Evaluating the effectiveness of maths anxiety awareness workshops

Authors: Ellen M. Marshall, Daniel A. Wilson, & Victoria E. Mann.

Abstract

Anxiety about maths affects a large number of students of all ages and stops many students from being able to study mathematics or statistics effectively as well as impacting on their subject choices. Maths anxiety is a learned emotional response, and becoming self-aware of one's maths anxiety and the effect that it can have on the brain can assist in its reduction. This article considers the impact that maths anxiety has on students, some of the strategies for overcoming this anxiety, and investigates the effectiveness of a maths anxiety awareness workshop. The content of the workshop was based on an extensive review of maths anxiety literature and explained the causes and impact of maths anxiety as well as encouraging students to dispel some maths myths, recognise when maths anxiety was affecting their work and use the suggested strategies. Feedback was collected using a questionnaire immediately after the workshop. Evaluation of the pilot maths anxiety workshops suggested an immediate impact on student anxiety, with 78% of students with moderate to high anxiety reporting a reduction in their anxiety and 59% reporting an increase in confidence.

This project is a collaboration between the Maths and Statistics Help centre (MASH) and the Specialist Learning Difference (SpLD) service at the University of Sheffield. Workshops and material have also been developed for staff training to enable staff to recognise maths anxious students and suggest strategies directly.

Keywords: maths anxiety, mathematics support, lifelong learning, strategies**.**

Introduction

Maths anxiety can be described as an irrational fear of mathematical situations which stops the brain being able to process maths effectively. It has been defined as *"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"* (Richardson and Suinn 1972). This fear, which is thought to stem from negative learning experiences and beliefs about maths (Tobias 1993), stops individuals who are capable of learning maths performing to the best of their ability.

Perry (2004) reported that 85% of undergraduate students experience at least mild math anxiety and Jones (2001) found that 26% of 9,000 American students had moderate to high levels of maths anxiety, which has a serious impact on students' ability to study maths effectively. Statistics anxiety, which is strongly related to maths anxiety has shown to be the highest predictor of poor performance in research methods courses

(Onwuegbuzie 2000). Statistics anxiety not only affects a student's ability to use statistical methods but can also impact on their ability to read research articles using quantitative methods.

Causes

Numerous studies have shown that maths anxiety is primarily caused by negative teacher behaviours and approaches starting in early childhood (Finlayson 2014; Jackson and Leffingwell 1999; Harper and Daane 1998; Bekdemir 2010). Maths teaching often focuses on memorisation, rote calculation, and timed assessment rather than active content-based learning and group discussion (Greenwood 1984; Finlayson 2014).

Pre-service teachers have higher levels of maths anxiety compared to most undergraduates (Gresham 2007) and this anxiety can be transferred to their students (Wood 1988). Teachers who are anxious themselves make less effective teachers and often over-compensate by emphasising a black-and-white, right-or-wrong approach (Finlayson 2014).

Most people have had negative maths experiences such as embarrassment or humiliation from failure, teachers who are insensitive or uncaring (Jackson and Leffingwell 1999), and negative peer culture (Frenzel et al. 2007). It is very common for people to state that they are bad at maths (Haylock and Manning 2014) and students only need to be told this once to believe it (Perry 2004). They also tend to inherit attitudes and anxieties about maths from family members (Eccles et al. 1990; Soni and Kumari 2015; Scarpello 2007; Maloney et al. 2015; Furner and Duffy, 2002). Maths therefore triggers negative thoughts and memories which have a detrimental effect on confidence, motivation to learn, perseverance, and ultimately, performance (Gresham 2007; Ashcraft & Krause, 2007).

Impact

Students with high levels of maths anxiety will experience many emotions such as general anxiety, fear, frustration, worrying about looking stupid (Buston, 1981), feeling like there is no point in trying, and not appearing to take anything in. These symptoms are observed frequently at the MASH centre especially near exam or coursework deadlines. The following description of the first maths lesson for one of our students, details how maths anxiety affected her learning.

"*Well what can I say? After losing sleep worrying about maths, my fear was true. I arrived this morning with complete brain block and anxiety. Nervous, scared, and petrified of the maths lesson, even though I had read the class notes. Once the teacher started talking, my mind went blank as if she was talking a different language: everything she said went in one ear and out the other. As she asked us to practise questions, my mind went on shut down, I started sweating, thinking 'oh my god what if she asks me?' I could feel myself trying to hide, wondering what I let myself in for, thinking to myself, 'I am not cut out for this.' Nothing she said sank in....*"

Although it is difficult to measure anxiety directly, recent neuroscience research (Pletzer et al. 2015; Young et al. 2012; Lyons and Beilock 2012), used brain scanners to demonstrate that maths anxiety has a measurable effect on the brain. This was measured using functional magnetic resonance imaging (fMRI). Working memory is essential for performing mathematical tasks but maths anxiety activates the part of the brain associated with worry instead. Worrying about negative consequences of doing maths uses up working memory resources that could otherwise be used for learning maths (Young et al. 2012). This means that whilst someone is in a state of anxiety, they will struggle to understand the maths being taught, won't be able to attempt questions, and won't be able to properly engage with the learning activity. Another impact is the activation of brain networks associated with pain processing (Lyons and Beilock 2012) when the student thinks about doing maths. Importantly, these networks are not activated when the student is actually doing maths, which suggests maths anxiety is an *anticipative* fear of maths. Activation of pain networks also prevents the brain from turning off its "idling gear" and directing attentional resources to maths (Pletzer et al. 2015).

The combination of the impact on the brain and the resulting negative emotions make studying maths an unpleasant experience for students with maths anxiety so the brain aversively conditions the student away from learning maths. The key behavioural consequence of maths anxiety is maths avoidance (Woodard 2004; Hembree 1990; Brady and Bowd 2005), due to the brain treating maths as an aversive stimulus -- something threatening that should be avoided. This often means avoiding subjects or modules thought to contain maths or statistics altogether (Ashcraft and Moore, 2009; Brady and Bowd, 2005) which impacts on subject and career choices. In an earlier study, we found that 44% of University of Sheffield students have let a fear or dislike of maths affect their subject choices (Marshall, 2016). However, avoiding maths or statistics is becoming increasingly impractical, given that most degrees now require students to study at least some degree of maths or statistics. Indeed (Hogden et. al., 2014) reports that,

> *"All the disciplines in the Higher Education Academy STEM project require Mathematics and/or Statistics to some extent*", and "*many students arrive at university with unrealistic expectations of the mathematical and statistical demands of their subjects.*" and highlight that a "*Lack of confidence and anxiety about Mathematics/Statistics are problems for many students.*"

When avoiding maths is not possible, students with moderate to high levels of maths anxiety will still attempt to avoid studying for their maths or statistics courses until the last minute (Jackson, 2008; Woodard, 2004) inevitably leading to poor performance (Ashcraft, 2002) which reinforces their belief that they are useless at maths. Maths anxiety has shown to be negatively related to maths achievement (Hembree 1990; Woodard 2004) due to the lack of preparation on the part of the student. Poor performance affects confidence, progression (Lawson et al. 2003) and retention so tackling anxiety early is vital to ensure students reach their full potential.

Strategies for overcoming maths anxiety

Research suggests that a number of strategies can reduce anxiety and help students succeed with maths or statistics (Geist 2010; Iossi 2013; Finlayson, 2014; Uusimaki & Kidman, 2004; Harper & Daane, 1998). These strategies include awareness of maths anxiety and its effects on the brain, improving self-efficacy, and receiving individual support.

Awareness

Students are not usually aware that maths anxiety is a recognised phenomenon, the impact it has on the brain and maths performance, or how many other people feel the same way. According to Uusimaki & Kidman (2004), becoming self-aware of one's maths anxiety, the effect that it can have on the brain and subsequently their emotional state, can assist in its reduction. If students are aware of their negative beliefs and recognise when their anxiety is affecting their performance, they can learn to control and overcome the anxiety (Martinez & Martinez, 1996; Pintrich, 2000). Iossi (2013) discusses the various maths anxiety courses offered by several American Universities (Carroll, 2006; Butte College, 2006; American River College, 2006; Chabot College, 2006). Whilst some have been running for a number of years, very little is known about the effectiveness of reducing anxiety.

Self-efficacy

Self-efficacy is the belief that one is capable of successfully performing a task (Bandura 1977) and several studies have shown that high scores of self-efficacy are related to good exam performance (McMullan et al. 2012; Maag 2004; Warwick, 2008). Mathematical self-efficacy is based on different sources of evidence (Warwick, 2008) with 'performance experience' being the key source. This is where students reflect on their previous mathematical attainment when making judgements about their ability; with success increasing self-efficacy and poor performance reducing it. 'Vicarious performance' is the comparison to peers and 'verbal persuasion' is the comments or feedback received by others. Achieving higher grades than peers and receiving positive feedback strengthen self-efficacy. The fourth aspect discussed by Warwick (2008) is that of the negative effect of maths anxiety on self-efficacy. It is the impact of self-efficacy on attendance, engagement (Pajares & Miller, 1994) and the willingness to ask for help (Ryan & Pintrich, 1997) which impact on success with maths. Students with high self-efficacy are motivated to persevere with maths (Bandura, 1997) and put the work in to achieve higher grades rather than exhibit maths avoidance. This leads to better exam performance (Bandura 1986). Students need to accept that effort is needed to pass, get help from peers or one-to-one support if needed, and believe that they can pass (Perry 2004).

One-to-one support and peer learning

For students to overcome maths anxiety, positive teaching and learning experiences are required to help break the avoidance cycle, improve student engagement and eventually

lead to improved exam performance. Most universities (Perkin et al, 2012) now have dedicated Maths Support Centres (MSCs) which primarily offer individual support, improving the performance and retention of students (O'Sullivan et al. 2014; Dowling &Nolan, 2006). These centres provide students with relaxing, non-threatening maths experiences in a supportive environment, and teach at a slower pace, allowing enough time for inquiry and individual development (Woodard 2004).

Receiving extra help from someone other than their lecturer offers students alternative explanations which may be easier for the student to understand (Blazer, 2011) and students expect staff in support centres to offer emotional as well as practical support (Lawson, 2008). In a one-to-one setting, students feel more comfortable getting feedback on their work and asking questions without feeling stupid, so can progress much more quickly. Immediate feedback reduces the time it takes for students to achieve a desired level of understanding (Anderson et al. 1989) and reduces the negative impact of maths anxiety (Núñez-Peña et al. 2015). Cooperative learning in which students discuss and check understanding with peers is also seen as beneficial (Geist 2010; Woodard 2004) especially if others in the group are more knowledgeable (Vygotsky, 1978). This type of group work is encouraged within MSCs. The quality of the staff employed at the MSC is also important (Lawson et al, 2003) to ensure students receive the positive verbal persuasion and encouragement needed to overcome their anxiety. Students need to replace their previous negative experiences of maths with positive interactions from staff who are knowledgeable, enthusiastic and show belief in the student's ability to succeed (Finlayson 2014).

Positive one-to-one support is the most effective method for overcoming maths anxiety (Núñez-Peña et al. 2015), but an estimated 33% of students who are 'at-risk' of failing or dropping out, do not use MSC support (O'Sullivan et al. 2014). Students with low self-efficacy are less likely to ask for help out of fear or embarrassment that they may appear stupid (Warwick, 2008) and O'Sullivan (2014) reports that fear was the main reason for non-engagement with the MSC at Maynooth University. Given the large number of 'at-risk' students not accessing MSC's, Symonds (2008) suggests a more proactive approach to advertising and encouraging MSC attendance is needed.

The long-term goal of this study is to improve attendance of maths anxious students at the Maths and Statistics Help centre (MASH). This paper discusses the construction of a maths anxiety awareness workshop and the evaluation of its immediate effectiveness on reducing anxiety and increasing confidence. The workshop aims to increase awareness of maths anxiety, repudiate some myths about learning maths, increase self-efficacy, and encourage students to make use of the Maths and Statistics Help (MASH) centre at the University of Sheffield.

Marshall, E.M., Wilson, D.A., and Mann, V.E. (2017). Evaluating the effectiveness of maths anxiety awareness workshops. *Journal of Learning Development in Higher Education.*

Methods

Content of Workshop

The workshop used a Constructivist teaching approach which builds upon students' existing knowledge, used active rather than passive learning (Blazer, 2011; Finlayson, 2014), and utilised cooperative small-group discussion. Students were first asked to reflect upon any anxieties they had about maths and how this impacted on them physically and emotionally. The plenary for this section was an exemplary list of physical, emotional, and cognitive anxiety symptoms.

Definitions of maths anxiety were given followed by a brief showcase of 3 recent neuroscience papers underline the impact of maths anxiety on the brain and how this affects the manipulation of numbers and the acquisition of maths skills. Images from brain scans were shown connecting brain events (e.g. activation of pain networks) to students' experiences when learning maths (e.g. anticipative fear of doing maths). This aspect of the workshop is crucial, as it provides an objective explanation for their negative feelings and legitimises maths anxiety as a specific learning difference. Indeed, the presence of brain images has been shown to make psychological arguments more persuasive (McCabe & Castel, 2008). Figure 1 is an example of a brain scan showing maths anxiety using up working memory resources that could otherwise be used for solving maths problems.

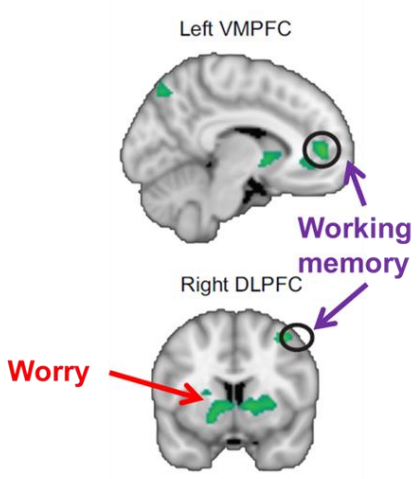

Figure 1: Brain images indicating the parts of the brain associated with anxiety and working memory (adapted from Young et al., 2012)

Students were then asked to take part in a group discussion and reflect upon on negative experiences they thought led to maths anxiety; how many students they think suffer from it; and whether it has impacted upon any of their maths learning or educational choices. The discussion's plenary included examples of negative maths experiences as well as prevalence figures. Allowing students to reflect on where their negative attitudes came from and how it makes them feel is the starting point for addressing the anxiety. Many students feel like they are the only person who is bad at or anxious about maths so giving them the prevalence figures demonstrates that they are not alone with their anxieties; rather, their feelings are very common.

It is widely reported that there are common misconceptions and incorrect beliefs about maths and it is important to dispel these myths if students are to engage with maths effectively (Blazer, 2011; Jackson, 2008; Ashcraft & Krause, 2007; Woodard, 2004). For example, many people believe that only certain people can succeed with maths and these people are born with a 'mathematical mind' (Furner and Duffy, 2002), or are "left-brain dominant" and can solve all mathematical problems quickly and in their heads

without the need for study (Jackson, 2008). We used a true/false quiz to encourage students to reflect and question beliefs they previously held. The feedback for the quiz included information about the importance of self-efficacy and regular study on improving maths performance. The workshop concluded with strategies that students could use to reduce their anxiety and succeed with their maths or statistics modules. The main strategies promoted were, a) encouraging self-efficacy; b) the use of the Maths and Statistics Help (MASH) centre for 1:1 support; c) encouragement of peer learning. The slides for the workshop are available in the Supplementary Information.

Pilot workshop

In order to measure the effectiveness of workshop addressing maths anxiety, 83 foundation-year students in the Department of Lifelong Learning (DLL) received a maths anxiety workshop during their first maths lesson in September 2015. Academics within this department had previously expressed concerns about the large number of maths anxious students and the impact this had on their mathematical learning and so were keen to get involved in this project. The group primarily consisted of mature students who do not specialise in a particular subject until the second year. As a consequence, the group comprised science, humanities, and social science students, ensuring that the research considers maths anxiety across a diverse range of disciplines. Many mature students have low mathematical self-efficacy and exhibit signs of maths anxiety (O'Sullivan et al, 2014; Klinger, 2006), with maths being their main concern when starting university. Students who do not perceive maths as useful for their chosen profession also have lower self-efficacy (Warwick, 2008). As this group contained mostly mature students who were not expecting to study maths as part of their chosen degree, high maths anxiety and low self-efficacy were expected. Given maths avoidance is a key coping strategy for those with high anxiety; the session was compulsory rather than voluntary. This also meant that there were some students with no anxiety and high self-efficacy who attended the workshop.

Evaluation of the awareness workshop

In order to measure the immediate effectiveness of the session, the DLL students were asked to fill in some information about their anxiety levels before the class. Additionally, students were asked to fill-in a short feedback survey after the workshop, which was completed by 57 students.

Overall, the results for the whole group were very positive: 91% of students agreed or strongly agreed that the session was useful, and 87% agreed that the session was interesting.

As part of the feedback survey, students were asked to assess their own anxiety using a 5-point scale ranging from "none" to "very high". Of the 57 respondents to the feedback survey, 40% classified themselves as having moderate to very high levels of maths anxiety, and 18% said they had no anxiety about maths at all. Participants were asked whether they felt less anxious about maths (Figure 2) and more confident about maths

(Figure 3) as a result of the workshop. Those classifying themselves as having moderate to high levels of maths anxiety were grouped together as this is the target audience for a maths anxiety workshop. Figures 2 and 3 show the full breakdown of responses for the two questions by anxiety level.

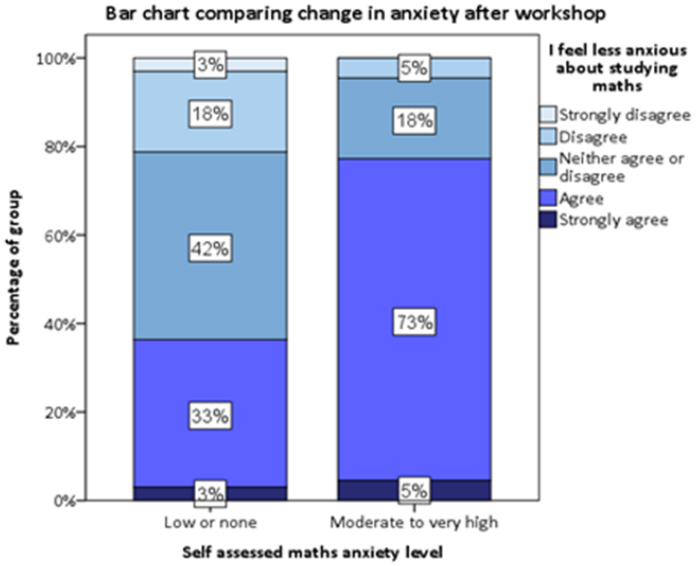

Figure 2: Change in anxiousness about maths after workshop.

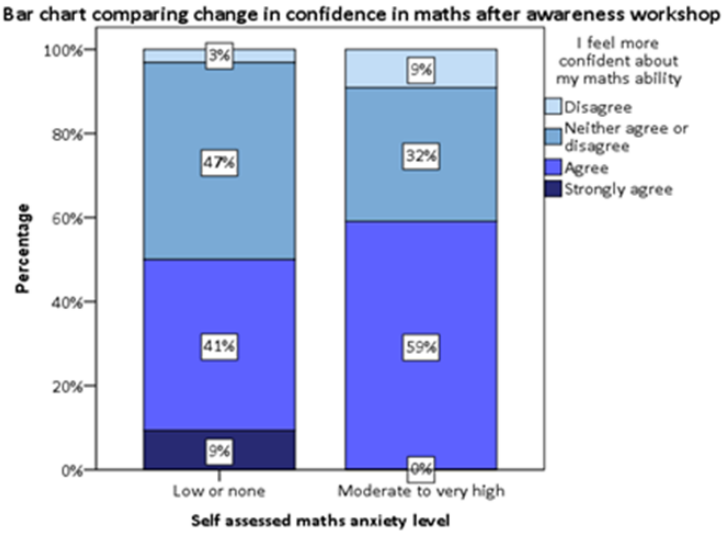

Figure 3: Change in confidence about maths after workshop.

78% of those classified as moderate to very high levels of anxiety felt less anxious (Figure 2) as a result of the session and 59% felt more confident (Figure 3) about their maths ability.

Of those who classified themselves as having no or low anxiety, 36% of them felt less anxious and 50% felt more confident. These results suggest that a maths anxiety awareness workshop which discusses the causes and impact of maths anxiety and strategies for effective can be effective in reducing students' anxiety.

The students also gave verbal feedback to the maths teacher on how useful they had found the session and the department has asked for the session to be repeated for next year's cohort. The department have also expressed an interest in adding the workshop to the Widening Participation Programme to encourage more students to overcome their anxiety prior to making degree choices.

Discussion and Further Work

Whilst the initial feedback from the session was very positive, one of the main strategies was to encourage the use of the one-to-one support available at the MASH centre, but very few students did. Those who did use the service benefited greatly and went on to pass the course, but there were several who failed having never attended. From the numerous anxious students who have used MASH, it is clear that attending the first appointment is the hardest. Once students have attended their first session, they see the immediate benefits and regret not coming before. We also asked the students to fill in a survey at the end of the course but there were very few respondents especially from the anxious group so we could not draw any conclusions on what helped students reduce their anxiety or why they did not use MASH. Further work will investigate the reasons why at-risk students do not engage with the support offered.

Following the positive feedback of the pilot workshops, the workshop was added to the general Academic Skills workshop programme, but very few students have attended so far. Whilst feedback from the general workshops has still been positive, the peer-group nature of departmental workshops seemed to work better as students could see that many of their peers were also anxious and it encouraged group work. Students in the general workshops found it hard to believe that their peers would also be worried or struggling with work and didn't feel confident approaching others about working together. They were also asked which of a number of different strategies would encourage them to come to MASH and 'having an appointment with a named tutor' was the top response. All attendees are given the email address for a named MASH contact to encourage them to attend.

Further work as part of this study will focus on methods for improving attendance at the general workshops, encouraging the use of MASH, and evaluating the effectiveness of online tests and apps for reducing anxiety.

In addition to the student workshops, training has been given to a range of support staff and information sheets, which can be used with students, produced. These guides can be downloaded from the web (https://www.sheffield.ac.uk/mash/anxiety), and the authors hope to expand on the resources over time. Increasing awareness of maths teaching staff and those working in non-maths support services is important so that students with maths anxiety can be identified and supported as early as possible. The SpLD and maths support teams work closely together at the University of Sheffield, with SpLD tutors bringing students to MASH for the crucial first visit and explaining any difficulties that individual students may have to the maths tutors. This collaborative

approach to student support has benefited students and both teams.

Conclusion

In conclusion, large numbers of students are affected by maths anxiety, often as a result of negative learning experiences at an early age, which interferes with their ability to solve mathematical problems. These students tend to practice maths avoidance as a coping strategy, which increases anxiety further and influences A-level, degree, module, and ultimately, career choice. Given that studying maths or statistics is almost impossible to avoid in higher education nowadays, addressing maths anxiety earlier in education can enable students to study maths effectively and progress on their courses. The findings of the present study suggest that the use of a workshop which addresses maths anxiety could be a useful tool for reducing maths anxiety in students. By discussing maths anxiety and its impact on learning, tutors can instil a sense of self-efficacy in students and reduce maths avoidance.

References

American River College. (2006). *Fall 2006 class schedule: Mathematics.* Retrieved September 16, 2006, from http://www.losrios.edu/arc/fall/Mathematics-MATH.htm

Anderson, J. R., Conrad, F. G., & Corbett, A. T. (1989). Skill Acquisition and the LISP Tutor. *Cognitive Science*, *13*(4), 467–505.

Ashcraft, M.H., Krause, J.A. (2007). Working memory, math performance, and math anxiety. *Psychon. Bull. Rev 14*(2).

Ashcraft, M. H., & Moore, A. M. (2009). Mathematics Anxiety and the Affective Drop in Performance. *Journal of Psychoeducational Assessment*, *27*(3), 197–205.

Bandura, A. (1986) *Social foundations of thought and action: a social cognitive theory*. New Jersey: Prentice-Hall Inc.

Bandura, A. (1977) *Self-efficacy: The exercise of control*. New York: Freeman.

Bekdemir, M. (2010). The pre-service teachers' mathematics anxiety related to depth of negative experiences in mathematics classroom while they were students. *Educational Studies in Mathematics*, *75*(3), 311–328.

Blazer, C. (2011) Strategies for Reducing Math Anxiety. Information Capsule. Volume 1102. *Research Services, Miami-Dade County Public Schools.*

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

Buston, L. (1981). *Do You Panic About Maths? Coping with maths anxiety*. Heinemann, London.

Marshall, E.M., Wilson, D.A., and Mann, V.E. (2017). Evaluating the effectiveness of maths anxiety awareness workshops. *Journal of Learning Development in Higher Education.*

Butte College. (2006). *Math catalog*. Retrieved September 16, 2006, from http://www.butte.edu/information/catalog/course_descriptions/catalog_math.html

Carroll, C. (2006). *Developing math confidence.* University of Florida Counseling Center. Retrieved September 17, 2006, from http://www.counsel.ufl.edu/brochure.asp?include=brochures/developing_math_confidence.brochure

Chabot-Las Positas Community College. (2006). *Web course catalog academic year 2006-2007: Psychology.* Retrieved September 16, 2006, from https://bw4.clpccd.cc.ca.us/clpccd/2006/cat_pscn.htm

Dowling, D. and Nolan, B. (2006). Measuring the effectiveness of a maths learning centre - The Dublin City University experience*. Proceedings of the CETL MSOR Conference 2006*, (pp. 51-54).

Eccles, J. S., Jacobs, J. E., & Harold, R. D. (1990). Gender Role Stereotypes, Expectancy Effects, and Parents' Socialization of Gender Differences. *The Journal of Social Issues*, *46*(2), 183–201.

Finlayson, M. (2014). Addressing math anxiety in the classroom. *Improving Schools*, *17*(1), 99–115.

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

Furner, J. M. and Duffy, M. L. (2002) Equity for all students in the new millennium: Disabling math anxiety. *Intervention in School & Clinic, 38*(2), 67.

Geist, E. (2010). The anti-anxiety curriculum: Combating math anxiety in the classroom. *Journal of Instructional Psychology*, *37*(1), 24.

Greenwood, J. (1984). Soundoff: My Anxieties about Math Anxiety. *Mathematics Teacher*, *77*(9), 662–663.

Gresham, G. (2007). A Study Of Mathematics Anxiety in Pre-Service Teachers. *Early Childhood Education Journal*, *35*(2).

Harper, N.W. and Daane, C.J. (1998) Causes and Reduction of Math Anxiety in Preservice Elementary Teachers. *Action in Teacher Education*, *19*(4), 29-38.

Haylock, D. (2003) *Mathematics Explained For Primary Teachers.* 2nd Edition. London: Paul Chapman.

Hembree, R. (1990). The Nature, Effects, and Relief of Mathematics Anxiety. *Journal for Research in Mathematics Education*, *21*(1), 33–46.

Hodgen, J., McAlinden, M., and Tomie, A. (2014). Mathematical Transitions: a report on the mathematical and statistical needs of students undertaking undergraduate studies in various disciplines. *Higher Education Academy*.

Marshall, E.M., Wilson, D.A., and Mann, V.E. (2017). Evaluating the effectiveness of maths anxiety awareness workshops. *Journal of Learning Development in Higher Education.*

Iossi, L. (2013). Strategies for reducing math anxiety in post-secondary students. In S. M. Nielsen & M. S. Plakhotnik (Ed.), *Proceedings of the Sixth Annual College of Education Research Conference: Urban and International Education Section* (pp. 30–35). Miami: Florida International University.

Jackson, C. D., & Leffingwell, R. J. (1999). The Role of Instructors in Creating Math Anxiety in Students from Kindergarten through College. *The Mathematics Teacher*, 92(7), 583–586.

Jackson, E. (2008). Mathematics Anxiety in Student Teachers*. Practitioner Research in Higher Education, 2(1), 36-42.*

Jones, W. G. (2001). Applying Psychology to the Teaching of Basic Math: A Case Study. *Inquiry: A Journal of Medical Care Organization, Provision and Financing, 6*(2), 60–65.

Klinger, C. (2005). Challenging negative attitudes, low self-efficacy beliefs and math-anxiety in pretertiary adult learners. In M. Horne, and B. Marr, (Eds) Connecting voices in adult mathematics and numeracy: practitioners, researchers and learners. *Proceedings of the Adults Learning Mathematics (ALM) 12th annual international conference* (pp. 164-171). Australian Catholic University, Melbourne.

Lawson, D., Croft, A.C. and Halpin, M. (2003*). Good Practice in the Provision of Mathematics Support Centres (2nd edn.)*. Birmingham: LTSN Maths, Stats and OR Network.

Lyons, I. M., & Beilock, S. L. (2012). When math hurts: math anxiety predicts pain network activation in anticipation of doing math. *PloS One*, *7*(10), e48076.

Maag, M. (2004). The Effectiveness of an Interactive Multimedia Learning Tool on Nursing Students' Math Knowledge and Self-efficacy. *Computers, Informatics, Nursing: CIN*, *22*(1), 26.

Marshall, E.M., Wilson, D. and Mann, V.E. (2016). Attitudes and anxiousness about maths*.* In *Brave New World*: *Proceedings of the CETL MSOR Conference 2016*, (pp. 66–74). Loughborough.

Martinez, J. G. R., & Lawson, D. (2008). *Mathematics Support Centres: Who uses them and who doesn't? Why not?* Keynote presentation at the 3rd Irish workshop on Mathematics Learning and Support Centres. NUI Maynooth.

Martinez, N. C. (1996). Math without fear. Needham Heights, MA: Allyn and Bacon.

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*(9), 1480–1488.

McCabe, D.P. and Castel, A.D. (2007). Seeing is believing: The effect of brain images on judgements of scientific reasoning. *Cognition 10*(7), 343–352.

McMullan, M., Jones, R., & Lea, S. (2012). Math anxiety, self-efficacy, and ability in British undergraduate nursing students. *Research in Nursing & Health*, *35*(2), 178–186.

Marshall, E.M., Wilson, D.A., and Mann, V.E. (2017). Evaluating the effectiveness of maths anxiety awareness workshops. *Journal of Learning Development in Higher Education*.

Núñez-Peña, M. I., Bono, R., & Suárez-Pellicioni, M. (2015). Feedback on students' performance: A possible way of reducing the negative effect of math anxiety in higher education. *International Journal of Educational Research*, *70*, 80–87.

Onwuegbuzie, A. J. (2000). Statistics Anxiety and the Role of Self-Perceptions. *The Journal of Educational Research*, *93*(5), 323-330.

O'Sullivan, C., Mac an Bhaird, C., Fitzmaurice, O., & Ni Fhlionn, E. (2014). *An Irish Mathematics Learning Support Network (IMLSN) Report on Student Evaluation of Mathematics Learning Support: Insights from a large scale multi-institutional survey*. Ireland: National Centre for Excellence in Mathematics and Science Teaching and Learning (NCEMSTL).

Pajares, F. and Miller, M. (1994) Role of Self-efficacy and self-concept beliefs in mathematical problem solving: A path analysis. *Journal of Educational Psychology*, *86*, 193-203.

Perkin, G., Lawson, D., and Croft, A.C. (2012). Mathematics learning support in UK higher education: the extent of provision in 2012. Loughborough: Maths, Stats and OR network.

Perry, A. B. (2004). Decreasing math anxiety in college students. *College Student Journal*, *38*(2), 321.

Pintrich, P. R. (2000). An achievement goal theory perspective on issues in motivation terminology, theory and research. *Contemporary Educational Psychology*, *25*, 92-104.

Pletzer, B., Kronbichler, M., Nuerk, H.-C., & Kerschbaum, H. H. (2015). Mathematics anxiety reduces default mode network deactivation in response to numerical tasks. *Frontiers in Human Neuroscience*, *9*, 202.

Richardson, F. C., & Suinn, R. M. (1972). The Mathematics Anxiety Rating Scale: Psychometric data. Journal of Counseling Psychology, *19*(6), 551.

Ryan, A. and Pintrich, P. R. (1997) Should I ask for help?: The role of motivation and attitudes in adolescents' help seeking in math class. *Journal of Educational Psychology*, *89*, 329-341.

Tobias, S. (1993). *Overcoming math anxiety*. New York: W.W. Norton and Company Inc.

Scarpello, G. (2007). Helping Students Get Past Math Anxiety. Techniques*: Connecting Education and Careers* (J1), *82*(6), 34–35.

Soni, A., & Kumari, S. (2015). The Role of Parental Math Anxiety and Math Attitude in Their Children's Math Achievement. *International Journal of Mathematical Education in Science and Technology*, 1–17.

Symonds, R., Lawson, D. and Robinson, C. (2008). Promoting student engagement with mathematics support. *Teaching Mathematics and its Applications*, *27*(3), 140-149.

Uusimaki, L. S., & Kidman, G. C. (2004). Reducing maths-anxiety: Results from an online anxiety survey. Presented at the AARE Annual Conference, Melbourne, Australia:

Marshall, E.M., Wilson, D.A., and Mann, V.E. (2017). Evaluating the effectiveness of maths anxiety awareness workshops. *Journal of Learning Development in Higher Education.*

Australian Association for Research in Education.

Vygotsky, L. S. (1978). *Mind in society: The development of higher psychological processes*. Cambridge, MA: Harvard University Press.

Warwick, J. (2008) Mathematical self efficacy and student engagement in the mathematics classroom*, MSOR Connections 8(3).*

Wood, E. F. (1988). Math Anxiety and Elementary Teachers: What Does Research Tell Us? *For the Learning of Mathematics*, *8*(1), 8–13.

Woodard, T. (2004). The Effects of Math Anxiety on Post-Secondary Developmental Students as Related to Achievement, Gender, and Age. *Inquiry: A Journal of Medical Care Organization, Provision and Financing*, *9*(1), n1.

Young, C. B., Wu, S. S., & Menon, V. (2012). The neurodevelopmental basis of math anxiety. *Psychological Science, 23*(5), 492–501.