat similar to Stephens' experience in this study, who's journey in mathematics was 'quite good at math' who stated "*I used to watch the others getting sort of a beaten for not knowing them. So I always was able to sing off the tables you know that was in second and third class, I suppose with an Element of fear as well*". Corporal punishment is banned in Ireland since 1982, however, learners who experiences this still present themselves in both further and higher education, as evident in the two previous examples. Furthermore, victims of corporal punishment may also come from other jurisdictions "*the teacher used to come and the mosque there was a few trees there is so he'd got a big stick from one of the trees. Get ready, really nicely and in the classroom at the end of the day, the stick would have been to 20 pieces*". Teachers and institution in FET need to be cognisant that learners may have had a history of corporal punishment. Another form of traditional teaching was didactic teaching or what is sometimes referred to 'chalk and talk'.

There has been a growing demand to change traditional teaching methods to more contemporary approaches, despite this; the former is still commonly used (Earle & Rickard, 2018; Geist, 2010; Geist & King, 2008). It is important to note that many learners in this study were returning to education after a significant time period and there has been a number of initiatives for more active learning approaches in mathematics at leaving certificate such as 'project maths' (Shiel & Kelleher, 2017). Within this study, many learners also complained of traditional teaching or didactic teaching that they found to be very ineffective. Robert felt that how mathematics was taught didn't relate to the outside world "*I really didn't like it cause it didn't teach anything about the outside world. It was only as I learned before that Maths in school was only useful if you wanted to*

become a teacher afterwards". Linda complained of didactic teaching and lack of active learning *"it was just teacher sitting by the desk or standing by the board. Explaining and writing and we didn't really had that kind of classes that we could measure something or like in like Maths In practice it was very low in my life"*. Stephen shared didactic experiences to learning where questioning was not tolerated, *"No, he (The Teacher) just went to the board and he just said opened up page 55 yeah*. Stephen then asked the Teacher to explain and he was met with aggression *"You know he come down to me and then he 'grabbed me'"*. David also shared the issue of questioning, *"Sometimes the teacher would be like come on I'm not going to answer this, you know it says. Come on, you know you're in higher level"*. This study found that traditional teaching methods do not work for adult learners who have had negative experiences in mathematics (Klinger, 2011, Mutodi, 2014, Delikta and Stojkovska, 2019) and that the incorrect teaching approach can result in mathematics anxiety for learners (Wilbert, 2008 Ashcraft, 2002; Hellum, 2010). Shields (2005) warns that mathematics anxiety will continue to develop unless such interventions as effective pedagogy and classroom focus of inquiry, enthusiasm and discovery are not implemented. Teachers of Mathematics in FET need to be aware of these consequences and incorporate alternative approaches to teaching mathematics. An alternative approach to reduce mathematics anxiety is to include less lecture, student directed classes and more collaboration (Mutodi, 2014; Curtain-Phillips, 1999). Another example is the use of the flipped classroom, Segumpan and Tan (2018) an advocate of this approach found that math anxiety was decreased significantly compared to the traditional classroom, they felt that the asynchronous aspect gave students ample time to prepare outside and before class. Asynchronous can include the use of notes, books, podcasts or videos. . Indeed the use of ICT to facilitate mathematics learning has been used to counteract Mathematics anxiety (Furner & Duffy, 2002; Sun & Pyzdrowski, 2009). Non-traditional approaches are not limited to the use of ICT, for example, Lavasani and Khandan (2011) found the use of cooperative learning beneficial and that learners experience less math anxiety compared with students who were taught in traditional method of learning. These interventions are required in order to reduce mathematics anxiety for learners, however adequate support is also required which will now be discussed. However, it is important that despite the widespread availability of online mathematics resources, a recent study found that most mature students held a preference for the interpersonal engagement

of teaching staff (Breen, Prendergast & Carr, 2015). Indeed, mathematics support was a significant theme within this study.

5.1.7 Mathematics Support

Stacy felt that being left behind and not successfully progressing through a topic leaves her confused and anxious: *“you don't understand it, they're just moving on and it's leaving you just lost and confused”*. The concept of being ‘left behind’ is not unique to this study, indeed in *‘An Investigation into the Extent and Derivation of Mathematics Anxiety among Mature Students in Ireland’* there was also an example of this issue. Ryan (2019) stated, *“Lecturers need to ensure they are aware of students being lost or left behind, and in this regard allowing time to go through concepts again in detail is necessary in order to engage these students at risk of falling behind”*. This prompts a discussion on why Teachers are so eager to move on in terms of teaching. One reason for this could perhaps be the large classroom sizes in Ireland. According to the latest OECD (2022) ‘Education at a Glance’ report, the average class size of 24 in Irish primary schools is the highest among all 22 EU countries. A significant investment would be required to bring down these class sizes, parental investment however, in private tuition is another focus in terms of mathematics support.

“If a parent throws enough money at the problem, the problem will be solved ...” (Teacher response in Prendergast et al., 2020, p. 760). Indeed the privation tuition (grinds) culture in Ireland is not without its problems. Prendergast et al (2022) found that most teachers (n=305) were in agreement that receiving grinds increases students’ confidence and their performance in mathematical assessments. However, the same study found that the use of grinds can cause students to disengage in class and to be less responsible for their own individual work ethic. MacCoy and Byrne (2022) found that the grinds culture in Ireland supplements mainstream educational provision, where students and teachers complain of the issues in having to complete curriculum and course within the allocated time. In terms of support, ‘grinds’ in Ireland can be beneficial in terms of support, Brendan for example displayed very low levels of mathematics anxiety and stated *“I did get grinds outside school as well which definitely helped”*. However, it well documented that there are issues with educational inequality. MacCoy and Byrne (2022) found that nearly 60 percent of final year students are

engaging in grinds and that it contributes towards educational inequality, this reflects the issue of social and culture capital which was referenced to in the first chapter.

One approach from the Irish government to address educational inequality in mainstream education was the inception of the YouthReach. The nature of YouthReach can be very beneficial for learners as it offers smaller class sizes (Smyth, E et al., 2019) and it is an alternative to mainstream education. The YouthReach programme was *“introduced in 1989 which attempted to address the then high levels of early school leaving, by providing young people with access to second-chance education and training”* (Smyth, E et al., 2019, p.1). Stacy found YouthReach programme very helpful and gave it a lot of praise *“there was six of us (learners)... The teachers are really nice as well, and if you were stuck on maths, they definitely wait”*. It is interesting to note that there is YouthReach employ a variety of teaching methods and there is little use of a didactic teaching approach compared to mainstream second-education.

These alternative approaches are important for policy makers in FET to consider. For example, Gal et al (2020, p391) suggest that *“numeracy skills and practices that adults need should be continuously monitored and adjusted by policy bodies, researchers, and practitioners involved in adult learning and skills”*. For example, in higher education, the University of Limerick introduced a mathematics bridging course, entitled ‘Head Start Maths’ where the aim of the course was to revise mathematics fundamentals before the commencement of third-level education so as to lessen the anxiety levels of adult learners towards mathematics (Johnson and O Keefe, 2016), this is an example of an intervention that could be used in Further Education and Training. The results did not explicitly state that there was a reduction in the levels of mathematics anxiety. However, it did indicate that rates of learner’s dropouts who attended the bridging course were far less than those that did not attend it. This model could be adopted within a VTOS setting and a broader FET provision, in order to address adult learners’ mathematics anxiety, particularly for those recently returning to education.

5.1.8 Role of Parents

The role of parents in this study was examined and arose as a critical environmental antecedent in terms of the learners' mathematics anxiety and their general experiences with mathematics. In terms of this research study, there was varying level of parental supporting terms of mathematics. What perhaps may have been unique to this study was that Thomas's parents has passed away at a young age and Stacy's' father had dropped out of school from a young age, meaning that neither of them received parental support, both Thomas and Stacy showed to have high levels of mathematics anxiety, particularly around mathematics test anxiety.

Parents can have an impact on their children's attitude and behaviour towards mathematics, (Casad, Hale, & Wachs, 2015). Those learners who had positive experiences in mathematics, had support from their parents, conversely those with negative experiences did not have support from theirs. Indeed, in most cases those parents who did not have the support was mainly due to an inability rather than a reluctance. This prompts the question of what supports are required to facilitate Parents on how they can support their children with the development of their mathematics education. It was unclear however, if the role of parents contributed directly towards a leaners mathematics anxiety.

In the context of VTOS, perhaps consideration is required from a reactive position regarding how best to respond and support adult learners in FET that may not have had parental support in the past. If they have low levels of social capital as a consequence of historic antecedent variables, what can be put in place to mitigate that within FET? The previous section outline teaching methods, supports the use of assessments. There were a number of participants who were parents themselves and were motivated to help their own children, there are a number of supports available to them to not only reduce their own mathematics anxiety but also to help their kids with their mathematics studies.

A recent study suggested that one way to support parents would be to provide mathematical examples or to record a short video so that learners can re- watch the example rather than feeling frustrated and fostering negative homework experiences around math (Kiss & Vukovic, 2020). Indeed, this could also benefit parents who may feel more confident in helping their children with their mathematics homework (Kiss & Vukovic,

2020). Another interesting concept was the use of mathematics strategy training which in a study found that not only in improved mathematics abilities, but also in reduced mathematics anxiety through repetition, where children developed a sense of self-control by immersing themselves in mathematical tasks, and reducing their mathematics anxiety (Passolunghi et al, 2020). Petronzi et al (2021) provides a comprehensive table of intervention studies, see appendix (1) for more information. Scarpello (2007) suggested that there are links between parental attitudes towards mathematics, their educational level and their child's level of mathematics anxiety; the stronger their negativity towards mathematics and the lower the educational level of the parents, the higher the levels of mathematics anxiety experienced by their child.

5.1.9 Mathematics Test Anxiety

Mathematics Test Anxiety was prevalent among a number of learners in the study. This included experiences in mathematics test anxiety in primary schools, post primary schools and the leaving certificate state exam. The latter was particularly stressful for learners within this study. However, it's not just the actual test or evaluation that can give rise to mathematics test anxiety but also the anticipation of being examined that can be lead to significant stress (Hembree, 1990; Young et al., 2012). Many learners conveyed this stress and recalled been awake all night, pains in their stomach and sweating because of mathematics test anxiety. Such physical symptoms are not unique to this study. For example Lyons and Beilock (2012) found that some learners would incur physical pain as a result of the anticipation of math-related activities, whilst Kelly et al (2015) stated that math anxiety can result in a learners to exhibit "*clammy hands, upset stomach, and lightheadedness*" (Kelly, Rice, Wyatt, Ducking, & Denton, 2015, p.174). Hembree (1990) also warns that test anxiety can lead to poor performance, which is something that needs to be considered within such assessments as the Leaving Certificate in Ireland.

Zeidner (2007) advocates the use of interventions that would both reduce test anxiety and associated emotional stress, as well as improve the classroom experience, and overall academic performance. These include providing students with ample information in advance of the examination; a task-oriented rather than competitive approach; a balance of easy and more challenging questions; allowing choice in the examination,

as well as open book approach; allowing students a chance to comment on the examination during the examination; a reduction in time limitation and associated pressure; provision of reassurance and emotional support; and the provision of a 'recovery room' where very anxious students can take time out before continuing with the examination (Zeidner, 2007). These suggestions could reduce FET learner's mathematics anxiety and should all be considered for this purpose.

Chapter 6 Conclusion

6.1 Introduction

This chapter provides a concluding summary of the main findings of this research study. The purpose of this study is to explore mathematics anxiety amongst a group of adult learners and the potential associated environmental antecedents. It is envisaged that the outcomes of this research will inform Mathematics and Numeracy Teachers/Tutors in Further Education and Training on the prevalence of mathematics anxiety and the associated environmental antecedents. This information holds the potential to support andragogical interventions to help mitigate mathematics anxiety amongst FET students and to reduce associated negative outcomes. Moreover, the findings also hold the potential to help advance teachers' empathy and emotional generosity by better understanding the mathematics life stories of such adult learners? Research shows that negative attitudes towards mathematics may well have been learned by students and have developed over a sustained period of time (Prendergast et al, 2020), therefore it is important that FET Teachers convey a positive attitude towards mathematics. There is a significant gap in the study of Mathematics anxiety within Further Education, as well as very limited research in an Irish context.

Three key research questions underpinned the foundations of the thesis.

1. What level of mathematics anxiety, if any, exist amongst a cohort of adult learners?
2. What, if any, environmental antecedents contribute towards mathematics anxiety in an adult learner's mathematics learning journey?
3. What impact, if any, do environmental antecedents have on students' experiences of mathematics?

The findings of this study confirm the existence of varying levels of mathematics anxiety among a cohort of adult learners in a Further Education setting, with very high specific mathematic test anxiety. Traditional teaching methods including punishment, embarrassment and anger can have negative learning outcomes for learners including mathematics anxiety. There is evidence within the literature review that a lack of parent support can lead to a learner's mathematics anxiety (Buckley et al. 2016, Dreger & Aiken, 1961, Soni and

Kamurai, 2017) as well as their attitudes and behaviour towards mathematics (Casad, Hale, & Wachs, 2015). A lack of parental support was a common environmental antecedent for most learners in this study and as a negative experience for learners. These negative experiences included self-efficacy, performance and negative learning outcomes.

6.2 Implications of this research

The potential of understanding the experience of adult's mathematics anxiety in further education could benefit FET practitioners and provide practical findings for learners experiencing mathematics anxiety. Understanding the influence that a teacher can have on a learner's experience of mathematics cannot be underestimated. For example, learners identified traditional teaching methods as a negative experience in mathematics. Furthermore, the use of assessments is something that needs to be explored, particularly the Leaving Certificate examination.

The findings cover a range of implications for the delivery of mathematics across Further Education and Training in Ireland. The research findings indicate a number of environmental antecedents which give rise to a learner's mathematics anxiety and negative experiences in mathematics. Through the mathematics life story interview, these environmental antecedents can be identified across the range of different stages of learners education. The influence of teachers and parents and the different cultures and social expectations, not limited to just Ireland, emerged as important factors.

6.2.1 Implications for policy

The findings from this study, can draw on a number of implications for numeracy and mathematics policy for adult learners in further education and training in Ireland. Financial investment has significantly increased within Further Education and Training in Ireland, particularly since 2020. This approach has had a positive impact and perhaps on a sector which was often overlooked, often undervalued and less prestigious (McGuinness et al., 2014). The (ALL) Strategy was recently established and has taken a positive approach towards addressing numeracy, one specific target was to reduce the number of adults in Ireland with unmet numeracy needs from 25% to 12% (Government of Ireland, 2023). This objective is significant, as not only

does numeracy have economic implications for society, but it can also lead to socioeconomic disadvantage, and intergenerational cycles of low levels of mathematics anxiety for individuals (NALA, 2019). Whilst not limited to any specific sector of society, some marginalised groups that require numeracy support can include refugees, long-term unemployed, low-paid workers, persons with disabilities, and ethnic minority groups such as Irish Travellers (Government of Ireland, 2021). With this mind it is important to view all of these important details within the context of government and numeracy policy.

The findings from this study show that how mathematics is taught and assessed could benefit future numeracy policy. Learners have shown to have significant mathematics test anxiety which can often lead to disengaging in learning mathematics. SOLAS (2021, p.31) in the numeracy report '*Good Practice in Integrated and Standalone Numeracy Provision at Levels 1-3*', correctly highlight that "it is valuable to develop approaches to assessment that are focused on assessment at all stages of the learning cycle". One limitation to this policy is that it only captures numeracy levels 1 to 3, and a much broader policy which encapsulates all levels of numeracy is required. Moreover, mathematics test anxiety requires specific focus in FET policy as many learners who have entered FET have had challenges within the traditional school setting. Additionally, Goos et al (2023) suggests that adult numeracy in Ireland, is typically aimed at learners who have experienced interruptions or dropped out from school. With this in mind, numeracy policy should identify measures which can alleviate mathematics test anxiety.

6.2.2 Implications for future research

SOLAS (2021) the state body for Further Education and Research have acknowledged that adult numeracy is under researched and is also an under-theorised field. Not only is numeracy under researched, there is also a struggle to understand what exactly numeracy is. For example the '*Towards a New Literacy, Numeracy and Digital literacy Strategy*' suggests that there is no consensus as to what exactly numeracy is (Government of Ireland, 2023). This is reaffirmed, where Goos et al (2023) claims that numeracy in Ireland has always incorporated a broad definition in terms of adult education.

In terms of research for mathematics anxiety, there is also potential for future research, particularly within the context of numeracy. Within an Irish context, there has been two primary papers on mathematics anxiety research, Ryan & Fitzmaurice (2017) and Ryan et al (2019), both of which are in the context of mature students in higher education. Additionally these papers focus on mathematics and not numeracy per se. Within this study, one limitation that emerged from the quantitative data was the issue of categorising high mathematics anxiety and low mathematics anxiety. There is no agreed cut off point in the MAS UK and this can be problematic in determining levels of mathematics anxiety. Indeed, Cipora (2021) supports this view and recommends that future research should focus on developing better diagnostic/cut-off criteria for mathematics anxiety diagnosis. This would help in defining learners who have high levels of mathematics or alternatively low levels of mathematics anxiety.

6.2.3 Implications for practice.

In terms of implications for practice, a significant theme can be drawn from the influence of the teacher. We see the negative implications from this research study that have negative implications for the learners, including corporal punishment, mathematics test anxiety and teacher centred learning. All of these implications require consideration for FET Teachers which will be addressed in the next section.

6.3 Recommendation(s)

The recommendations following from this study will be categorised by the three themes of Mathematics Test Anxiety, Influence of Teacher and Influence of Parent

6.3.1 Mathematics Test Anxiety

The findings of this research study have shown that mathematics test anxiety can result in raised levels of mathematics anxiety for learners. These scenarios include formal or non-formal assessment where the leaving certificate examination was a dominant feature in mathematics test anxiety. Two prominent deliberations from the study of test anxiety that resonate with the study of mathematics anxiety include the contention that there exists a negative correlation between test anxiety and performance, and that test anxiety develops as a

consequence of repeated poor performance (Reyes, 1984; Zan et al., 2006). To note, it is well established that the leaving certificate is not ideal in terms of assessment (Smyth et al, 2011).

According to Smyth et al (2011) in a ERSI study 'From Leaving Certificate to Leaving School' it was suggested that Leaving Certificate was perceived as a very 'high stakes' exam where participants exhibited high levels of stress, particularly among females and in some cases learners felt that "*The Leaving Cert exams are more a test of memory than intelligence*" (Smyth et al, 2011, p23). , Boaler (2015) claimed that all subject areas require some form of memorization but that Maths is the only subject which requires memorization quickly to earn high scores which compounds the level of Mathematics anxiety. According to Boaler (2015), approximately one-third of students across all socioeconomic groups experience severe anxiety during timed math tests.

There has been changes suggested for the leaving certificate examinations in English and Irish, for example, with future students expected to sit their paper 1 in the respective exams in fifth year of school, meaning that they will only have to sit paper 2 in 6th year (Department of Education, 2022). If this approach was also used for mathematics, it would then it would mitigate the impact of such a 'high stakes' exam where participants exhibit high levels of stress (Smyth et al, 2011). Moreover, the time constraints on the leaving certificate are well established, Boaler (2015), suggests that approximately one-third of students across all socioeconomic groups experience severe anxiety during timed mathematics tests. Boaler (2015) claimed that mathematics is the only subject which requires memorization quickly to earn high scores which compounds the level of mathematics anxiety, this is important considering that "*The Leaving Cert exams are more a test of memory than intelligence*" (Smyth et al, 2011, p23). *Research also shows that* learners induce significant stress due to the constant reminders of the leaving certificate examination and the use of 'past examination mathematics papers' as a teaching strategy (Smyth and Banks (2012). Indeed, generally speaking, the concentration of working towards a mathematics assessment or examination at the end of the academic year compounds the concept of mathematics as a difficult subject (NCCA, 2006; Prendergast, 2011). Perhaps in lieu of an examination, there could be a similar approach to the CBA (continuous based assessment). Recently, the

Minister for Education Norma Foley, suggested that she will take ‘appropriate time’ to explore the challenges of running Leaving Cert papers at end of fifth year. Whilst this would be welcomed and would avoid an all stakes exams, it would be cognisant to explore recent research into the CBA’s at Junior Cert level. Indeed, a report by McGarr & McCormack (2021) found stark findings following a four-year study into Junior Cycle reforms. The intentions of the reform sought to reduce the emphasis on final stakes exams and to encourage a more student-centred learning experience, with a greater emphasis on group work and continuous assessment. However, it was found that learners reported significant stress as they struggled to balance homework, CBAs and study for tests and exams.

A final consideration is that there could be an alternative to the Leaving Certificate. Learners could enrol in the various QQI mathematics modules which foster a greater emphasis on continuous assessment than examinations. Dalby (2021) advocated that mathematics teachers can harness a positive image of mathematics for learners, but warns that they are constrained in England by a policy that focuses on achievement of the same GCSE qualification that students have taken and ‘failed’ in school. The GCSE is the equivalent to the leaving certificate in the United Kingdom. However, participants within this study, specifically chose the leaving certificate as a course and didn’t opt for course which contained QQI mathematics modules. Some learners did however complain of the use of examination papers as a teaching methodology. This supports the view of Smyth and Banks (2012) who found that learners illicit significant stress due to the constant reminders of the leaving certificate examination and the use of ‘past examination mathematics papers’. In terms of recommendation, an approach for FET Teachers would be to have less focus on the leaving certificate and greater focus on student centred learning and to reduce the use of examination papers.

6.3.2 Influence of teacher

The findings of this research showed that teacher had a negative influence on learners’ mathematics anxiety. Some adults reported that they developed their mathematics anxiety consequently from a teacher reacting angrily when the learner asked for help when they struggled with mathematics, which is also evident in other

studies (Jackson & Leffingwell, 1999). In some cases, this can be extreme as was the case in this study where learners developed anxiety from teachers, including corporal punishment.

Corporal punishment is now banned in Ireland since 1982 when Minister for Education John Boland brought legislation into the Dail, which outlawed the practice. FET practitioners need to be cognisant that many learners returning to education may have been subject to corporal punishment in the past. Some measures FET Teachers could take would be to more cautious regarding the language, tone and feedback they give to adult learners. This would be supported by Knowles (1980) theory of andragogy who advocated that adult learners should feel respected, supported and that the classroom should be constructed in an 'adult friendly' manner, he also suggested that adults should never be 'talked down to'.

Many learners also complained of traditional teaching or didactic teaching that they found to be very ineffective. This study found that traditional teaching methods do not work for adult learners who have had negative experiences in mathematics, this has also been the case in other studies (Klinger, 2011, Mutodi, 2014, Delikta and Stojkovska, 2019). It is established in other studies that the incorrect teaching approach can result in mathematics anxiety for learners (Wilbert, 2008 Ashcraft, 2002; Hellum, 2010). From these findings, it is also the case for adult learners in a FET settings, that the incorrect teaching approach can result in mathematics anxiety and that mathematics teachers in FET, should move towards a student centred approach to learning. The former statement also supports Mutodi (2014) supports a student centred approach and specifies that the best way to reduce mathematics anxiety is to include less lecture, student directed classes and more collaboration. Mathematics anxiety is one of the issues that teaching practitioners should consider with importance and seriousness and it is critical to ascertain the mathematics anxiety levels to determine the factors that cause student failure (Mehmet, C. & Hulya, S., 2021). Interventions in these are required for FET in mathematics or/and numeracy. Moreover, professional development for adult numeracy practitioners needs to be accessible and promoted to all FET teachers (Goos et al, 2021. Prendergast et al, 2022). These new teaching approaches could incorporate mathematics anxiety training and a student centred approach to learning mathematics.

6.3.3 Influence of parents

The findings of this study show that parents can have a significant impact on a learners' mathematic life story. It was evident that there was a lack of parental support for learners in primary school and post primary school. It is difficult to determine that lack of parental support was a significant environmental antecedent of mathematics anxiety for FET learners, but those learners who did not have parental support also experienced negative learning outcomes including mathematics anxiety, avoidance of mathematics and poor self-efficacy. Indeed a number of learners, identified the ability to support their own children as a motivation factor for learning and progressing in mathematics. Considering this, it is paramount that parents have the ability and knowledge to provide parental support for their children in mathematics education. It is important the parents are therefore provided with sufficient support structure where they can develop their own mathematical skills. There are for example, concepts such as strong school-family partnerships and cooperation, which is one method in improving the quality of parental involvement in children's homework (Haris & Goodall, 2008). Silinskas & Kikas (2017) suggest that teachers through cooperating with families can guide parents on how best to assist their children with homework. For Teachers in FET they also have to be cognisant that learners may have had little or no support returning to FET and they should make them aware of all the various support structures that are in place within their FET provision such as the AISS (Active Inclusion Support Service) which seek to enable *“access for socially, economically or educationally disadvantaged groups, such as long-term unemployed people, those facing literacy and numeracy challenges”* (AISS Framework, p.8).

Bibliography

- Abeysekera, L., and P. Dawson. 2014. "Motivation and Cognitive Load in the Flipped Classroom: Definition, Rationale and a Call for Research." *Higher Education Research & Development* 34(1): 1–14.
- Aiken, L.R. (1976). Update on Attitudes and Other Affective Variables in Learning Mathematics, *Review of Educational Research* 46(2), pp. 293-311.
- Alexander, L. & Cobb, R. (1984). Identification of the Dimensions and Predictors of Math Anxiety among College Students, Paper presented at the annual meeting of the Mid-South Educational Research Association, New Orleans, LA. Retrieved from ERIC database.
- AONTAS, (2019), Submission to the SOLAS FET Strategy 2020-2024, accessed online on 14th May 2020 at: <https://www.aontas.com/AONTAS%20Response%20FET%20Strategy%202020-2024%20FINAL-.pdf>
- Ashcraft, M.H. (2002). Math Anxiety: Personal, Educational, and Cognitive Consequences, *Directions in Psychological Science* 11, pp. 181-185.
- Ashcraft, M.H. & Faust, M.W. (1994). Mathematics Anxiety and Mental Arithmetic Performance: An Exploratory Investigation, *Cognition and Emotion* 8, pp. 97-125.
- Ashcraft, M.H. & Kirk, E.P. (2001). The Relationships among working Memory, Math Anxiety, and Performance, *Journal of Experimental Psychology* 130, pp. 224–237.
- Ashcraft, M.H., Kirk, E.P. & Hopko, D.R. (1998). On the Cognitive Consequences of Mathematics Anxiety. In C. Donlan (ed.) *The Development of Mathematical Skills*. Hove: Psychology Press
- Ashcraft, M.H. & Krause, J.A. (2007). Working Memory, Math Performance, and Math Anxiety, *Psychonomic Bulletin & Review* 14, pp. 243–248.
- Aysel, T., Ann, O.S. and Breen, S., 2020. Students' Attitudes to Mathematics Learning and Assessment in Turkey and Ireland. *International Journal of Educational Studies in Mathematics*, 7(1), pp.26-38.

- Akinsola, M. K., Tella, A., & Tella, A. (2007). Correlates of academic procrastination and mathematics achievement of university undergraduate students. *Eurasia Journal of Mathematics, Science & Technology Education*, 3(4), 363–370
- Baloglu, M. (1999). A Comparison of Mathematics Anxiety and Statistics Anxiety in Relation to General Anxiety, Texas A&M University-Commerce Department of Psychology, paper sourced at <https://files.eric.ed.gov/fulltext/ED436703.pdf> on 11/09/2022, pp. 1-33
- Baloglu, M. & Koçak, R. (2006). A Multivariate Investigation of the Differences in Mathematics Anxiety, Personality and Individual Difference 40, pp. 1325–1335.
- Bandura, A. (1993). Perceived Self-Efficacy in Cognitive Development and Functioning, *Educational Psychologist* 28(2), pp. 117-148.
- Baumeister, R. F. (Ed.) (1999). *The self in social psychology*. Philadelphia, PA: Psychology Press (Taylor & Francis)
- Belbase, S. (2013). Images, Anxieties, and Attitudes towards Mathematics. *International Journal of Education in Mathematics, Science, and Technology* 1(4), pp. 230-237.
- Beilock, S.L., Gunderson, E.A., Ramirez, G. & Levine, S.C. (2010). Female Teachers’ Math Anxiety affects Girls’ Math Achievement, *Proceedings of the National Academy of Sciences* 107, pp. 1860–1863.
- Beilock, S.L. & Maloney, E. (2015). Math Anxiety: a Factor in Achievement not to be ignored. *Behavioral and Brain Sciences* 2(1), pp. 4-12.
- Beilock, S.L. & Willingham, D.T. (2014). Math Anxiety. Can Teachers help Students Reduce it? *American Educator* Summer 2014, pp. 28-32.
- Bergin, A., E. Smyth and A. Whelan, 2019. “Post-Leaving Certificate education” in Gallacher, J. and F. Reeve, Ireland: Managing Different Goals, *New Frontiers for College Education: International Perspectives*, Chapter 3, London and New York: Routledge.
- Bergmann J., & Sams A. (2012). *Flip your classroom. Reach every student in every class every day*. Washington, DC: International Society for Technology in Education (ISTE).

- Beilock, S.L., Gunderson, E.A., Ramirez, G. & Levine, S.C. (2010). Female Teachers' Math Anxiety affects Girls' Math Achievement, *Proceedings of the National Academy of Sciences* 107, pp. 1860–1863.
- Beilock, S.L. & Maloney, E. (2015). Math Anxiety: a Factor in Achievement not to be ignored. *Behavioral and Brain Sciences* 2(1), pp. 4-12.
- Beilock, S.L. & Willingham, D.T. (2014). Math Anxiety. Can Teachers help Students Reduce it? *American Educator* Summer 2014, pp. 28-32.
- Bergmann, J. & Sams, A. (2012). *Flip your Classroom. Reach Every Student in Every Class Every Day*. Washington, DC: International Society for Technology in Education (ISTE).
- Betz, N.E. (1978). Prevalence, Distribution, and Correlates of Math Anxiety in College Students, *Journal of Counseling Psychology* 25, pp. 441– 448
- Boaler, J. (2012). Timed Tests and the Development of Math Anxiety, Commentary. *Education Week*, sourced at <https://www.edweek.org/ew/articles/2012/07/03/36boaler.h31.html> on 15/06/2022
- Boaler, J. (2016). *Mathematical Mindsets: Unleashing Students' Potential Through*
- Boaler, J. (2010). *The Elephant in the Classroom: Helping Children love and learn Mathematics*, Souvenir Press.
- Boaler, J., Dieckmann, J.A., Pérez-Núñez, G., Liu Sun, K. & Williams, C. (2018). Changing Students Minds and Achievement in Mathematics: The Impact of a Free Online Student Course, *Frontiers in Education* 2018(3), pp. 1-7.
- Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3, 77-101.
- Brown et al., A. B., Westenskow, A., and Moyer-Packenham, P. S. (2011). Elementary preservice teachers: Can they experience mathematics teaching anxiety without having mathematics anxiety? *Issues in the Undergraduate Mathematics Preparation for School Teachers*, 5, 1–14
- Boeve, A.J., Meijer, R.R., Bosker, R.J., Vugteveen, J., Hoekstra, R. and Albers, C.J. (2017), “Implementing the flipped classroom: an exploration of study behaviour and student performance”,

HigherEducation, Vol.74No.6, pp.1015-1032, available online at: <https://doi.org/10.1007/s10734-016-0104-y>

- Boyatzis, R. (1998). Transforming qualitative information: Thematic analysis and code development. Thousand Oaks, CA: Sage.
- Byrd, P.G. (1982). A Descriptive Study of Mathematics Anxiety: Its Nature and Antecedents, dissertation submitted in partial fulfilment of Ph.D. Indiana University
- Braun, V., Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3, 77–101.
- Brockett, R. G. & Hiemstra, R (1991). Self-Direction in adult learning: Perspectives on theory, research, and practice. New York: Routledge.
- Brush, L. R. (1981). Some Thoughts for Teachers on Mathematics Anxiety. *The Arithmetic Teacher*, 29(4) 37-39.
- 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.
- Burton, G. M. (1979). Getting comfortable with mathematics. *The Elementary School Journal*, 79(3), 129–135.
- Carpentieri, J. D., Litster, J. & Frumkin, L. (2010). Adult numeracy: A review of research. National Research and Development Centre for Adult Literacy and Numeracy.
- Carroll, E., Ye, K. and McCoy, S., 2022. Educationally maintained inequality? The role of risk factors and resilience at 9, 13 and 17 in disabled young people’s post-school pathways at 20. *Irish Educational Studies*, 41(3), pp.573-594.
- Cemen, P.B. (1987). The Nature of Mathematics Anxiety. Stillwater, OK: Oklahoma State University.
- Chapline, E. B. (1980). Teacher education and mathematics: Program development and evaluation. Retrieved from <https://eric.ed.gov/?id=ED186272>

- Chavez, A., & Clark, K.(2015), “The effects of the flipped model of instruction on student engagement and performance in the secondary mathematics classroom”, The Journal of Educators Online, Vol. 12 No. 1, available at: <http://doi.org/10.9743/jeo.2015.1.5>
- Clarke, V., Burns, M. and Burgoyne, C. 2006: ‘Who would take whose name?’ An exploratory study of naming practices in same-sex relationships. Manuscript under submission.
- Cipora, K., Artemenko, C., & Nuerk, H.-C. (2019). Different ways to measure math anxiety.
- Cipora K., F. Santos, K. Kucian, et al. 2021. Mathematics anxiety – where are we and where shall we go? PsyArXiv.
- Cosso, J., A. Ellis, C.D. O’Rear, et al. Conceptualizing the factor structure of parents’ math anxiety and associations with children’s mathematics skills. Ann. N.Y. Acad. Sci. In press. <https://doi.org/10.1111/nyas.14736>
- Creamer, E. (2017). An Introduction to Fully Integrated Mixed Methods Research, 1st Ed., Thousand Oaks, CA: Sage
- Creswell, J. W., & Plano Clark, V. L. (2011). Designing and Conducting Mixed Methods Research. Thousand Oaks, California, USA: Sage
- Curtain-Phillips, M. (1999). Math attack: How to reduce math anxiety in the classroom, at work, and in everyday personal use.
- Chinn, S. (2017). More Trouble with Maths: A Complete Manual to Identifying and Diagnosing Mathematical Difficulties. Abingdon Oxon: Routledge.
- Dalby, D. (2021). Changing Images of Mathematics in the Transition from School to Vocational Education. Adults Learning Mathematics, 15(1), 45-57.
- Dale, E. (1969). Audiovisual methods in teaching. NY: Dryden Press
- Daly, J., Kellehear, A., & Gliksman, M. (1997). The public health researcher: A methodological approach. Melbourne, Australia: Oxford University Press.
- Department of Education and Science, (July 2000), Learning for Life: White Paper on Adult Education, Dublin, Government Publications.

- Department of Education and Skills statistics hosted by the CSO, <https://statbank.cso.ie/px/pxeirestat/Statire/SelectVarVal/saveselections.asp>
- Dewey, J. *How We Think*. Boston, MA: Heath, 1933.
- Dewey, J. *Experience and Education*. New York: Macmillan, 1938.
- Di Martino, P. & Zan, R. (2011). Attitude towards Mathematics: A Bridge between Beliefs and Emotions, *International Journal on Mathematics Education* 2011, pp. 1-19.
- Dowker, A. (2017). Interventions for Primary School Children With Difficulties in Mathematics, *Advances in Child Development and Behavior* 53, pp. 255-287.
- Dowker, A., Bennett, K. & Smith, L. (2012). Attitudes to Mathematics in Primary School children, *Child Development Research* 2012, pp. 1-8.
- Dowker, A., Sarkar, A., & Looi, C.Y. (2016). Mathematics Anxiety: what have we learned in 60 years? *Frontiers in Psychology* 7, pp. 1-16.
- Dreger, R.M. & Aiken, L.R. (1957). The Identification of Number Anxiety in a College population, *Journal of Educational Psychology* 48, pp. 344-351.
- El-Banna, M.M., Whitlow, M. and Mcnelis, A.M. (2017), “Flipping around the classroom: accelerated bachelor of science in nursing students satisfaction and achievement”, *Nurse Education Today*, Vol. 56, pp.41-46
- ERSI (2020), Mohan, G., Mccoy, S., Carroll, E., Mihut, G., Lyons, S., & Domhnaill, C.M, *LEARNING FOR ALL? SECOND-LEVEL EDUCATION IN IRELAND DURING COVID-19*, available online at https://www.esri.ie/system/files/publications/SUSTAT92_3.pdf , accesss on the 2nd September 2020
- Eun, B. “The zone of proximal development as an overarching concept: A framework for synthesizing Vygotsky’s theories,” *Educational Philosophy and Theory*, vol. 51, no. 1, pp. 18–30, 2019, doi: <https://doi.org/10.1080/00131857.2017.1421941>.
- Jameson, M. & Fusco, B. (2014). Math Anxiety, Math Self-Concept, and Math Self-Efficacy in Adult Learners Compared to Traditional Undergraduate Students. *Adult Education Quarterly* 4(64) 306-322

- Fennema, E. & Sherman, J. (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), pp. 324-326.
- Finlayson M. (2014) Addressing math anxiety in the classroom. *Improving Schools* 17(1): 99–115.
- Fitzmaurice, O., Mac an Bhaird, C., Ní Fhloinn, E. & O’Sullivan, C. (2015). Adult Learners and Mathematics Learning Support. *Adults Learning Mathematics: An International Journal*, 10(1), 68-83.
- Frank, K.A., Muller, C., Schiller, K.S., Riegler-Crumb, C., Strassmann Mueller, A., Crosnoe, R. & Pearson, J. (2008). The Social Dynamics of Mathematics Course taking in High School, *American Journal of Sociology* 113(6), pp. 1645-1696.
- Freire, P. (1972). *Pedagogy of the Oppressed*. Middlesex: Penguin Education.
- Frenzel, A.C., Goetz, T., Pekrun, R. & Watt, H.M.G. (2010). Development of Mathematics Interest in Adolescence: Influences of Gender, Family and School Context. *Journal of Research on Adolescence*, 20(2), 507-537.
- 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, pp. 478-493.
- Friedel, J. M., Cortina, K. S., Turner, J. C., & Midgley, C. (2007). Achievement goals, efficacy beliefs and coping strategies in mathematics: The roles of perceived parent and teacher goal emphases. *Contemporary Educational Psychology*, 32, 434–458
- Gal, I., Grotlüschen, A., Tout, D., & Kaiser, G. (2020). Numeracy, adult education, and vulnerable adults: A critical review of a neglected field. *ZDM – Mathematics Education*, 52(3), 377–394.
- Gallacher, J. and F. Reeve, 2019. “New Frontiers for College Education” in Gallacher J. and F. Reeve, *New Frontiers for College Education: International Perspectives*, Chapter 1, London and New York: Routledge.

- Gill, O. and O'Donoghue, J. (2007). Justifying the existence of Mathematics learning support: Measuring the effectiveness of a mathematics learning centre. In J. O'Donoghue and T. Maguire (Eds.) *The Changing Face of Adults Mathematics Education: Learning from the Past, Planning for the Future*. Proceedings of the Adults Learning Mathematics (ALM) 14th annual international conference (pp 146-153). University of Limerick, Ireland.
- Goos, M., Prendergast, M., O'Meara, N., and O'Sullivan, K. (2023). Supporting adults to become numerate citizens: a study of adult numeracy provision in Ireland. *ZDM Mathematics Education* (2023). <https://doi.org/10.1007/s11858-023-01480-9>
- Gordon, S. & Nicholas, J. (2013). Students' conceptions of mathematics bridging courses. *Journal of Further and Higher Education*, 37, 109–125.
- Government of Ireland (2021). *Adult literacy for life: A 10-year adult literacy, numeracy and digital literacy strategy*. https://www.solas.ie/f/70398/x/b78324692b/15607_all_strategy_web.pdf
- Government of Ireland (2023). *Towards a New Literacy, Numeracy and Digital literacy Strategy* [gov.ie available online - Literacy, Numeracy and Digital Literacy Strategy Consultation \(www.gov.ie\)](http://www.gov.ie), accessed on 7th May 2023
- Government of Ireland (2023, 20th March). Minister Harris announces €1 million for projects to address literacy and digital literacy needs. [Press release]. [gov.ie - Minister Harris announces €1 million for projects to address literacy and digital literacy needs \(www.gov.ie\)](http://www.gov.ie)
- Hammond, L. & Hyler, M. (2020): Preparing educators for the time of COVID ... and beyond, *European Journal of Teacher Education*, DOI: 10.1080/02619768.2020.1816961
- Higher Education Authority (HEA) (2004) *Achieving Equity of Access to Higher Education in Ireland, Action Plan 2005-2007*, Dublin: National Office for Equity of Access to Higher Education.
- Higher Education Authority (HEA) (2008) *National Plan for Equity of Access to Higher Education 2008-2013*, Dublin: National Office of Equity of Access to Higher Education.
- Higher Education Authority (HEA) (2016) *A Study of Progression in Higher Education 2012/13 to 2013/14*, Dublin: Higher Education Authority.

- Hembree, R. (1990). The Nature, Effects, and Relief of Mathematics Anxiety, *Journal for Research in Mathematics Education* 21(1), pp. 33-46.
- Henschel, S. & Roick, T. (2018). The Multidimensional Structure of Math Anxiety Revisited: Incorporating Psychological Dimensions and Setting Factors. *European Journal of Psychological Assessment* 20180803, pp. 1-14
- Hopko, D.R. (2003). Confirmatory Factor Analysis of the Math Anxiety Rating Scale— Revised. *Educational and Psychological Measurement* 63, pp. 336-351.
- Hopko, D.R., Mahadevan, R., Bare, R.L. & Hunt, M.A. (2003). The Abbreviated Math Anxiety Scale (AMAS): Construction, Validity, and Reliability, *Assessment* 10, pp. 178- 182.
- Hunt, T. E., Clark-Carter, D. & Sheffield, D. (2011) The Development and Part Validation of a U.K. Scale for Mathematics Anxiety, *Journal of Psychoeducational Assessment* Vol. 29, pps. 455-466
- Hussey, T. & Smith, P. “Transitions in higher education. Innovations”, in *Education and Teaching International*, (2010): 155-164; Hazel Christie,
- Iossi, L. (2007). Strategies for reducing math anxiety in post-secondary students. Proceedings of the Sixth Annual College of Education Research Conference: Urban and International Education Section, Miami, Florida, 2007.
- Jameson, M. M. (2013b). Contextual factors related to math anxiety in second grade children. *The Journal of Experimental Education*, (e-pub ahead-of-print), 1-19. doi:10.1080/00220973.2013.813367
- Jones, K. (2000). Providing a foundation for deductive reasoning: students’ interpretations when using Dynamic Geometry software and their evolving mathematical explanations. *Educational Studies in Mathematics*, 44(1-2), 55-85.
- Keengwe, J., Onchwari, G. and Oigara, J.N. (2014), “Promoting active learning through the flipped classroom model”, *Information Science Reference, an imprint of IGI Global, Hershey, PA.*
- Kessels, J.W. and Poell, R.F., 2004. Andragogy and social capital theory: The implications for human resource development. *Advances in developing human resources*, 6(2), pp.146-157.

- Klinger, C.M. (2011). ‘Connectivism’: A new paradigm for the mathematics anxiety challenge? *Adult Learning Mathematics: An international journal*, 6(1), 7-19.
- Klinger, C. (2006). Challenging Negative Attitudes, Low Self-Efficacy Beliefs, and Math-Anxiety in Pre-Tertiary Adult Learners, Paper presented at Adults Learning Mathematics 12, Melbourne, Australia, pp.164–171.
- Klinger, C.M. (2011). ‘Connectivism’: A New Paradigm for the Mathematics Anxiety Challenge? *Adult Learning Mathematics: An International Journal* 6 (1), pp. 7–19. 403 Knowles, M.S., Holton, E.F. III & Swanson, R.A. (2005). *The Adult Learner: the Definitive Classic in Adult Education and Human Resource Development* (6th Ed.). San Diego: Elsevier.
- Kirvan, R., Rakes, C. R., & Zamora, R. (2015). Flipping an algebra classroom: Analyzing, modeling, and solving systems of linear equations. *Computers in the Schools*, 32, 201–223.
- King, Nigel; Brooks, Joanna (2016). Template analysis for business and management students
- Knowles, M. S. 1975. Adult education: New dimensions. *Educational Leadership*. 33: 85-88.
- Knowles, M.S. 1976. Separating the amateurs from the pros in training. *Training & Development Journal*. 30(9): 16.
- Knowles, M. S. (1980). *The modern practice of adult education: From pedagogy to andragogy* (2nd ed.). New York, NY: Cambridge Books.
- Langpaap, J (2005). Real-life Aspects in Number Stories in an Adult Math-Avoider – A Case Study, *Adults Learning Mathematics (ALM) 12 Proceedings*, Melbourne, Australia, pp. 180-187.
- Lundin, M. Bergviken Rensfeldt, A. Hillman, T. Lantz-Andersson, A. & Peterson, L. (2018). Higher education dominance and siloed knowledge: a systematic review of flipped classroom research. *International Journal of Educational Technology in Higher Education*
- Lo, C. K., & Hew, K. F. (2017). A critical review of flipped classroom challenges in K-12 education: Possible solutions and recommendations for future research. *Research and Practice in Technology Enhanced Learning*, 12(4), 1–22.

- Long, T., Cummins, J. and Waugh, M. (2017), “Use of the flipped classroom instructional model in higher education: instructors’ perspectives”, *Journal of Computing in Higher Education*, Vol. 29 No. 2, pp.179-200
- Maloney, E.A., Ansari, D., & Fugelsang, J.A. (2011). The Effect of Mathematics Anxiety on the Processing of Numerical Magnitude, *Quarterly Journal of Experimental Psychology* 64(1), pp. 10–16.
- Maloney, E.A. & Beilock, S.L. (2012). Math Anxiety: Who has it, why it develops, and how to guard against it, *Trends in Cognitive Sciences* 16(8), pp. 404–406. 406
- Maloney, E.A., Ramirez,G., Gunderson, E.A., Levine, S.C. & Beilock, S.L. (2015). Intergenerational Effects of Parents’ Math Anxiety on Children’s Math Achievement and Anxiety. *Psychological Science* 26, pp. 1480–1488
- Mann, L.C. and Walshaw, M., 2019. Mathematics anxiety in secondary school female students: issues, influences and implications. *New Zealand Journal of Educational Studies*, 54(1), pp.101-120.
- Mammarella, S. Caviola, A. Dowker (Eds.), *Mathematics Anxiety : what is known, and what is still missing*. (pp. 20-41). New York, NY: Routledge
- Markovits, Z. (2011). Beliefs hold by pre-school prospective teachers toward mathematics and its teaching. *Procedia—Social and Behavioral Sciences*, 11, 117–121.
- Marshall, N., Buteau, C., Jarvis, D. H., & Lavicza, Z. (2012). Do mathematicians integrate computer algebra systems in university teaching? Comparing a literature review to an international survey study. *Computers & Education*, 58(1), 423-434.
- Mattarella-Micke, A., Mateo, J., Kozak, M. N., Foster, K., and Beilock, S. (2011). Choke or thrive? The relation between salivary cortisol and math performance depends on individual differences in working memory and math-anxiety. *Emotion* 11, 1000–1005. doi: 10.1037/a0023224
- Mazzocco, M.M.M. (2007). Defining and Differentiating Mathematical Learning Disabilities and Difficulties, in D.B. Berch & M.M.M. Mazzocco (eds.), *Why is Math so hard for some Children? The Nature and Origins of Mathematical Learning Difficulties and Disabilities*, Baltimore: Paul H. Brookes, pp. 29-47.

- McAdams, D.P. (1993). *The Stories we live by: Personal Myths and the making of the Self*, New York: The Guilford Press. McAdams, D.P. (1996). *Personality, Modernity, and the Storied Self: A Contemporary Framework for Studying Persons*, *Psychological Inquiry* 7(4), pp. 295-321.
- McAdams, D.P. (2012). *Exploring Psychological Themes through Life Narrative Accounts*. In J.A. Holstein & J.F. Gubrium (eds.) *Varieties of Narrative Analysis*, London: Sage, pp. 15-32
- McCasUn, M., & Hickey, D. T. (2001). Educational psychology, social constructivism, and educational practice: A case of emergent identity. *Educational Psychologist*, 36,133-140
- McGarr, O. (2009). A review of podcasting in higher education: Its influence on the traditional lecture. *Australasian Journal of Educational Technology*, 25, 309–321.
- McNeal, R.B. (1999). Parental involvement as social capital: Differential effectiveness on science achievement, truancy, and dropping out, *Social Forces*, 78 (1), 117-144.
- Moira Munro and Tania Fisher, “Leaving University early: Exploring the differences between continuing and non-continuing students”, *Studies in Higher Education* 29, no. 5, (2004): 617-636
- Neufeld, B., Paige, C., Rapke, T., Karrass, M., & Hall, J. (2018). Exploring wellness practices with pre-service teachers to manage mathematics anxiety. *Canada International Conference on Education 2018*, Infonomics Society, 490-494.
- OECD, (2009) *PIAAC Numeracy: A Conceptual Framework*, 2009. OECD Working Papers, No.35, OECD Publishing, OECD.
- OECD. (2013). *PISA 2012 Results: Ready to learn: Students’ engagement, drive and self-beliefs (Volume III)*, PISA, OECD Publishing.
- OECD. (2015). *PISA in Focus: Does math make you anxious?* 48, OECD Publishing
- O’ Donoghue, J. (1999). *An Intervention to assist ‘at risk’ Students in Service Mathematics Courses at the University of Limerick: Teaching Fellowship Report*, Ireland: U.L.
- O’Donoghue, J. (2011). *Literacy and Numeracy – Beyond Definitions?* Paper presented at SCOTENS conference, Cavan, Ireland, pp. 41-48.

- O'Donoghue, John. (2018). Chapter 3. Contemporary Research in Adult and Lifelong Learning of Mathematics. *International Perspectives*: p39-58
- O'Meara, N., O. Fitzmaurice, and P. Johnson. 2017. "Old Habits Die Hard: An Uphill Struggle Against Rules Without Reason in Mathematics Teacher Education." *European Journal of Science and Mathematics Education* 5 (1): 91–109.
- Organization for Economic Co-operation and Development. (2013a). *OECD skills outlook 2013: First results from the survey of adult skills*. Paris, France: Author.
- Organization for Economic Co-operation and Development. (2013b). *PISA 2012 results: Ready to learn: Students' engagement, drive and self-beliefs (Vol. 3)*. Paris, France: Author.
- Piaget, J. (1952). The origins of intelligence in children (Vol. 8, No. 5, pp. 18-19).
- Petronzi, D., Hunt, T. E. & Sheffield, D. (2021). Interventions to address mathematics anxiety: An overview and recommendations. In S.A . Kiray & E. Tomevska-Ilievska (Eds .), *Current Studies in Educational Disciplines 2021* (pp. 169–194). ISRES Publishing.
- Pletzer, B., Kronbichler, M., Nuerk, H.-C., and Kerschbaum, H. H. (2015). Mathematics anxiety reduces default mode network deactivation in response to numerical tasks. *Front. Hum. Neurosci.* 9:202. doi: 10.3389/fnhum.2015.00202
- Pletzer, B., Wood, G., Moeller, K., Nuerk, H. C., and Kerschbaum, H. H. (2010). Predictors of performance in a real-life statistics examination depend on the individual cortisol profile. *Biol. Psychol.* 85, 410–416. doi: 10.1016/j.biopsycho.2010.08.015
- Lipnevich, A. A., MacCann, C., Krumm, S., Burrus, J., & Roberts, R. D. (2011). Mathematics attitudes and mathematics outcomes of US and Belarusian middle school students. *Journal of Educational Psychology*, 103 (1), 105. Retrieved from https://www.researchgate.net/profile/Jeremy_Burrus/publication/232478953 New York: International Universities Press.
- Parsons, S., & Bynner J. (2005) *Does numeracy matter more?* London: National Research and Development Centre for Adult Literacy and Numeracy.

- Prendergast, M. (2011). Promoting Student Interest in Mathematics: A Framework for Effective Teaching of Algebra at Junior Cycle, Unpublished Ph.D. Dissertation, University of Limerick, 2011.
- Prendergast, M., & O'Donoghue, J. (2014). Unravelling the myth of effective teaching in mathematics. *Irish Journal of Academic Practice*, 3(1), 8. <http://dx.doi.org/10.21427/D7WX43>
- Prendergast, M., P. Johnson, O. Fitzmaurice, M. Liston, L. O'Keeffe, and N. O'Meara. (2014). "Mathematical Thinking: Challenging Prospective Teachers To Do More Than 'Talk the Talk'." *International Journal of Mathematical Education in Science and Technology* 45 (5): 635–647.
- Prendergast, M., M. Ní Ríordáin, A. Ní Shúilleabháin, P. Johnson, and I. O' Rourke. (2020). "An Attitudinal Snapshot of Pre-service Secondary Mathematics Teachers." *Issues in Educational Research* 30 (1): 283–301.
- Pullen, C., Varley-Winter, O., Khwaja, R., & Donovan, C. (2013). *Young people and vocational choices in Ireland*. London: City & Guilds Centre for Skills Development.
- Richardson, F.C. & Suinn, R.M. (1972). The Mathematics Anxiety Rating Scale: Psychometric data. *Journal of Counseling Psychology*, 19(6), 551-554.
- Ramirez, G. & Beilock, S.L. (2011). Writing about Testing Worries Boosts Exam Performance in the Classroom, *Science* 331, pp. 211–213.
- 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), pp. 187-202.
- Ritt, E. (2008). Redefining tradition: Adult learners and higher education. *Adult Learning*, 19, 12-16
- Ryan, M., & Fitzmaurice, O. (2017) Behind the numbers. The preliminary findings of a mixed methods study investigating the existence of mathematics anxiety among mature students. *Adults Learning Mathematics: An International Journal*, 12(1), 49-58
- Ryan, M. D., Fitzmaurice, O. & Johnson, P. (2019). Divorce, evil and the regime of terror: personal characterisations of mathematics in the lives of mature students. *Adults Learning Mathematics: An International Journal*, 14(1), 34-40.

- Russell, R. (2009). Why do Parents help their Children with Maths? In M. Joubert, (ed.). Proceedings of the British Society for Research into Learning Mathematics 29(2), June 2009 (BSRLM). sourced at <https://bsrlm.org.uk/wp-content/uploads/2016/02/BSRLM-IP-29-2-13.pdf> 15/09/2020.
- Russell, L. (2017). Pedagogical leadership of VET within a confused FET context. *The Irish Journal of Adult and Community Education*, 43–57. Retrieved from https://www.aontas.com/assets/resources/Adult-LearnerJournal/14218_Aontas_Adult_Learner_2017_Final.pdf
- Smyth, E., & Banks, J. (2012). High stakes testing and student perspectives on teaching and learning in the Republic of Ireland. *Educational Assessment, Evaluation and Accountability*, 24(4), 283-306.
- Smyth, E., Banks, J., & Calvert, E. (2011). From Leaving Certificate to leaving school: A longitudinal study of sixth year students. Economic and Social Research Institute (ESRI) Research Series.
- SOLAS (2014) Further Education and Training Strategy 2014–2019, Department of Education and Skills, Dublin
- SOLAS (2018) Progress Review of the Further Education and Training Strategy 2014 – 2018 https://www.solas.ie/f/70398/x/fd331c2bf7/fet-review_final_10_5-7.pdf
- SOLAS (2021) Good Practice in Integrated and Standalone Numeracy Provision at Levels 1-3 Background Report, Guidelines and Recommendations, <https://www.solas.ie/f/70398/x/75f591a099/solas-numeracy-report.pdf>
- Spicer, J., 2004. Resources to combat math anxiety. *Eisenhower National Clearinghouse Focus*, 12(12).
- Stewart, D. W., Shamdasani, P. N., & Rook, D. W. (2007). *Focus groups: Theory and practice* (Vol. 20). Thousand Oaks, CA: Sage.
- Strauss, A. and Corbin, J. (1998) *Basics of Qualitative Research*, 2nd edn. London: Sage.
- Suinn, R.M., Edie, C.A., Nicoletti, E., & Spinelli, P.R. (1972). The MARS, a Measure of Mathematics Anxiety: Psychometric Data, *Journal of Clinical Psychology* 28, pp. 373- 375.

- Suinn, R.M. & Edwards, R. (1982). The Measurement of Mathematics Anxiety. The Mathematics Anxiety Rating Scale for Adolescents-MARS-A, *Journal of Clinical Psychology* 38, pp. 576-577.
- Suinn, R.M., Taylor, S. & Edwards, R.W. (1988). Mathematics Anxiety Rating Scale for Elementary School Students (MARS-E): Psychometric and Normative Data, *Educational and Psychological Measurement* 48(4), pp. 979-986.
- Suinn, R.M. & Winston, E.H. (2003). The Mathematics Anxiety Rating Scale, a Brief Version: Psychometric data. *Psychological Reports* 92, pp. 167-173.
- Teddlie, C. & Tashakkori, A. (2009). *The Foundations of Mixed Methods Research: Integrating Quantitative and Qualitative Techniques in the Social and Behavioral Sciences*. Thousand Oaks, CA: Sage
- Thode HJ. *Testing for normality*. New York: Marcel Dekker; 2002.
- Thompson R., Wylie J., Hanna D. (2016). Maths anxiety in psychology undergraduates: A mixed-methods approach to formulating and implementing interventions. *Psychology Teaching Review*, 22, 58–68.
- Tobias, S. (1985). Test Anxiety: Interference, Defective Skills and Cognitive Capacity, *Educational Psychologist* 20, pp. 135-142.
- Tobias, S. (1993). *Overcoming Math Anxiety*, New York: W.W. Norton.
- Tobias, S., & Weissbrod, C. (1980). Anxiety and mathematics: an update. *Harvard Educational Review*, 50(1), 63-70
- Tout, D. (2020). Evolution of adult numeracy from quantitative literacy to numeracy: Lessons learned from international assessments. *International Review of Education*, 66(2), 183–209.
- Tse, W.S., Choi, L.Y.A. and Tang, W.S. (2017), “Effects of video-based flipped class instruction on subject reading motivation”, *British Journal of Educational Technology*, Vol. 50 No. 1, pp. 385-398
- Turner, J.C., Midgley, C., Meyer, D.K., Gheen, M., Anderman, E.M., Kang, Y., & Patrick, H. (2002). The classroom environment and students’ reports of avoidance strategies in mathematics: A multimethod study. *Journal of Educational Psychology*, 94, 88–106

- Virginia Braun & Victoria Clarke (2006) Using thematic analysis in psychology, *Qualitative Research in Psychology*, 3:2, 77-101, DOI: 10.1191/1478088706qp063oa
- Vygotsky, L. (1978). Interaction between learning and development. *Readings on the development of children*, 23(3), 34-41.
- Vygotsky, L. (1978). *Mind and society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.
- Walsh, J.N.; O'Brien, M.P.; Slattery, D.M. Video Viewing Patterns Using Different Teaching Treatments: A Case Study Using YouTube Analytics. *Res. Educ. Learn. Innov. Arch.* 2019, 22, 78–95.
- Wilder, S. (2013). Dimensions of Math Anxiety as Measured by the MARS-Brief: Factor Analysis. Sourced at <http://interstat.statjournals.net/YEAR/2013/articles/1308001.pdf> on 09/04/2020 , pp. 1-17.
- Willig, C. 1999: Beyond appearances: a critical realist approach to social constructionism. In Nightingale, D.J. and Cromby J., editors, *Social constructionist psychology: a critical analysis of theory and practice*. Open University Press, 37/51.
- Willig, C. 2003: Discourse analysis. In Smith, J.A., editor, *Qualitative psychology: a practical guide to research methods*. Sage, 159/ 83.
- Zan, R., Brown, L., Evans, J. & Hannula, M. (2006). Affect in Mathematics Education: an Introduction, *Educational Studies in Mathematics* 63(2), pp. 113-121.
- Zaslavsky, C. (1994). *Fear of Math, how to get over it and get on with your Life*. New Brunswick, NJ: Rutgers University Press.
- Zengin, Y. (2017). Investigating the Use of the Khan Academy and Mathematics Software with a Flipped Classroom Approach in Mathematics Teaching. *Educational Technology & Society* 20 (2), pp. 89–100.

Appendices

Appendix 1 Mathematics Anxiety (MA) Intervention Studies, Petronzi et al (2021).

Study	Sample size	Population	Type of intervention	Measures of maths anxiety	Additional outcomes	Main findings
Lavasani & Khandan (2011).	40	Secondary school students (aged 13-14 years), Iran.	Co-operative learning vs. traditional method	“18-item mathematics anxiety scale”.	Help-seeking behaviour.	Co-operative learning resulted in significantly lower MA, decreased help avoidance behaviour and increased help seeking behaviour.
Segumpan & Tan (2018).	90	Secondary school students (aged 12-13 years), Philippines.	Secondary school students (aged 12-13 years), Philippines.	Mathematics Self-Efficacy and Anxiety Questionnaire. (MSEAQ; May, 2009).	Mathematics Self-Efficacy and Anxiety Questionnaire. (MSEAQ; May, 2009).	Significantly lower MA and greater maths performance in the flipped classroom condition compared to the control condition post-intervention.

Passolunghi et al (2020).	224 (3 studies; n = 76, n = 76, n = 72)	Fourth grade children, (aged 9-10 years; mean age = 9.60 years; SD = 0.27). Italy	MA training; maths strategy training.	Abbreviated Math Anxiety Scale (AMAS; Hopko et al., 2003; Caviola et al., 2017).	General anxiety; Primary mental abilities.	Repetition and exposure to maths, including focused training on basic emotions can increase maths ability and decrease MA.
Supekar et al (2015).	28	Third grade children (aged 8-9 years; low & high MA), USA.	Intensive 8-week one-to-one cognitive tutoring program to improve mathematical skills and reduce MA (3 weekly sessions).	Intensive 8-week one-to-one cognitive tutoring program to improve mathematical skills and reduce MA (3 weekly sessions).	Intelligence; Achievement; Working memory; Brain activity	Sustained exposure to mathematical stimuli can reduce MA

Alanazi (2020)	60	First grade primary school children (aged 6-7 years), Saudi Arabia.	Active recreational maths games (24 sessions over 2 months; 3 weekly sessions).	Mathematics Anxiety Scale for Children (Chiu & Henry, 1990); Arabic translated (Adnan & Ibrahim, 1990).	Maths performance.	MA was significantly lower in the intervention group post intervention.
Jansen et al (2013).	207	Grades 3-6 primary school children (aged 6-10 years), Netherlands.	Grades 3-6 primary school children (aged 6-10 years), Netherlands.	The Math Anxiety Scale for Children (Chiu & Henry, 1990); Dutch translated (MASC-NL; Jansen et al., 2013).	Cognitive competence; social competence; general self-worth; maths task performance.	Computer based activity resulted in a small performance improvement, but there was an absence of effect on MA.
Karimi & Kenkatesan (2009).	25	High school students (aged 13-16 years), Iran.	Cognitive Behavioural Group Therapy (CBGT) (15	Mathematics Anxiety Rating Scale (Alexander &	None.	MA reduced following CBGT and suggests that reappraisal may be

			sessions for 1.5 hours).	Martray, 1989).		an effective strategy.
Sheffield & Hunt (2006).	154	Children (aged 10-11 years), UK.	Modified systematic desensitization.	Anxiety Scale for Children (MASC; Chiu & Henry, 1990).	Maths performance.	The use of a physiological strategy resulted in decreased MA and improved performance.
Brunyé et al (2013).	36	University students (low & high MA), mean age = 20.80 years, SD = 2.60. USA.	Breathing exercises.	30-item Mathematics Anxiety Rating Scale (MARS; Suinn & Winston, 2003)-but only to define different groups.	Mood; Arithmetic performance.	Focused breathing improved calmness ratings and mitigated maths anxiety effects on arithmetic performance.
Salazar (2019).	106	UG students (aged 18-45 years; mean age = 21.03	Colouring Mandalas vs. Free form vs.	Abbreviated Math Anxiety Scale (AMAS;	None.	Colouring (both groups) was associated with

		years; SD = 0.49. USA.	Doodle before maths problems.	Hopko et al., 2003).		reduced MA (control was not).
Davis & Kahn (2018).	59	Undergraduate students (aged 18-23 years; mean age = 21 years) USA.	Virtual reality relaxation vs. Passive control.	Math Anxiety Rating Scale - Revised (MARS-R; Plake & Parker, 1982).	Maths performance.	Significantly lower MA and higher maths performance between groups post-intervention.
Gan et al (2016).	105	Undergraduate students (aged 19-31 years; mean age = 22.23 years; SD = 2.08). Singapore.	Stimulating vs. Sedative music vs. No music before maths problems.	Abbreviated MARS (Alexander & Martray, 1989).	State anxiety, blood pressure and heart rate.	Sedative music associated with reduced MA and STAI
Jamieson et al (2016).	93	Community college students (aged 18-58 years; mean age =	Community college students (aged 18-58 years; mean age =	Abbreviated Math Anxiety Scale (Hopko et al., 2003).	Stress appraisals; Maths performance.	MA decreased, coping resources increased and performance improved in reappraisal group

		29.40 years). USA.	= 29.40 years). USA.			compared to suppression control. Resource appraisals mediated performance.
Dorothea (2016).	5	Secondary school students (aged 17-19 years). Italy.	Dramatherapy.	“Personal questionnaire” involving a range of items pertaining to MA/stress; Interview.	Maths self- efficacy	Some descriptive evidence to support a decrease in stress associated with maths, along with increased maths self- efficacy.
Samuel & Warner (2021); Experiment 1.	40	Community college students (mean age 17.92 years). USA.	Combined mindfulness and growth mindset intervention embedded into curriculum vs. Passive Control.	Revised Math Anxiety Rating Scale (RMARS; Alexander & Martray, 1989).	Maths selfefficacy.	MA decreased and self-efficacy decreased in the intervention group but not control group.

Source: Table 1. Mathematics Anxiety (MA) Intervention Studies, Petronzi et al (2021).

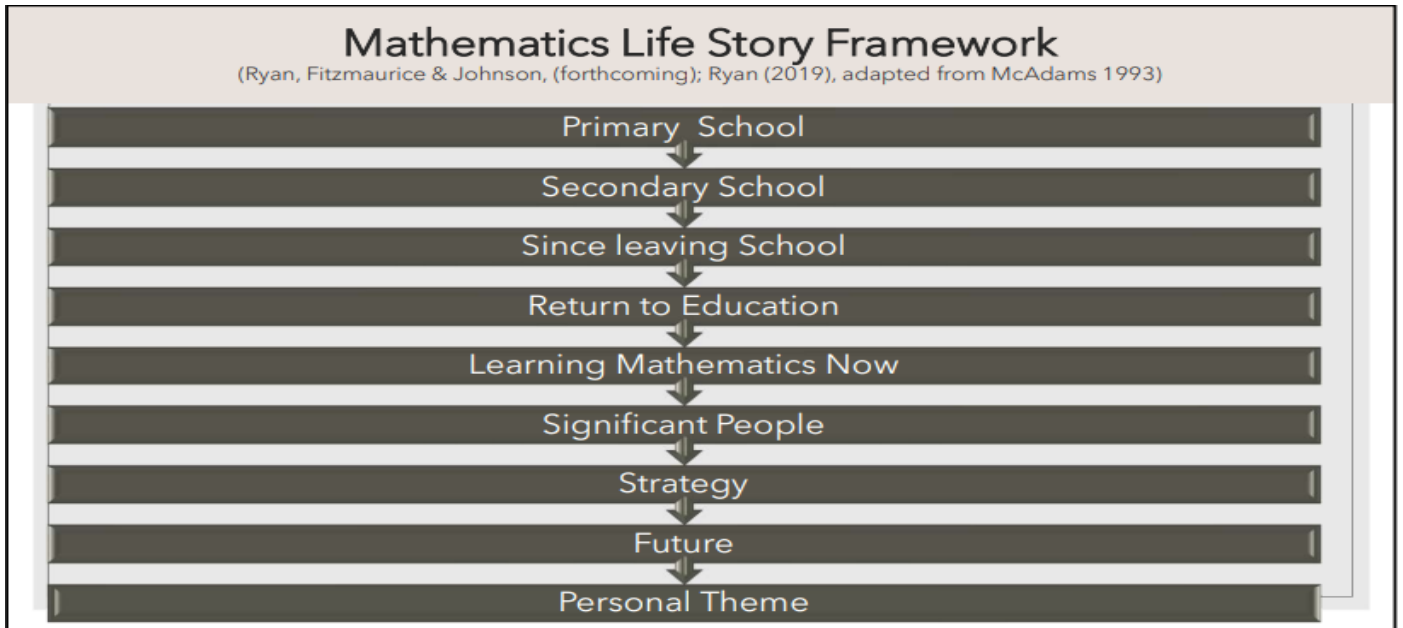
Appendix 2 Mathematics Anxiety Scale-UK (MAS-UK)

How anxious would you feel in the following situations?

Please circle the appropriate numbers below.

	Not at all	Slightly	A fair amount	Much	Very much
1. Having someone watch you multiply 12×23 on paper.	1	2	3	4	5
2. Adding up a pile of change.	1	2	3	4	5
3. Being asked to write an answer on the board at the front of a maths class.	1	2	3	4	5
4. Being asked to add up the number of people in a room.	1	2	3	4	5
5. Calculating how many days until a person's birthday.	1	2	3	4	5
6. Taking a maths exam.	1	2	3	4	5
7. Being asked to calculate $\pounds 9.36$ divided by four in front of several people.	1	2	3	4	5
8. Being given a telephone number and having to remember it.	1	2	3	4	5
9. Reading the word "algebra".	1	2	3	4	5
10. Calculating a series of multiplication problems on paper.	1	2	3	4	5
11. Working out how much time you have left before you set off to work or place of study.	1	2	3	4	5
12. Listening to someone talk about maths.	1	2	3	4	5
13. Working out how much change a cashier should have given you in a shop after buying several items.	1	2	3	4	5
14. Deciding how much each person should give you after you buy an object that you are all sharing the cost of.	1	2	3	4	5
15. Reading a maths textbook.	1	2	3	4	5
16. Watching someone work out an algebra problem.	1	2	3	4	5
17. Sitting in a maths class.	1	2	3	4	5
18. Being given a surprise maths test in a class.	1	2	3	4	5
19. Being asked to memorise a multiplication table.	1	2	3	4	5
20. Watching a teacher/lecturer write equations on the board.	1	2	3	4	5
21. Being asked to calculate three fifths as a percentage.	1	2	3	4	5
22. Working out how much your shopping bill comes to.	1	2	3	4	5
23. Being asked a maths question by a teacher in front of a class.	1	2	3	4	5

Appendix 3 Mathematics Life Story Framework



Guidelines for eliciting the mathematics life story using all themes listed (Ryan, 2019) (Depending on how the conversation is going, you can be selective from the above list. For example, you may focus only on the school experiences and significant people.)

- The conversation could start with: how does mathematics make you feel. This is an open question that can lead in any direction, including addressing some of the other themes listed.
- Following this, you can ask the student in turn to tell you about their experiences of maths at primary school, then secondary school perhaps including the transition from primary to secondary; difficult mathematics topics; state examinations, etc
- Ask if they have engaged with mathematics or numbers since leaving school. This may include reference to further education, training, or work contexts.
- Ask about their decision to return to education, and perhaps the role that mathematics has played in that decision.
- How do they feel about learning mathematics now, in their current programme?
- Ask if they can identify any significant people in terms of their engagement with mathematics. This may include teachers, parents, siblings, friends, celebrities, etc.
- Ask if they have any strategy for engaging with maths what techniques help them to get by, or have helped them to get by in the past; i.e. how they deal with tests or exam situations; or when they get stuck what techniques help them to get by, or have helped them to get by in the past; i.e. how they deal with tests or exam situations; or when they get stuck
- Ask what role they see mathematics playing in their future? For example, in their work or career plans, helping their children, day-to-day budgeting, etc.
- This is a nice way to round up the conversation - ask the student to characterise or give a personal theme to their relationship with mathematics. They may use a symbolic image (e.g. mount Everest, a brick wall) or analogy (e.g. a love-hate relationship; red rag to a bull).

References McAdams, D.P. (1993). *The Stories we live by: Personal Myths and the making of the Self*, New York: The Guilford Press. Ryan, M.D. (2019). *An Investigation into the Extent and Derivation of Mathematics Anxiety among Mature Students in Ireland*. Unpublished Doctoral Dissertation, University of Limerick, Limerick.

Appendix 4 Codes from thematic analysis

Name	Code(s)
Linda	Mathematics Anxiety
Linda	Stressed in front of class
Linda	Mathematics Anxiety
Linda	Strict Control
Linda	Lack of Support
Linda	Giving Right Answer
Linda	Nervous Teacher/Teacher Anxiety
Linda	Lack of classroom management
Linda	Teacher relationship
Linda	Mathematics Anxiety
Linda	Rote Learning
Linda	Lack of support from home
Linda	Teacher Style
Linda	Lack of confidence
Linda	Positive Influence
Linda	Different ways of doing maths
Linda	Teacher Style
Linda	Relaxed and able to concentrate/focus
Linda	Start maths from beginning
Linda	Self-Efficacy
Linda	Teacher Style
Linda	Mistake is wrong!
Linda	Correctness
Linda	Cultural Expectations/In Poland it was like mistake is wrong
Linda	Positive impact of boyfriend & current Teacher
Linda	Negative impact of old Teacher
Linda	Self-Efficacy
Brendan	Positive view on maths
Brendan	Very friendly environment
Brendan	Teacher Style/Positive influence of Teachers
Brendan	Relaxed environment
Brendan	Good learning atmosphere
Brendan	Positive Learning Environment
Brendan	Strong at Maths
Brendan	Positive impact of 'Grinds' (Private Tuition)
Brendan	Personal Issues have negative impact on maths
	Importance of 'Higher Level' Mathematics

Brendan	Importance of practice based maths
Brendan	Positive impact of brother/family support
Brendan	Positive impact of 'Grinds' (Private Tuition)
Stephen	Teacher relationship
Stephen	Mathematics Anxiety before VTOS
Stephen	Nervous about mathematics
Stephen	Going back to basics/principals/fundamentals/rudiments
Stephen	Corporal punishment 'Big Stick'
Stephen	Severe consequences
Stephen	Autocratic/Strict Teacher
Stephen	Good relationship with 'lay' teacher
Stephen	Bad relationship with 'Brother'
Stephen	Personal Injury
Stephen	Corporal punishment
	Enforcement
	'Feel good about yourself'
Stephen	Streaming
Stephen	Corporal punishment
Stephen	Motivated by fear
Stephen	extreme disciplinarian
Stephen	Expectations of Father to be an Accountant
Stephen	Anxiety of gulf between ordinary and higher level
Stephen	Father had expectations for him to do higher level
Stephen	Teacher not allowing questioning
	Lack of interest
	Teacher inducing fear into students
Stephen	
Stephen	Emphasis on Maths
	Trepidation/Worry/Apprehensive
Stephen	Importance of Maths
	Falling behind
Stephen	
Stephen	Constant Struggle
	Mathematics Language
Stephen	Nervous about Leaving Cert/Sense of Failure
	Trepidation/Worry/Apprehensive
Stephen	
Stephen	Nervous about Leaving Cert
Stephen	Apprehensive about maths

Stephen	Past negative experience in leaving cert maths
Stephen	Feels disciplinary methods work for him
Stephen	Nuns were disciplinarian were good teachers
Stephen	Democratic Teacher motivated him and made him feel great about himself
Stephen	Laizze Faire Teacher who had no interest in Maths and didn't teach him anything
Stephen	Avoiding maths due to negative experiences
Stephen	Poor strategy- doesn't engage in maths outside of class
Stephen	Language of maths is difficult
Stephen	Doesn't like to come out of his comfort zone.
Stephen	If you look at those maths papers, you 'will get hurt'
Stephen	Doesn't give maths time it needs
Stephen	Lack of engagement
Stephen	Wiping out Ghost's
David	Negative outcomes resulted in maths anxiety
David	Self-Efficacy
David	Low Confidence
David	Societal and Cultural Expectations in India
David	Strict and humiliating practice
David	'Lower' students not allowed to ask questions
David	Strictness
David	Made feel stupid
David	Unorganised Teacher
David	Private Tuition
David	Unmotivated Teacher
David	Parental pressure
David	Experience in VTOS reducing Mathematics Anxiety
David	Private Tuition
David	Confidence
David	Teacher explains methods (Positive)
David	Low Confidence from negative learning outcomes
David	Disengagement due to negative learning outcomes
David	Correctness/Disengagement
David	Peer/Friend Support
David	Lack of Scaffolding

David	Benefits of Active Learning
David	Teacher style
David	Teacher Style
David	Understanding maths
David	Negative consequences of Rote learning
Thomas	Dislike of Maths
Thomas	Perception of 'Maths not for me'
Thomas	Avoidance of Maths
Thomas	Math Anxiety
Thomas	Incorrect answer leading to embarrassment towards peers
Thomas	Lack of adequate facilities
Thomas	Avoidance of Maths
Thomas	Avoidance of Maths because perception of being 'bad' at maths
Thomas	Career Implications
Thomas	Avoidance of Maths
Thomas	Self Efficacy
Thomas	Educational implication due to self-efficacy in Maths
Thomas	Motivated to learn maths in order to help his kids with maths
Thomas	Avoidance of Maths
Thomas	No history of sibling or parents in formal education lead to lack of support/influence
Thomas	Now understands that maths is very interesting as an Adult but didn't as a child
Thomas	Strict Teachers/ scared from teachers from getting it wrong
Thomas	Corporal Punishment 'big stick from trees'
Thomas	Correctness
Thomas	Motivated to help children/family

Thomas	Self Efficacy
Stacy	Confused and Anxious
Stacy	Maths Anxiety
Stacy	Confused
Stacy	Math Anxiety having to stand in front of class
Stacy	Embarrassment
Stacy	Correctness
Stacy	Embarrassment
Stacy	Correctness
Stacy	Teacher Style
Stacy	Embarrassment
Stacy	Lack of support due to large class size (n=33)
Stacy	Support/Positive outcome
Stacy	Large Class size
Stacy	Confused
Stacy	Lack of support
Stacy	Have to learn for yourself no one will help you in the real world.
Stacy	Teacher Style
Stacy	Lack of support
Stacy	different method not allowed by teacher: we get same answer, they rip it out, make you do it again
Stacy	Correctness
Stacy	Lack of support
Stacy	Maths Avoidance
Stacy	Lack of support from Mom and Dad
Stacy	YouthReach positive experience
Stacy	Small Class size: positive experience
Stacy	Teacher Style
Stacy	Motivated to help siblings
Stacy	High Maths Anxiety due to state exams
Stacy	Lack of Teacher support
Stacy	Anxiety of State Exams
Stacy	Teacher Style/YouthReach
Stacy	Peer Support in YouthReach had a positive experience
Stacy	Motivated to help future children
Robert	Anxiety of State Exams
Robert	Injury impacts on Maths Development
Robert	Irrelevance of Maths impacted on lack of motivation
Robert	Lack of motivation for State Exams
Robert	Relevance of maths motivating
Robert	Lack of support from Guardians
Robert	Active Learning effective for learner
Robert	Active Learning effective
Robert	Teacher style
Robert	Importance of maths motivating

Robert	Math Anxiety towards state exam
Sarah	Strict Teacher/Discipline
Sarah	Loss of interest in maths due to very disciplined education
Sarah	Confusion in maths due to varying approaches
Sarah	Strict Teacher/Discipline: Not allowed to ask question
Sarah	Lack of Teacher Support
Sarah	Rote Learning
Sarah	Cultural Expectations
Sarah	Correctness
Sarah	Discipline/Correctness
Sarah	Correctness
Sarah	Self-Efficacy
Sarah	Strict/Rules
Sarah	Higher Level Maths
Sarah	Real Life Maths
Sarah	Society/Cultural Expectations
Sarah	Support from Parents
Sarah	Anxiety due to assessment
Sarah	Avoidance

Appendix 5 Phase 3: Searching for themes

<p>Theme: Self-Efficacy</p> <p>Codes:</p> <ul style="list-style-type: none"> ● Strong at Maths ● Lack of confidence ● Start maths from ‘beginning’ ● Strong at Maths ● Fear of falling behind ● Apprehensive about maths ● Past negative experience in leaving cert maths ● Low Confidence from negative learning outcomes ● Disengagement due to negative learning outcomes 	<p>Theme: Learning Culture</p> <p>Codes:</p> <ul style="list-style-type: none"> ● Strict Control ● Teacher Relationship ● Lack of classroom management ● Positive Learning Environment ● Unorganised Teacher ● Importance of Practice based maths ● Very friendly environment ● Teacher inducing fear into students ● Bad relationship with a ‘Brother’ in school (catholic school) ● Corporal Punishment ● Autocratic Teacher 	<p>Theme: Personal Issues</p> <p>Codes:</p> <ul style="list-style-type: none"> ● Personal Issues/Injury ● Lack of interest ● Doesn’t like to come out of their comfort zone. ● Doesn’t give maths the time it needs ● Perception of ‘Maths not for me’ ● Importance of maths ● Injury impacts on Maths ● Irrelevance of Maths impacted on lack of motivation
<p>Theme: Support Outside Classroom</p> <p>Codes:</p> <ul style="list-style-type: none"> ● Positive impact of grinds ● Positive impact of brother/family support ● Falling Behind ● Constant Struggle ● Parental Pressure ● Lack of support from mom and dad ● No history of education in family 	<p>Fear of Maths Exams</p> <p>Codes:</p> <ul style="list-style-type: none"> ● Incorrect answer leading to embarrassment towards peers ● Nervous about Leaving Cert ● Anxiety of State Exams ● Nervous about Leaving Cert/Sense of Failure ● Past negative experience in leaving cert maths 	<p>Theme: Traditional/Non Traditional Learning</p> <p>Codes:</p> <ul style="list-style-type: none"> ● Rote Learning ● Very friendly environment ● Importance of Practice based maths ● Corporal Punishment ● Autocratic Teacher ● ‘Big Stick’ ● Severe Consequences ● Teacher inducing fear into students ● Benefits of active learning
<p>Theme: ‘Correctness’</p> <p>Codes:</p> <ul style="list-style-type: none"> ● Giving the right answer: ● Incorrect answer leading to embarrassment towards peers ● Strict Teachers/ scared from teachers from getting it wrong ● Discipline/Correctness ● Strict rules 	<p>Theme: Cultural/Societal Expectations</p> <p>Codes:</p> <ul style="list-style-type: none"> ● Father had high expectations to work as an accountant ● Cultural expectations ● Society expectations 	<p>Theme: Motivations</p> <p>Codes:</p> <ul style="list-style-type: none"> ● Lack of interest ● Motivated by Fear ● Unmotivated Teacher ● Career Implications ● Lack of motivation for State Exams

Appendix 6 Sample Timeline

The below is a sample timeline which may give you an idea of what a timeline would look like. Please take your time in reflecting on your past experiences in order to develop your own timeline.

- Born in 1988
- 1996 Found high or low level of Mathematics Anxiety due to a Teacher
- 1997 Found high or low level of Mathematics Anxiety studying for test
- 2001 Junior cert or finished equivalent study in home country (ESOL learner)
- 2002 Found Algebra easy/difficult
- 2004 Found Parents supportive/not supportive in Mathematics
- 2005 I received extra support with Mathematics/I got help with my SNA
- 2006 Leaving Cert/Leaving Cert Applied or finished equivalent study in home country (ESOL learner)
- 2006 I got grinds/private tuition in Mathematics
- 2009 Considered that I wasn't 'good' at maths
- 2010 I went to a College of Further Education and found a module in Maths easy/ok/hard
- 2012 Went to an Institute of Technology and found maths related modules easy/difficult
- 2014 Recently undertook an online Maths Class during COVID and found learning mathematics online easy/ok/hard

RESEARCH PRIVACY NOTICE

Note for PI when completing this Privacy Notice Template:

- You should first read the *Guidance on the Research Privacy Notice*
- Please review all prompts marked in yellow and populate so that they accurately reflect the proposed research project to go before the REC.
- Material which is italicised in the template below is mandatory for inclusion, and the wording should not be changed or deleted.
- Once the Research Privacy Notice template has been populated, please delete this comment box and any remaining yellow prompts. Include your edited Research Privacy Notice as an attachment with your Research Ethics Approval submission to the REC.

Introduction

This Research Privacy Notice governs the use and storage of your personal data by the University of Limerick (the “University”). The processing of this data is carried out in accordance with the General Data Protection Regulation (GDPR) / Data Protection Acts 1988-2018 (“Data Protection Law”) and in accordance with this Research Privacy Notice.

Any personal data which you provide to the University as part of this research project will be treated with the highest standards of security and confidentiality, in accordance with Irish and European Data Protection Law. This Notice sets out details of the information that we collect, how we process it and who we share it with. It also explains your rights under data protection law in relation to our processing of your data.

1. Title and Purpose of the research project

Exploring mathematics anxiety amongst a group of adult learners and the potential associated environmental antecedents

2. Research Ethics Committee

2.1 Ethical approval was granted by [EHS Research Ethics Committee] on [9th November 2021]. The research ethics approval number is [2021_04_03_EHS (ER)].

3. Identity of the Data Controller(s)

3.1 The Data Controller is:

- University of Limerick, Plassey, Limerick.

4. Identity and Contact Details of the Data Protection Officer of the Data Controller(s)/

4.1 You can contact the University of Limerick's Data Protection Officer at dataprotection@ul.ie or by writing to Data Protection Officer, Room A1-073, University of Limerick, Limerick.

5. The Identity of the Principal Investigator

5.1 The Principal Investigator for this Research Project is Dr Raymond Lynch, School of Education, Lecturer And EHS Dean Academic Affairs.

6. How we will use your personal data

6.1 The University must process your personal data in order to undertake research relating to this project/study. The MAS UK questionnaire should take approximately 20 minutes for learners to complete and a Mathematics Life Story Framework interview should take approximately 40- 60 minutes individually with each learner.

6.2 The personal data collected and used in this research will include: demographic data such as age, sex, email address and leaving certificate group.

6.3 You provide us with your personal data to enable us to undertake the research project. Participation in this research project is voluntary and participants may withdraw without giving any reason. Should you wish to withdraw, you may do so by contacting the Principal Investigator at raymond.lynch@ul.ie or in writing to Dr Raymond Lynch, School of Education, Room DM-032, Main Building, University of Limerick.

7. Lawful Basis for University Processing Personal Data

7.1 *Data Protection Law requires that the University must have a valid legal reason to process and use your personal data. This is often called a 'lawful basis'. GDPR requires us to be explicit with you about the lawful basis upon which we rely in order to process information about you.*

7.2 *The University is carrying out this research in the public interest and for scientific, historical or statistical purposes. In doing so, we are relying on Article 6(1)(e) of the GDPR. Where we are processing special category or sensitive personal data, we are relying on Article 9(2)(j) of GDPR. As required under Data Protection Law, we have appropriate safeguards in place in order to protect your personal data; these are set out in the next section.*

8. Protecting Your Personal Data

8.1 *We have the following measures in place to help ensure we keep your personal data safe:*

- *All researchers at the University must adhere to University policies and procedures that tell our staff and students how to collect and use your information safely;*
- *Training is made available to all researchers to ensure our staff and students understand the importance of data protection and how to protect your personal data;*
- *The University has security arrangements and technical measures in place that ensure your information is stored safely and securely;*
- *All research projects involving personal data are reviewed and approved by a research ethics committee in line with University policies and procedures;*
- *Where a research project may involve a high risk, we first carry out a data protection impact assessment to assess risks and ensure adequate safeguards are in place;*
- *Where your personal data is processed for health research, we will always obtain your explicit consent in advance (in line with the Health Research Regulations 2018).*

8.2 Personal data collected for this research project will be pseudonymised within one month after collection and will be fully anonymised within 12 months. Truly anonymised data is not Personal Data. Once data is anonymised for the purposes of this research project, the terms of this Privacy Notice will no longer apply.

9. Sharing Your Personal Data with Third Parties

9.1 The University will not disclose your personal data to third parties. [Anonymous data may be shared with third parties. In this situation, you will not be identifiable from any data we share with the third party.]

10. Transfer of personal data to Other Countries Outside the EEA

- Not applicable

11. How Long Will We Keep Your Data

11.1 All Personal Data collected for this research project will be retained for 7 years.

12. Your Rights

12.1 *Depending on the lawful basis which we rely on to process your Personal Data, you may have the right to request that we:*

- *provide you with information as to whether we process your data and details relating to our processing, and with a copy of your personal data;*
- *rectify any inaccurate data we might have about you without undue delay;*
- *complete any incomplete information about you;*
- *under certain circumstances, erase your Personal Data without undue delay;*
- *under certain circumstances, be restricted from processing your data;*
- *under certain circumstances, furnish you with the Personal Data which you provided us within a structured, commonly used and machine readable format;*

12.2 *Requests for any of the above should be addressed by email to the Principal Investigator at raymond.lynch@ul.ie AND the Data Protection Officer at dataprotection@ul.ie. Your request will be processed within 30 days of receipt. Please note, however, it may not be possible to facilitate all requests, for example, where the University is required by law to collect and process certain personal data including that personal information that is required of any research participant.*

12.3 *It is your responsibility to let the Principal Investigator know if your contact details change.*

13. Queries, Contacts, Right of Complaint

13.1 *Further information on Data Protection at the University of Limerick may be viewed at www.ul.ie/dataprotection. You can contact the Data Protection Officer at dataprotection@ul.ie or by writing to Data Protection Officer, Room A1-073, University of Limerick, Limerick.*

13.2 *You have a right to lodge a complaint with the Office of the Data Protection Commissioner (Supervisory Authority). While we recommend that you raise any concerns or queries with us first at the following email address raymond.lynch@ul.ie, you may contact that Office at info@dataprotection.ie or by writing to the Data Protection Commission, 21 Fitzwilliam Square South, Dublin 2, D02 RD28.*

Appendix 7 Information Email (VTOS Coordinator)

Date: TBC

Research title: *Exploring mathematics anxiety amongst a group of adult learners and the potential associated environmental antecedents*

Dear Co-ordinator,

As you are aware, I am enrolled as a student of the Structured Masters by Research Programme in the School of Education, University of Limerick, under the supervision of Dr. Raymond Lynch and Dr. Orla McCormack. Over the coming months, I aim to undertake a research study to explore mathematics anxiety and any potential environmental antecedent factors with adult learners in a VTOS setting. The target participants are students studying for the Leaving Certificate as part of the Vocational Training Opportunities Scheme (VTOS).

The study aims to investigate the extent of mathematics anxiety which exists among adult learners in a VTOS setting. Furthermore, the study seeks to explore the environmental antecedents factors that may contribute to mathematics anxiety through the use of a Mathematics Life Story Framework for qualitative interviews. The Guidance Counsellor and AISS (Active Inclusion Support Service) will be made aware of the study and are available to meet with any student who experiences difficulties as a result of the study.

The study will be carried out through the use of a 23 items (MAS UK Questionnaire), which asks the learner their level of anxiety on a scale from 1 to 5 from 'not at all' to 'very much'. In conjunction, a Mathematics Life Story Framework will be held with consenting participants to capture richer qualitative data on participants' perspectives. The Guidance Counsellor and AISS (Active Inclusion Support Service) will be made aware of the study and are available to meet with any student who experiences difficulties as a result of the study.

The below timeline attempts to provide an indicative overview of the research study, which aims to include a Pilot Programme. The MAS UK questionnaire should take approximately 20 minutes for participants to complete, and each Mathematics Life Story Framework interview should take between 40 and 60 minutes.



All information gathered will be held in the strictest of confidence and pseudonyms will be used to ensure anonymity. Mathematics Life Story Interview and Questionnaires will be recorded and stored on a secure UL OneDrive folder. The data will be held and destroyed after completion of the study in accordance with the UL data retention policy. Participation in the study is completely voluntary and participants can withdraw from the research at any time.

The results from this research study will be reported in my final dissertation and may also be disseminated through other professional publications. It is important to note that the school's name and the name of the individual participants will not be identified in any publication and the school will not be identifiable to anyone other than those directly involved.

I am seeking your permission to conduct this study in the school. If you approve this study being conducted in Limerick City VTOS could I please request that another Mathematics Teacher could forward the attached documentation (information sheet, consent form and research privacy statement) via email to learners in due course.

If you have any questions in relation to this study, please contact me, or my supervisor, on the details below.

Kind regards

Researcher:

Supervisor:

Appendix 8 Recruitment Email



Recruitment Email (sent to students by a teacher who doesn't teach them)

Date: TBC

Research title: *Exploring mathematics anxiety amongst a group of adult learners and the potential associated environmental antecedents*

Dear Student,

I am contacting you on behalf of Adrian O'Hanlon to see if you would be willing to participate in a research study he is conducting as part of his Structured Masters by Research Programme in the School of Education, University of Limerick, under the supervision of Dr. Raymond Lynch and Dr. Orla McCormack.

Over the coming months, Adrian is hoping to undertake a research study on I aim to undertake a research study on *Exploring mathematics anxiety amongst a group of adult learners and the potential associated environmental antecedents*, as outlined in the attached information sheets. Please see the attached information sheet which gives in depth detail on both phases of the study. If you are interested in taking part in the study, please complete and return the attached consent form.

Kind regards,

Greg Dillon

AISS Support

Volunteer Information Sheet (Full study)

Research Title: *Exploring mathematics anxiety amongst a group of adult learners and the potential associated environmental antecedents*

Dear student,

I am enrolled as a student of the Structured Masters by Research Programme in the School of Education, University of Limerick, under the supervision of Dr. Raymond Lynch and Dr. Orla McCormack. Over the coming months, I am attempting to undertake a research study Exploring mathematics anxiety amongst a group of adult learners and the potential associated environmental antecedents

What is the study about? The study aims to explore mathematics anxiety amongst a group of adult learners and the potential associated environmental antecedents

What will I have to do? Your involvement in the study would be to complete a questionnaire which has 23 statements which asks the learner their level of anxiety on a scale from 1 to 5 from 'not at all' to 'very much', this should take approximately 20 minutes. In conjunction, a Mathematics Life Story Framework interview will be facilitated to capture the qualitative and richer data for the research focus. The Mathematics Life Story Framework interview should take approximately 40 to 60 minutes.

What are the benefits? The findings of the study hold the potential to raise the extent of mathematics anxiety in Further Education.

What are the risks? You may experience some embarrassment and discomfort when answering some questions. No life style changes are expected as a result of the study'. You are not required to answer any question you are uncomfortable with. The Guidance Counsellor and AISS (Active Inclusion Support Service) will be made aware of the study and are available to meet with any student who experiences difficulties as a result of the study.

What if I do not want to take part? Participation in this study is entirely voluntary and you can choose not to take part or to stop your involvement in this study at any time.

What happens to the information? All information gathered in the questionnaires and the Mathematics Life Story Framework interview will be held in the strictest of confidence and in accordance with the University of Limerick policy on data retention. The information that is collected will be kept private and stored securely and safely on the researchers' UL OneDrive account. The OneDrive accounts are protected with a password. Your name will not appear on any information. The information that is gathered in the study will be kept for seven years and after this time, it will be destroyed.

Who else is taking part? The only participants will be VTOS learners in the Leaving Certificate Mathematics class.

What if something goes wrong? In the unlikely event that something goes wrong during the Mathematics Life Story Framework interview session, the interview session will immediately stop until the investigator and participant(s) are ready to resume the session or the session would be stopped completely. Similarly, participants can stop completing the questionnaire at any stage and in the event that something goes wrong can choose to complete at a later point if so wish or cease involvement in the study as appropriate.

What happens at the end of the study? At the end of the study, the information will be used to present anonymised results, which will be reported in my thesis. All data gathered from the research will be stored securely and safely by the researcher, Adrian O Hanlon, in a secure location for 7 years. Information that is stored on OneDrive account will be stored by Adrian O Hanlon, in OneDrive.

What if I have more questions or do not understand something? If you have any questions about the study you may contact the Principal Investigator. See below contact details.

What happens if I change my mind during the study? At any stage should you feel that you want to stop taking part in the study, you are free to stop and opt out of the study. There are no consequences for changing your mind about being in the study.

Contact name and number of Project Investigators:

Principal Investigator(s)

Dr. Raymond Lynch,
School of Education,
University of Limerick.
Tel: +353 61 202359
Email: raymond.lynch@ul.ie

Dr Orla McCormack
School of Education,
University of Limerick.
+353 61 202760
orla.mccormack@ul.ie

Other investigator:

Adrian O Hanlon
School of Education,
University of Limerick.
Adrian.ohanlon@ul.ie

Thank you for taking the time to read this. I would be grateful if you would consider participating in this study.

Yours sincerely

Faculty Member

Student

This research study has received Ethics approval from the Education and Health Sciences Research Ethics Committee (quote approval number).

If you have any concerns about this study and wish to contact someone independent, you may contact:

**Chair Education and Health Sciences Research Ethics Committee EHS Faculty Office, University of Limerick Tel:
(061) 234101**

Appendix 10 Research Ethics

FACULTY OF EDUCATION AND HEALTH SCIENCES
RESEARCH ETHICS COMMITTEE (EHSREC)



Ethical Consent Form

I, the undersigned, declare that I am willing to take part in research for the project entitled

Investigation into the existence of Mathematics Anxiety in Adult Learners in a VTOS setting

- I declare that I have been fully briefed on the nature of this study and my role in it and have been given the opportunity to ask questions before agreeing to participate.
- The nature of my participation has been explained to me, and I have full knowledge of how the information collected will be used.
- I am aware that my participation in phase 2 of this study will be audio recorded and I agree to this. However, should I feel uncomfortable at any time, I can request that the recording software be switched off.
- I am aware that such information may also be used in future academic presentations and publications about this study.
- I fully understand that there is no obligation on me to participate in this study.
- I fully understand that I am free to withdraw my participation without having to explain or give a reason, up to a period of two weeks after the data collection is completed.
- I know that I have been asked not to discuss the content of any Mathematics Life Story Framework interview discussion, or the identity of its participants with anyone.
- I acknowledge that while the researcher has asked all Mathematics Life Story Framework interview participants to maintain confidentiality in the above manner, the researcher cannot guarantee that individual participants will adhere to this request.
- I acknowledge that the researcher does not guarantee that they will not use my name or any other information that would identify me in any outputs of the research.
- I declare that I have read and fully understand the contents of the Research Privacy Notice.

Signature of Participant

Date

Signature of Investigator

Date

Yes No

Consent to Contact about Similar Future Research I explicitly consent to the University contacting me as part of current or similar future research and holding my contact details on its database for the purpose of contacting me.

The purpose of this section is to collect information about the extent of mathematics anxiety among mature students at this HEI. The information you provide will be used only for this research project. For each of the 23 statements listed below, please show

how you feel about each of the statements right now (rather than in the past, for example) by circling one of the numbers from 1-5. Each number represents a measurement:

1= not at all 2 = slightly 3 = a fair amount 4 = much 5 = very much

Please measure all 23 statements. How anxious would you feel in the following situations right now?

Please circle one number (1 to 5) for each statement.

	Not at all	Slightly	A fair amount	Much	Very much
1. Having someone watch you multiply 12×23 on paper.	1	2	3	4	5
2. Adding up a pile of change.	1	2	3	4	5
3. Being asked to write an answer on the board at the front of a maths class.	1	2	3	4	5
4. Being asked to add up the number of people in a room.	1	2	3	4	5
5. Calculating how many days until a person's birthday.	1	2	3	4	5
6. Taking a maths exam.	1	2	3	4	5
7. Being asked to calculate $\text{€}9.36$ divided by four in front of several people.	1	2	3	4	5
8. Being given a telephone number and having to remember it.	1	2	3	4	5
9. Reading the word "algebra".	1	2	3	4	5
10. Calculating a series of multiplication problems on paper.	1	2	3	4	5
11. Working out how much time you have left before you set off to work or place of study.	1	2	3	4	5
12. Listening to someone talk about maths.	1	2	3	4	5
13. Working out how much change a cashier should have given you in a shop after buying several items.	1	2	3	4	5
14. Deciding how much each person should give you after you buy an object that you are all sharing the cost of.	1	2	3	4	5
15. Reading a maths textbook.	1	2	3	4	5
16. Watching someone work out an algebra problem.	1	2	3	4	5
17. Sitting in a maths class.	1	2	3	4	5
18. Being given a surprise maths test in a class.	1	2	3	4	5
19. Being asked to memorise a multiplication table.	1	2	3	4	5
20. Watching a teacher/lecturer write equations on the board.	1	2	3	4	5
21. Being asked to calculate three fifths as a percentage.	1	2	3	4	5
22. Working out how much your shopping bill comes to.	1	2	3	4	5
23. Being asked a maths question by a teacher in front of a class.	1	2	3	4	5

Dear _____,

Thank you kindly for completing the MAS UK questionnaire over the past number of weeks. Your data has been anonymised and stored safely and securely as per the Data Protection notice.

As per the consent form, I will now kindly ask if you will complete stage 2 of the research. This will consist of a 40-60-minute Mathematics Life Story Framework interview.

Timeline: In advance of the interview, I will ask you to reflect on your past experiences with mathematics and create a timeline of all the significant experiences in your mathematics learning journey. You can write this down on paper or you do this on Microsoft Word. The purpose of this is to highlight any negative or positive incidents which have shaped your mathematics learning journey. You can include experiences in primary school, post primary school, further education, work, outside of school, family life, experience with Teachers, experiences with tests or anything else that you might feel that is relevant. The timeline which you will complete will provide a framework for the interview upon which I may ask follow up questions. With this in mind, I might kindly ask you to submit this by email prior to the interview.

Interview: I will meet with you in Kilmallock Road Campus and a specified room location which will be agreed with adequate notice for approximately 40 to 60 minutes. The focus of the interview will be to discuss your experiences with mathematics with reference to the timeline you submitted. The interview will be recorded on Microsoft Teams where the camera will be turned off and all data will be transcribed into text. The purpose of the meeting will be to talk about your relationship with mathematics, focusing on your timeline and your experiences with maths throughout your life. The interview will take place at a classroom, time and date that will be agreed by both of us.

Post Interview: I will send you a copy of the transcripts for review and should you think of any further information that you omitted in the interview, then you might kindly send these on for inclusion.

I would like to thank you in advance to reviewing my invitation. I would be very grateful if you can continue to stage two of the research. I have attached the Information Sheet and Consent Form for your consideration. If you would like to participate, please complete and return both forms by email attachment to Adrian.ohanlon@ul.ie as soon as possible. If you need further information about my study or further clarification on any aspect of this phase of the research, please email me or contact my supervisor, Dr. Raymond Lynch via raymond.lynch@ul.ie.

Appendix 11 Sample Timeline

Sample Timeline

The below is a sample timeline which may give you an idea of what a timeline would look like. Please take your time in reflecting on your past experiences in order to develop your own timeline.

- Born in 1988
- 1996 Found high or low level of Mathematics Anxiety due to a Teacher
- 1997 Found high or low level of Mathematics Anxiety studying for test
- 2001 Junior cert or finished equivalent study in home country (ESOL learner)
- 2002 Found Algebra easy/difficult
- 2004 Found Parents supportive/not supportive in Mathematics
- 2005 I received extra support with Mathematics/I got help with my SNA
- 2006 Leaving Cert/Leaving Cert Applied or finished equivalent study in home country (ESOL learner)
- 2006 I got grinds/private tuition in Mathematics
- 2009 Considered that I wasn't 'good' at maths
- 2010 I went to a College of Further Education and found a module in Maths easy/ok/hard
- 2012 Went to an Institute of Technology and found maths related modules easy/difficult
- 2014 Recently undertook an online Maths Class during COVID and found learning mathematics online easy/ok/hard

Appendix 12 Summary of transcribed interviews

5.2 Question 1: When you think of mathematics, how does it make you feel?

Prior to the interview, the interviewer went through the structure of the interview and reminded the participants that it was completely voluntarily and they could opt out at any time. The participants were reminded not to use any names during the interview.

The interview commenced with the question “*When you think of mathematics, how does it make you feel?*” Some learners gave a very brief response whilst others gave a detailed description of their feelings towards mathematics. Responses were varied, however, learners did not convey mathematics anxiety prior to coming to VTOS. Learners were very reflective on their journeys with mathematics where they drew on their experiences of mathematics from an early age and a number of learners elicited their experiences with mathematics text anxiety.

Positive responses

Brendan spoke very highly of mathematics and really sees the value of it: “*You know, ever since I came into the education system, maths has always been the subject that's kind of stood out for me more than any other, and something I hold to this day with pretty high regard*”

Sarah elicited an early memory of watching how mathematics was taught and it inculcated a strong motivation to learn mathematics: “*my first memory of maths returns to the age of five, I was watching a program in the television and it was just it way he was teaching the maths. And I was so interested in the past that man was teaching the math in the television, he was playing with the apples [and] with the orange and I just tried to copying that.*”

Negative responses

Linda highlighted that her past experiences of mathematics gave rise to her level of mathematics anxiety, highlighting her negative experiences from her education in Poland: “*so the maths in general make me feel ok, but I feel some a bit of a high level of anxiety about this. I think in general because of my experiences from the past I think.*”

Stephen had concerns about returning to education in VTOS, with specific anxiety towards mathematics: “*because when I came here first I was a bit nervous about maths*”

Thomas identified the avoidance and hatred of mathematics, which is very evident in mathematics anxiety research including poor performance (Ashcraft & Moore, 2009), “*Math is a subject that I always hated. I don't*

like maths in my life, even when I was at school when I was a kid. I always used to skip the math class and the math subject. And I thought it was just not for me.”

David lacked confidence and self-efficacy around mathematics from a very early age and exhibited mathematics anxiety as a result: *“my first memory of doing maths it was back in India. Uh, from age maybe 7 to about 10 in India and Math's always been one of the hardest subjects and my confidence was very low in doing maths so that was that wasn't good like it always affected my confidence. It made me feel anxious and I would always get many things wrong in maths”.*

The issue of Mathematics Test Anxiety was also prevalent with a number of learners, which included formal and informal assessment including the state leaving certificate examination.

Stacy identified the feelings of assessment as a negative response even though she did have a sense of liking mathematics in a general sense *“[I was] very ‘ify’ about maths’. I enjoy maths but I'm not really good at it. I do get kind of anxious when I get a lot of questions. 'cause, like you know when you get one, you focus on one (question) but when there were like 40 questions”.* Robert didn't raise any issues with mathematics in general sense, however, there was a very distinct response when he raised the issue of assessment: *“Maths in a general sense, doesn't bother me, doing an exam is a different story. Having to have the like complications and understanding of like all the different exam questions. That kind of throws me off because let's looking through the exam paper. I'm going, Nope, Nope, Nope”.*

‘Left Behind’

Stacy felt that being left behind and not successfully progressing through a topic leaves her confused and anxious: *“it leaves you confused state because like you come in. And they're (teachers) saying something to you? And then you're like but I don't get it? OK, yeah, we know time now for that will just move on. So it leaves you confused and kind of like even anxious, maybe. Stacy also raised the issue of ‘falling behind’: Yeah, because you have to think like, especially if they can still eventually, it's all gonna be using the exam, a state exam. And when you don't understand it, they're just moving. On it's leaving you just lost and confused.”*

Summary of Question 1 and Associated Environmental Antecedents

The majority of replies were of a negative nature where the concept of being in ‘large classes sizes’ or ‘left behind’, as well as test anxiety were referenced. Math Anxiety was evident as a consequence Stacy identified a number of environmental antecedents, she references being asked a large number of questions and this was something that was evoked when asked about her feelings towards mathematics. She also referenced the concept of being ‘left behind’. To note Brendan felt *“ever since I came into the education system, maths has always been the subject that's kind of stood out for me more than any other, and something I hold to this day with pretty high regard”.* Mathematics Test Anxiety was also elicited by Robert *“doing an exam is a different*

story. Having to have the like complications and understanding of like all the different exam questions. That kind of throws me off because let's looking through the exam paper. I'm going, Nope, Nope, Nope””. Both Linda and Stephen demonstrated high levels of maths anxiety.

Conversely, Brendan showed very low levels of mathematics anxiety and did not reference any negative environmental antecedents, we will also find in later sections that he had a positive relationship with his teachers, received family support and also benefited from private tuition.

5.3 Question 2: Tell me about your earliest memories of doing mathematics/mathematics at primary level?

Question 2 attempted to ask the learner to revisit their earliest memory with mathematics education, typically in a primary school. Majority of the experiences were negative, with Brendan being the exception. A common topic was that of learner embarrassment, as well as mathematics anxiety, inadequate teaching approach and corporal punishment.

Positive Experiences

Brendan had a very positive experience in school even though he felt there could have been a greater emphasis on maths: *“My primary school, I would say that would be, uh, I went to a kind of a religious primary school, so I'd say that emphasis on Religion was definitely. Pretty high for my primary school. So when it came to maths I feel like it could have been emphasized a bit more and the little Maths that I did do in primary school... definitely sparked something that you know that I think I would really enjoy for the rest of my life.”*

Robert had a positive experience in primary school: *“Primary school maths, I was able to understand everything I went through at all. I never really found a problem with education when I was younger. Alright till I got like till secondary school and that's when the problem started”.*

Negative Experiences

Embarrassment in front of class

Stacy would get embarrassed and anxious in being asked to recite multiplication tables in front of the class: *“Every Friday they'd make you stand up and ask you on your multiplications that you had to learn throughout the week. Could never catch on to it. That would make you anxious as well though. Like it was 33 kids in my premise in class and understand you stand up and do your multiplied by nines and you don't have a clue. Kids at that age are kind of ruthless So they were kind of laughing and smirking because I think at that age I should have known them”.*

Similar to Stacy, Linda elicits stressful memories of a Teacher who would call her to go to the board and was fearful of making a mistake: *“She wanted you give the answer quickly. You were really stressed in front of the class and I was scared that I would be called to the board... I was stressed because when you didn’t give the right answer, then you felt like you were kind of stupid”*.

Thomas’ experience appears to resonate with this feeling as he was fearful of his peers laughing at him: *“Maths time’ teacher used to make us stand and come on the board and just solve the questions in that and I never liked it anyway and that's why I never learned it. So I always hated going down on the board and solving out the questions because I knew that I was going to get it wrong and the whole class is going to laugh at me so”*.

Teaching Approach

Linda identifies carrying anxiety from primary to secondary school: *“After all those years I had anxiety about maths then I felt I kind of transferred that problem with me.”* She also stressed a lack of active teaching strategy in primary school, *“I think mostly it was just teacher sitting by the desk or standing by the board. Explaining and writing and we didn't really have that kind of classes that we could measure something or in like Maths in practice it was very low in my life.”*

Sarah raised concerns regarding the inconsistency of teaching methods *“The teacher said one thing and other teacher have different methods. I was completely confused”*. Sarah also added that Teachers wouldn’t allow questioning during the class: *“during the classroom time you are not allowed for asking question. You should write the question and ask after the class”*.

Stephen raised a more extreme approach to teaching of corporal punishment *“Again, I was quite good. It was because of the I used to watch the others getting sort of beaten for not knowing them. So I always was able to sing off The tables you know that was. In second and third class”*.

Physical Infrastructure

Thomas also identifies the school in Afghanistan as not having proper facilities; *“Yes, as I said, to be honest where I was living in a village where there was no proper school in the 1st place.... A lot of time they had a makeshift schools say in the camps or say in the kind of like shelters or in the mosques usually and used to be more like religious studies than the school studies. But yeah, you would do a little bit of school study there, but it wasn't. I wouldn't call it as a school”*

Summary of Question 2: Tell me about your earliest memories of doing mathematics/mathematics at primary level and Associated Environmental Antecedents

There is a significant trend in question two in primary school where the theme of embarrassment in front of others is very prevalent. For example, Stacy suggested that kids in primary school were ruthless and she was fearful of been laughed at which was also conveyed by Thomas. Linda had a similar experience where her main fear was feeling inferior or ‘stupid’ as she put it. Stephen raised the issue of corporal punishment for the first time, he would further raise this issue throughout the interview.

5.4 Question 3 Tell me about your experiences of doing mathematics at secondary school

Question 3 continued its focus on school education concentrating on secondary school including ‘gymnasium’ in Eastern Europe. Some positive experiences included private tuition which is often referred to as ‘grinds’ in Ireland and one learner spoke very well of the ‘YouthReach’ programme. The YouthReach programme was “*introduced in 1989 which attempted to address the then high levels of early school leaving, by providing young people with access to second-chance education and training*” (Smyth, E et al., 2019, p1). Some of the negative aspects were learners been ‘left behind’ by teachers, aggressive teachers, unsupportive teachers, unprofessional teachers and corporal punishment.

Positive

Private Tuition

Brendan did not have any issues in secondary school and actually benefited from private tuition: “*I did get grinds outside school as well which definitely helped towards that*”. Brendan did have issues but these were personal: “*I like it was a bit of a rough period for me personally, so I won't go into it... I felt like the junior cert was always something you could kind of wing it and I felt like I got a pretty good junior cert without really over extending myself, whereas the leaving cert*”.

Student-Teacher Interaction/YouthReach

Stacy found YouthReach programme very helpful and gave it a lot of praise “*I went into YouthReach and I love this, yeah. I restarted 5th during there and I loved it... there was six of us... The teachers are really nice as well, and if you were stuck on maths, they definitely wait, because like you know, any YouthReach in teams at that like... Your class you say you understand, and if you don't understand, you'll go back and do it again and you'll go back to and that's what they do*”.

Negative

Class Size

Stacy found her initial stages in secondary school particularly as there was a small class size: *“First year, I loved maths. I loved it. Teachers would help you it. Was great you know there was only like 9 or 10 (students) so it was great”*. However, Stacy had to move to another school with bigger classroom size and it proved to be problematic as she felt she was being left behind *“unfortunately, the school had to be closed down, so we moved to. I moved to a different school second year and everything just went backwards again...like, I said before hand, if you were stuck, you're stuck. You were left there just left there.”*

Thomas struggled in education from an early age and even when he moved country he still struggled with mathematics, *“To be honest, my education, I was left out because of the start the experience I had in the start with the maths and through my life journey which I had from Afghanistan to Pakistan”*... *“I used to get 0 every year in Maths anyway, even in Pakistan when I was I used to go to school”*.

Student-Teacher Interaction

Stacy found her Maths Teacher not supportive in 2nd year of secondary school: *“show you how to do it once. Yeah, and then they leave it on the boards. They give you all these questions to do in the book. Walking around to see if you owe me some stuff they say yeah, if you're stuck you have to learn to herself nor will help you in the real world. That was just that.”*

Stephen had a similar experience to Stacy *“he just he went to the board and he just opened up page 55 yeah! Could you explain? (asking the teacher). You know he come down to me, then he grabbed me... There's no questioning here (teacher stated).*

Stacy also added that her Teacher insisted that there was only one way to solve a maths problem *“in secondary school it's very by the book, so if they give you methods and you do different method, we get same answer, they rip it out, make you do it again. So you got the same answer, but just doing that by a different way. And I've had many pages of my math book ripped out”*.

Linda recalls her Teacher had a didactic approach to teaching where there was no active learning or ‘maths in practice’, *“I think mostly it was just teacher sitting by the desk or standing by the board. Explaining and writing and we didn't really had that kind of classes that we could measure something or like in like Maths In practice”*.

David felt his grades were poor because of a Teacher, who was not prepared for class and lacked motivation and interest: *“my grades were bad as well here because. My teacher went on. The main reason was our teacher was very bad. To be honest. Our whole class was performing very poorly. The teacher rarely kept coming in*

on time. We were always behind in chapters. We rarely get into covered. She'd go off talking about her life all the time. And that's where I got grinds from a teacher and he helped me get much better".

Stephen reports the issues of corporal punishment within his school culture as a source of anxiety towards performing well: *"Yeah, so I was quite good at maths back then because I was a very I was a quite studious. There was an element of anxiety because of course it was a big stick, you know and so I was quite nervous in CBS. It probably school because the teachers were very autocratic and if you didn't do it. You know the consequences were kind of quite severe".* Stephen reiterates the culture of fear within his primary school: *"Again, I was quite good. It was because I used to watch the others getting sort of a beaten for not knowing them. So I always was able to sing off the tables you know that was in second and third class, I suppose with an Element of fear as well".*

Personal Issues

Robert had a negative experience in secondary school: *"Primary school maths, I was able to understand everything I went through at all. I never really found a problem with education when I was younger. Alright till I got like till secondary school and that's when the problem started".* I ended up having a medical condition where I was kind of like it affected the stems, spine, it affected brain and stuff like that. So, when I went back to school all of a sudden I was from higher level everything to just about ordinary level in every class, including maths.

Summary of Question 3 Tell me about your experiences of doing mathematics at secondary school

A dominant issue from question 3 was the interaction between the Teacher and the Student on a broad level. Stephen and Stacy both were not allowed to ask questions and both their accounts was staggering. When seeking help with a maths questions, Stacy was informed by her teacher, *"that no one would help her in the 'real world'"* and Stephen was physically grabbed and told 'there's no questions here'. These incidences must have had a profound impact on the learner's mathematics journey. The culture in Stephen's school was also one of fear and if you got an answer wrong then you bare the brunt of a 'big stick'. David was frustrated with an unprofessional Teacher who was always late for class and fell behind in the curriculum meaning that there was some topics never covered. Both Brendan and David reported positive experiences in getting private tuition or 'grinds'.

5.5 Question 4 Tell me about your experiences of engaging with mathematics after school

Question 4 explores the students' experiences after school, which can include Further Education, Employment or Third level Education. The YouthReach programme was again referenced by Stacy as the programme overlaps Secondary Education and Further Education. Some learners referenced employed but in a numeracy context whilst Thomas conveyed mathematics avoidance due to previous poor performance. David, Robert

and Brendan did not engage with mathematics after school, as it wasn't part of the curriculum in their respective courses.

Positive

Benefits of YouthReach

Stacy found YouthReach restored her confidence and she was also now able to help her young brother: *"After YouthReach I found myself getting good at maths...by the time I left 6th year, my brother was in 3rd year so he's junior cert and at that stage I was able to help him I was able to help him... It made me feel it made me feel good because I remember being in his"*

Work Practice/Numeracy

Linda found using mathematics in work to be of benefit and it helped her confidence: *"I came into Ireland in 2012 and I started job, uh in in retail in 2014 and the only kind of problem or just kind of you know I was hindered by maths when I had to give away 'the change'. I was working in, I still actually work in supermarket when you had to do it really quickly and count it back to the customer. So like from the back to the front and that was a bit anxious for me, especially that it was new place, new job and I had to do really quickly so it will save a lot of stress and fast pace, you know. But then I manage that and I felt much better. good, much more confident after this."*

Negative

Thomas is very reflective on mathematics and shared his disappointment of not being able to go into Further Education as a consequence of his maths avoidance: *"I don't want to go near maths. And if I had if I had a little bit of interest before or I say if I if I knew 10% about maths I would have I could have got into maths in England and then go get further education and that because of the maths I was just left out"*.

Personal Reasons

Stephen did not engage a whole lot in mathematics after school as he attended LIT to study mechanics. He did not attend lectures as he was focused on socialising as well as the Lecturers' teaching approach, *"I didn't attend his lectures because he ...kind of put the fear into, you know"*.

David also did not engage in mathematics after school, as he didn't receive the points for third level college, *"I didn't really do anything for leaving cert since it was predicted grades. So after school closed, I basically*

did nothing and I just I was handed a pass and everything that that's not enough points to take me to 3rd level”.

Similarly, Robert had minimal interaction with mathematics after school *“Yes and no, but nothing to do with maths per se... I did a hospitality course. Which was just learning hospitality didn't have to learn about prices or anything else”.*

Brendan took a similar approach, *“I then decide to Level 5 course in LCFE, a liberal arts course which. Which was good experience, you know, good people there. Unfortunately, I wasn't doing any maths which would have been my favorite subject”.*

Summary of Question 4: Tell me about your experiences of engaging with mathematics after school

A trend from many of the participants was that they did not use mathematics after secondary school with the exception of Linda who really used numeracy and Stacy who used it to help her brother.

5.6 Question 5 Tell me about the role of mathematics in your decision to return to education

Question 5 asks the learner to reflect on why they decided to apply for the leaving cert programme in VTOS, and the role of mathematics in their decision-making. In question 5 learners displayed mathematics anxiety with mathematics text anxiety and more specifically the state examination of the leaving certificate having a profound effect on learners.

Motivated to help children

Thomas was highly motivated to help his children with their mathematics and this was a significant factor in returning to education: *“I just started doing my children homework. I have four boys and two of them obviously needs my help with their homework because they are 7-8 years old. And them because of them actually, I decided to study maths this year so I could learn something myself so I can teach them when they need me while I'm doing their homework. So because of my kids I'm actually doing math this year and I really I'm enjoying it.”*

Mathematics Anxiety

Stephen was anxious in terms of his decision to return to education, particularly around maths: *“Returning, yeah it was an element. Of trepidation about Math's yeah. OK, good. Yeah, because yeah there was because the emphasis on maths, you know in terms of I don't know doing what you want to do, and so I was a bit apprehensive coming in here. I overcame that and just came here, you know, and still I'm kind of struggling with it. You know that that's why I feel I have to attend every class because of that nervousness that I might fall behind or you know, but it's still there, even sort of looking at sort of some of the past papers... so yeah, it's a constant struggle”.*

David decided to enroll in the VTOS course as he was already had a positive experience with a Teacher that worked in the school and he was part of his decision in returning to education also alludes to previous mathematics anxiety which is now gone *“it was a teacher in school that works here. I won't mention the name, but yeah, he essentially said I shouldn't go to college even though I could get a course, It would be a lower end course. I should come in and repeat and he's the same teacher that gave me grinds back in junior cert. So I knew the level He'd be teaching it, and he said, he would be teaching maths and many other subjects. So I knew what he's like, so I knew he'd be able to get me back on track. So that's I just decided to take his advice and to be honest from now from then on it's been great, maths, my confidence went up. I can solve problems, I feel like I'm much better, but the anxiety is gone now to be honest there's no there's No Fear of maths.*

Previous negative experiences

Brendan: *“I was definitely a bit skeptical coming here (VTOS) because obviously. Deciding to come back but. I felt like it was the best decision for me for because. Obviously I can touch on the maths again and you know there. I felt like there was a bit of unfinished business because I felt like I could have done the higher maths when I was younger and I'm just thinking me I'll be doing the higher level exam. I'll be seeing the higher level exam this year. So hopefully that goes well for me.*

Test Anxiety

Stephen is also fearful of assessment in returning to education and specifically the state examinations i.e. the leaving certificate: *“I'm still nervous about the leaving Cert next year and why? That I might pass it or I go into the exam and it's a completely different language to what I've been doing, you know. Yeah, I'm quite apprehensive actually to be honest”.*

On returning to education, Stacy recalls her previous memories of test anxiety: *Oh, very, very anxious. And when I get nervous my still look like turns it not take wash machine so I remember, I feel sick!. I know, right? It's like. Sit down and examine. It comes in. It's when you see the examiner then you're like. Oh, this is real! And so when I set my junior cert, I was very, very nervous about doing junior cert, especially for math.*

Summary of Question 5: Tell me about the role of mathematics in your decision to return to education

There was mixed emotions in the role of mathematics in terms of the learner's decision(s) to return to education. Thomas was motivated to help his children with their mathematics despite his previous emotions of embarrassment and anxiety towards mathematics.

Stephen and David both reference their math anxiety as emotions in returning to education. David had a positive outlook and appear to have diminished his mathematics anxiety *“I feel like I'm much better, but the anxiety is gone now to be honest there's no there's No Fear of maths”.* Stephen was nervous that he might fall

behind and also mentioned his test anxiety “*looking at sort of some of the past papers... so yeah, it's a constant struggle*”. Stacy also elicited test anxiety recalling a previous experience in returning to education “, *I was very, very nervous about doing junior cert*”.

5.7 Question 6 Tell me about the mathematics in VTOS

Question 6 attempted to elicit the learners experience of mathematics in VTOS. Overall, the experiences were very positive and learners conveyed a much more open and relaxed environment towards learning compared to their previous experiences.

Positive: Student Teacher Interaction

Linda contrasts the difference between her maths class in gymnasium (secondary school in Eastern Europe) and now on VTOS, specifically around having to get all questions correct.

It's completely different, Yeah, completely different like, the style which I was taught here when everyone of us got a copy of a few pages with the questions and everyone was just left to do it in their own time and with their own skills. And that some mistakes are big and some are just a little mistake, you know. And yeah, you don't have to worry about it. No, in Poland it was like mistake is wrong! It's wrong, mistake is wrong you know you have to do and follow all the rules. OK, OK, like 100% accurately and you cannot make mistakes.

Thomas also shared the same experiences of Linda in terms of correctness but with more server consequence: “*I've been living in Europe now 27 years now so I know that here there is no punishment for getting the question wrong or something like that. In Afghanistan, it is different because in the morning, the teacher used to come and the mosque there was a few trees there is so he'd got a big stick from one of the trees. Get ready, really nicely and in the classroom at the end of the day, the stick would have been to 20 pieces. Yeah, cause I used to like proper beaten up every children students. So there was this kind of.. scared from teachers from getting it wrong or even coming to the math class or school in that case. But here is no pressure, nothing.*

Thomas also added that in VTOS he is now thriving in the change of culture “*I'm getting to like math now and I really enjoy math class and it's like for me now. At the moment I've. I think math is a very interesting subject and I wish I knew that. When I was young and now. It's never late anyway*”.

Stephen did have initial anxiety, but since coming to VTOS, this appears to have diminished “*Well since coming to the center (VTOS) here with (A Teacher). He has kind of gotten rid of any anxiety I initially had coming here because he went back to the very basics of math. So he has kind of shepherded out any misgivings, because when I came here first I was a bit nervous about Maths. But since then, by (the) Teacher going back over the rudiments of Maths, it's kind of helped me a little bit, so I'm not sort of making mistakes now that I probably would have if he hadn't have done the basics*”.

Project Maths/Active Learning

Sarah found mathematics more challenging as there was topics she had never covered but she enjoyed the 'real life mathematics': *"But there were some new completely new subjects to me after my Last education's, like a complex number. I didn't see complex numbers so far in VTOS and The problems in the problem solving integers in mathematics is related to life in 'higher level'. When you want to solve a problem, for example, algebra is not the formula of algebra you should compute the triangles, triangles, perimeters or something like that, and it's more challenging for me, but I like that.*

Summary of Question 6: Tell me about the mathematics in VTOS

The significant theme is the change of culture from correctness. Learners aren't anxious in VTOS where they are not compelled to have every answer correct and fearful of punishment or embarrassment. Linda states that *"It's (VTOS) completely different... in Poland it was like mistake is wrong! It's wrong, mistake is wrong you know you have to do and follow all the rules. OK, OK, like 100% accurately and you cannot make mistakes"*. Thomas also welcomes the change in Culture from Afghanistan to Europe *"I've been living in Europe now 27 years now so I know that here there is no punishment for getting the question wrong"*. Stephen welcomes a Teacher in VTOS going over the fundamentals of mathematics which helps in reducing his mathematics anxiety *"Well since coming to the center (VTOS) here with (A Teacher) he has kind of gotten rid of any anxiety I initially had coming here because he went back to the very basics of math"*.

5.8 Question 7 Tell me about significant people in terms of your engagement with mathematics?

Question 7 attempted to ask learners about any significant people who had a positive or negative influence in their mathematics journey. Significant people included teachers, parents, grandparents, a brother and a partner.

Positive

Teacher/Student relationship

The teacher/student relationship was certainly very significant when learners referenced significant people in their mathematics journey, which is evident in the below statements from learners.

Stephen references a teacher with a democratic style of teaching in secondary school: *"Going into 4th, there you had a democratic teacher, who was an excellent teacher and who kind of motivated me feel made me feel great about myself."*

Stacy also felt similarly to Stephen with her YouthReach Teachers *"Definitely YouthReach teachers really boosted my confidence for maths. When the rest of them were struggling, teacher was like, can you help this person and I ...I was happy I wasn't. Left behind"*.

Sarah is very complimentary of her parents who were both Teachers and makes a specific reference to them never putting pressure on her to achieve high grades *“They didn't pressure me about the grades. Even if the society was completely, you know, addicted to their grades, but my parents, even they are teachers”*.

Linda was very complimentary towards her current maths teacher in VTOS as well as her partner and his father. *“As I said, my partner and his father had definitely positive impact to show me and the current teacher of Maths here in VTOS is kind of the top of the mountain for me which I really feel comfortable”*.

Brendan spoke highly of his brother and the influence and help he gave him in terms of mathematics: *“Might be the typical answer, but I want to say my brother. He's about 10-15 years older than me...You know he had already done a good amount of this stuff, maths stuff and he would have sat the higher in leaving cert, you know he would have been very good at maths...I think he would have been the one. That kind of created that kind of interest in maths for me to be honest, 'cause he was always helping me after school in maths. Uhm my parents. I mean they would be pretty busy usually and you know, my brother usually was the one to help me with maths and stuff like that even to this day. I mean, I could ask him math questions, you know, and he would always, even though he hasn't told me in a long time now”*.

Negative

Linda's was left without any external support as her parents were not capable of helping her nor were her grandparents *“my parents actually were divorced so I had mother only at home. She was working so she really didn't have time to teach me at home. Sometimes my grandparents were trying to help me with some stuff at home but their methods were kind of old school and sometimes I couldn't really understand them and they couldn't understand me.*

Thomas felt helpless as he was the only one of his family to go to school including his sibling and once again he highlighted his maths avoidance: *“I was just running away from maths in anyway so there was no. They (Parents) never went to school anyway and my brothers they never. I was the only lucky one there at that time that I was going to school me and my elder brother were five brother. He also later in the interview that the: teachers back home and then when I was in the village they killed my interest.”*

Summary of Question 7 Tell me about significant people in terms of your engagement with mathematics?

Both Stephen and Stacy reference a 'learner centered' teacher as having a significant people in terms of their mathematics engagement. Interestingly, both Linda and Thomas mention the absence of their parents and how this had a negative impact on their mathematics engagement.

5.9 Question 8 What has been/How would you describe your strategy with mathematics

Question 8 attempted to understand what strategy learners developed in learning mathematics. Some strategies included learners taking responsibility for their own learning, repetition, active learning and concept learning.

Learner Responsibility/Test Anxiety/Past Papers

Stephen reflects on his own work outside of VTOS and he still holds anxiety towards tests, it also raises the questions why he is looking at past papers so early in the year! *“I try to attend every class. Try to keep up to date with, but I'm not doing enough outside of class as well. Yeah, again, there's a disconnect between I get home. My strategy is kind of quite poor because I don't tend to do any maths outside of school... I can kind of do past papers. But yeah, there's a fear I haven't gotten near the maths you're after. Yeah, I'm afraid of it... Yeah, of opening up past...Those math papers, you'll get hurt”.*

Repetition

Linda is very consistent and again she references active learning, repetition and confidence: *“I just read the examples you know or the information about this and then I just start practice it. You know, just with the example then without us then more and more and more until I feel confident that I can do it and I can remember. Yeah yeah, and I feel more confident. Obviously with every, you know exercise”.*

Brendan also advocated repetition and practice *“Well, as the one thing I feel like I learned the most over the years was.. just to practice, I mean matter very practice based subjects. It's just to follow each step as you can... But the reality is I just need to practice the questions in terms of maths”.*

Note taking

Stacy prefers to take notes as well as repetition so she can use them as a point of reference if she gets stuck on a question *“My math book is covered in notes left right and center, just little bits written in every corner”.*

Concept Learning

David's approach is in contrast with Stacy's note taking approach and seeks to understand what the Teacher is showing learners *“My strategy now. Is just pay very much lots of attention in class. Like really pay attention, stay focused...stopped taking notes in class.. instead I just sit watch the teacher do it very carefully ask questions and try to understand it rather than taking notes half on the board... and half listening. So then you go home you don't know what happened in class and you know it's you don't know what to notes about so you have the notes”.*

Independent Learning

Sarah believed that the best approach was to work independently and for the Teacher to work as a Facilitator *“When I came to the class, I learned I should read by my own because I'm higher level and if I had any question I should ask teacher. It was a good procedure for me for having this way, studying, practicing and asking the question from the teacher”*.

Summary of Question 8 What has been/How would you describe your strategy with mathematics

Overall, the theme for most learners is repetition, which was Brendan, Stacy and Linda. Stacy also referenced note taking but this was in contrast with David who abandoned note taking for a conceptual understanding of mathematics as his strategy. Sarah also preferred a more adult learning approach to the Teacher as a facilitator and working independently.

5.10 Question 9: Do you think mathematics will be part of your future

The purpose of question 9 was to ascertain if the learner believed that mathematics would feature in their progression to employment or/and higher education.

Linda initially held a mind-set that she was not good at maths and that it would not form part of her future, however after completing a maths assessment and a ‘careers interest exercise’ she changed her mind: *“I started to fill it up and, uh, after that I left it with them Guidance Counsellor. And he called me to his office and he said to you are very well at maths. What I'm not! yeah, you pass the test really well. I was so surprised, very surprised. And then we had, uh, an online and kind of survey about the subjects and your character and preferences where you should go. And then he found out that it was mostly an kind of business and mathematics subjects. For me. I was so surprised again. And then here the maths subjects I find it really easy, I'm one of the best, the fastest in the class”*

Stacy would like to pursue mathematics but not specifically in an educational setting, she would also like the ability to help: *“I think I'd like to continue learning maths, not even like learning in like a learning setting, but even like in a work setting, you know you learn. I suppose you learn something new about math everyday, no matter where you are, what you do, I'd like to understand maths as well for like in my future children, If I've kids in the future should be able to understand that because I wouldn't like my child to come to me and being the same situation that I was”*.

Thomas has a similar outlook to Stacy: *“I'm going to be ready to help my children with their homework, their math homework because my wife she's never been to school herself, even in Afghanistan. She's never been to school, so she has no education at all”*.

Linda is very reflective and appears to have addressed her mathematics anxiety and is now more confident but still feels that it might not be part of her future prospects *“I think I will keep that confidence level, definitely because I've proven myself that I can do it and it's no problem with this for me so I can keep the anxiety in the past completely. I'm still not sure if I if Maths is something I can go further with. I think I think I will. I will just I hope I will pass the Leaving Cert and it will be kind of closed subject for me”*.

Brendan who has very low level of mathematics anxiety whilst not entirely sure about his future, he appears to be more positive about mathematics in the future *“Yeah, and I mean in terms of the future after that. I mean, I, I think I potentially could be doing, Maths, maybe business course in in a university or in college, hopefully after this”*.

Summary of Question 9 Do you think mathematics will be part of your future

Majority of participants didn't want to pursue mathematics in terms of a formal education. Stacy and Thomas were both motivated to help their kids or future kids with mathematics as they both struggled it in the past. Brendan and Linda were also not sure if they would use mathematics in the future, at least not in a formal setting.

5.11 Question 10: What theme would you use to characterise your relationship with mathematics

Question 10 was the concluding question of the mathematics life story interview. This question asked the learner to use a metaphor, an image or any description that would conceptualise the learner's relationship with mathematics. The responses were very interesting and included such metaphors as a 'brick wall' 'a miner breaking through stone', mathematics as a 'mountain' , a learner describing themselves as Scrooge and incidentally the metaphor love/hate relationship was used twice by two different learners.

Linda uses a metaphor of a wall and conveys fear and anxiety. She says she might feel 'dumb' or anxious if she can't perform as well as her peers which might suggest that she still has the same fear as she did back in gymnasium(secondary school in Eastern Europe) which *“I think it's more like the most like a building. Uhm, brick wall where you need all the pieces to build the wall and when you lack some of them then you cannot build as quickly as others... Yeah and then you feel kind of dumb. Bad or anxious that you will not be able to be on the same level as orders and things like that or the wall will completely be ruined, now without the pieces you need”*.

Brendan keeps it quite simple and shows his mixed emotions for mathematics: *Kind of that love, hate relationship. I feel like it's good I could wait to describe it... I think is the best way to describe it because it's a subject that when I'm doing it and when I'm doing well in it, you know I definitely love it for sure. It's the fact that I like it so much that when I'm not able to do it or it's difficult it's also easy for me to hate it, you*

know, because I hate that I don't know, I hate that I can't do it sometimes, you know. Yeah, it's definitely hate relationship. I feel like it is the best way to describe it.

Interestingly, Stacy used the same metaphor:” *I think with maths there's definitely love/hate relationship. Some days you love it other days you want to throw it out the window*”.

Sarah shared similar sentiments to a love/hate metaphor and described her relationship with mathematics as a ‘Sine Graph’, which reflects highs and lows “*I can give you in the mathematics methods. It's a sign, I mean or me it's like a sine graph*”. A Sine Graph in mathematics is a visual representation of the ‘Sine Function’ which ‘illustrate ‘Sine Waves’ of a line which curves to a maximum and minimum point.

Stephen reflected on his own shortcomings in terms of his work commitment towards mathematics outside of VTOS where he describes himself as Scrooge “*It's like Christmas is coming now and the goals of leaving cert you know...I feel maybe they're Scrooge... or maybe I'm a Scrooge with my time that I'm not giving it enough time*”.

David feels that mathematics is like a mountain for him which indicates that it’s a big challenge for him “*That'd be more like a mountain, yet. So then they always never be able to climb. You never want to start because you're like, oh, it's too far away. That's always been the mindset. But now it's starting to change now, like it's always been like it's too difficult*”.

Robert had a similar metaphor when he described his relationship with mathematics as like “*A miner breaking through stone*”.

Thomas appears to indirectly reference his avoidance of mathematics and his self-efficacy by using himself and maths as a fire and water “*I was working in my security training, they said don't put water on to fire so but this is using this example not the right example that I said water with fire. But yes it's like water and fire me and maths were like, yeah, you see, we're far away from each*”.

Summary of Question 10 What theme would you use to characterise your relationship with mathematics

It’s interesting that there wasn’t one relationship that was wholly positive with the most positive being mixed i.e. Love/Hate and the other negatives as fire & water, mountain, brick wall and Scrooge. A closer analysis of this raises the relationship between mathematics and self-efficacy.

For example, Sarah suggested, for her that mathematics was like a ‘brick wall’ and that “*you need all the pieces to build the wall*”. She previously stated that she did not have external support from her family and she referenced negative influences of Teachers! Were these ‘all the pieces’? She later stated that “*when you lack some of them then you cannot build as quickly as others*” and then you feel kind of dumb”, perhaps she is still questioning her self-efficacy and drawing on her embarrassment as child in her gymnasium school.

What's significant also about the 'love/hate' sentiments is that Stacy also used it without any reference to it by the Interviewer. She also added that "*Some days you love it other days you want to throw it out the window*", perhaps also reflecting the same feelings around self-efficacy as Linda.

Brendan reflects on his relationship with mathematics and conveyed his relationship as one of love and hate. Even for the learner spoke highly of his Teachers and family support, he still shows some negative feelings towards mathematics. Similar to Linda, he also references his self-efficacy "*I hate that I can't do it sometimes, you know*".

The self-efficacy also arose with Sarah, she was concerned that "*I don't know about the next step in in which situation I am in the Maths. For example, if I go to an engineering course like biomedical engineering, maybe I'm in the middle or maybe I'm at the end and I should restart again*". Sarah was referring to being at the middle in terms of ability where the end where she feels at the 'end' which is such a low base that she should start all over again.

David feels that mathematics is like a 'mountain' for him which indicates that it's a big challenge for him "*That'd be more like a mountain...always never be able to climb. You never want to start because you're like, oh, it's too far away*".