Institution: University of Derby		
Unit of Assessment: 4		
Title of case study: Understanding and reducing mathematics anxiety		
Period when the underpinning research was undertaken: March 2011–December 2019		
Details of staff conducting the underpinning research from the submitting unit:		
Name(s):	**Role(s) (e.g. job title):**	**Period(s) employed by submitting HEI:**
Dr Thomas Hunt	Associate Professor in Psychology	January 2007–present
Professor David Sheffield	Director of Professional Psychology Programmes (online)	May 2010–present
Mr Paul Staples	Senior Lecturer in Psychology	September 2006–present
Dr Dominic Petronzi (UoA 23)	Lecturer in Psychology	September 2017–present
Period when the claimed impact occurred: August 2013–December 2020		
Is this case study continued from a case study submitted in 2014? No		

1. Summary of the impact (indicative maximum 100 words)

Maths anxiety is a pervasive psychological issue in education and beyond. It is associated with poor maths attainment and engagement with jobs and courses that involve numbers. Psychological research at the University of Derby (UoD) has enabled schools and educational specialists nationally and internationally to: i) measure maths anxiety in individuals, in order to identify those in need of support; and ii) implement strategies to reduce maths anxiety and increase maths attainment whilst also improving wellbeing and increasing access to maths education. Charities (e.g. National Numeracy), businesses (e.g. Vretta Inc.), and public health organisations (e.g. Health Education England) have recognised the importance of the research, resulting in changes in their policies, practices and strategic focus.

2. Underpinning research (indicative maximum 500 words)

Maths anxiety research at UoD is carried out by the Mathematics Anxiety Research Group (MARG). The research has three broad aims:

- Increasing understanding of the impact of maths anxiety on maths performance;
- Improving the measurement of maths anxiety; and
- Developing strategies to reduce maths anxiety.

Three self-report tools to measure maths anxiety have been published, including the first one for adults in the UK [3.1] and the first one for very young children [3.2]. Both have received much attention from teachers and researchers, with the authors regularly receiving requests from teachers across the UK to use the scales.

Whilst theoretically important, factors such as time pressure have not been researched sufficiently in the context of maths anxiety. We demonstrated the relevance of time pressure and the findings tally with discussions with teachers: time pressure can adversely affect maths performance if one is maths anxious [3.1, 3.3].

One extensive qualitative study was the first to investigate maths anxiety in very young children [3.4]. This produced several important findings. Firstly, children who were secure with numeracy expressed a desire for success and were motivated by reward, including being motivated by the presence of a teacher. Secondly, the link between fear and failure in maths was emphasised by the fact that children who were apprehensive sometimes viewed their teachers as figures of punishment. Finally, numeracy was seen by children as competitive and hierarchical; this was sometimes initiated or reinforced explicitly by teachers and at other times it could be implicit. The perceived impact of time pressure was a particular theme running throughout the findings. These

findings have been integral to the content of publications targeting key stakeholders and engagement events, including workshops delivered to teachers and other professionals.

One study with children was the first to show that self-reported maths anxiety positively correlated with psychophysiological reactivity to the increasing difficulty of maths problems [3.5]. This lends support to the argument that children may view maths as threatening and consequently react negatively, affecting their performance. Our work further emphasises the importance of studying neurophysiological aspects of maths anxiety, providing the first evidence that gamma-band brain activity is related to maths anxiety [3.6]. Again, these findings have contributed to work with various stakeholders to reduce the harm caused by maths anxiety.

The research findings have had an immediate, significant impact on a range of stakeholders, particularly educators, nationally and internationally.

3. References to the research (indicative maximum of six references)

UoD researchers are indicated by black, underlined text:

3.1 Hunt, T.E., Clark-Carter, D. and Sheffield, D. (2011) 'The development and part validation of a U.K. scale for mathematics anxiety', *Journal of Psychoeducational Assessment*, 29(5), 455-466. DOI: https://doi.org/10.1177%2F0734282910392892 [Internationally recognised. Large sample size. Highly used scale in and out of academia. Peer-reviewed journal.]

3.2 Petronzi, D., Staples, P., Sheffield, D., Hunt, T.E. and Fitton-Wilde, S. (2019) 'Further development of the children's mathematics anxiety scale UK (CMAS-UK) for ages 4-7 years', *Educational Studies in Mathematics,* 100(3), 231-249. DOI: https://doi.org/10.1007/s10649-018-9860-1 [Internationally recognised. Strong methodological development. First of its kind for very young children. Peer-reviewed journal.]

3.3 Hunt, T.E. and Sandhu, K. (2017) 'Endogenous and exogenous time pressure: Interactions with mathematics anxiety in explaining arithmetic performance', *International Journal of Educational Research,* 82, 91-98. DOI: https://doi.org/10.1016/j.ijer.2017.01.005 [Internationally recognised. Contributes to knowledge in the field as it is the first study to consider different forms of time pressure in the context of maths anxiety. Peer-reviewed journal.]

3.4 Petronzi, D., Staples, P., Sheffield, D., Hunt, T.E. and Fitton-Wilde, S. (2017) 'Numeracy apprehension in young children: insights from children aged 4-7 years and primary care providers', *Psychology and Education,* 54, 1-33. [Extensive qualitative piece. Peer-reviewed journal.]

3.5 Hunt, T.E., Bhardwa, J. and Sheffield, D. (2017) 'Mental arithmetic performance, physiological reactivity and mathematics anxiety amongst U.K primary school children', *Learning and Individual Differences,* 57, 129-132. DOI: https://doi.org/10.1016/j.lindif.2017.03.016 [Internationally recognised. Good sample size for a project of this kind. First study to consider children's self-reports of maths anxiety in the context of psychophysiological reactivity to maths. Peer-reviewed journal.]

3.6 Batashvili, M., Staples, A., Baker, I. and Sheffield, D. (2019) 'Exploring the relationship between gamma-band activity and maths anxiety', *Cognition and Emotion*, 33(8), 1616-1626. DOI: https://doi.org/10.1080/02699931.2019.1590317 [Internationally recognised. Strong methodology. Unique approach to investigating maths anxiety. Peer-reviewed journal.]

Funding

G3.1 The Derby City Schools Strategic Investment Fund for Numeracy: GBP1,650 (January 2019 to July 2019).
G3.2 Research England supported University of Derby Global Challenges Research Fund pump priming award. (GBP1,300) in February 2019.
G3.3 Research England supported University of Derby Global Challenges Research Fund pump priming award. (GBP2,300) in March 2020.

4. Details of the impact (indicative maximum 750 words)

According to National Numeracy's recent Impact Report, millions of people in the UK struggle with numbers. Those with poor numeracy skills are more than twice as likely to be unemployed and the average cost to individuals with poor numeracy is GBP460 a year. Nearly half (49%) of working age UK adults currently have the numeracy levels of a primary school age child, which has a significant negative impact on them, on employers and on society overall. This costs the UK economy an estimated GBP388,000,000 per week (National Numeracy, 2019). The Maths Anxiety Research Group (MARG) highlighted the importance of recognising anxiety in maths and worked with organisations such as schools, charities, businesses, and public health bodies to create improvements in maths achievement and changes to policy guidelines that have been realised internationally.

Professional practice and training: informing policy change and strategic direction

Numeracy is one of the key skills that is imperative to the NHS's vital support workforce. MARG research influenced the solutions identified by Health Education England (HEE) to address weaknesses in the functional numeracy skills of the UK support workforce. Dr Hunt is a member of the HEE National Special Interest Group of experts, which, "*influences* [HEE's] *strategy and national direction of travel*". MARG research was showcased through HEE events and webinars to support numeracy training on a national scale [5.1].

The UoD ran a research-informed maths anxiety workshop for educational psychologists (09-2018). Feedback from attendees demonstrated that they had subsequently changed their practices, embedding consideration of maths anxiety into their case work. Further feedback stated: "*it has been helpful to encourage teachers, parents and young people to think about their own beliefs, experiences and worries and how this might affect their learning*" [5.2].

National Numeracy (NN) are now focusing on maths anxiety and MARG research informed the content of NN workshops for tackling maths anxiety among healthcare assistants in the NHS and helped NN to, "*shape our approach and research around this subject area*" [5.3a]. The online 'National Numeracy Challenge' has been taken by around 250,000 people in the UK and the UoD supported the analysis of data from it; this contributed to a key report produced by National Numeracy [5.3b], the launch of which was introduced by the Chief Economist at the Bank of England (11-2019). There were two key findings reported: maths anxiety was the strongest predictor of maths attainment and a growth mind-set was the strongest predictor of improvement in numeracy skills. Maths anxiety further featured in a video produced by UoD as part of NN Day (May 2020), achieving over 500 views nationally. NN has also published several blogs produced by the UoD, with a wide readership, including approximately 400 views of two blogs since publication in March 2020: 'What is Maths Anxiety?' and 'What can be done to address maths anxiety?' [5.3c].

The British Dyslexia Association (BDA) is widely recognised and, having been established for almost 50 years, offers professional accredited training. One of our maths anxiety scales [3.1] appears among the list of keystone research in their policy document, 'Policy, Research, Identification and Intervention for Maths Learning Difficulties and Dyscalculia' [5.4a]. The MAS-UK [3.1] is the preferred scale for BDA training courses on maths difficulties and the UoD work on maths anxiety has had "*significant influence*" on the establishment of a new sub-committee to, "*advise on a new definition and assessment guidance for the assessment of dyscalculia*" [5.4b]. This emphasises the reach of the research through crossing boundaries and the inclusion of the scale as a key tool used in the training of staff demonstrates the impact of the research on organisational policy.

Education: inclusivity, widening participation and reducing the attainment gap

The Derby City Schools Strategic Investment Fund for Numeracy [G3.1] funded MARG work with local schools (10-2018–07-2019). This involved a workshop for teachers at a primary school and an infant school, raising awareness of the impact of maths anxiety and teaching research-based strategies that teachers can employ in the classroom to reduce it. It also supported the design and evaluation of research-based strategies to reduce maths anxiety in an infant school, with the

Acting Deputy Head Teacher adding: "*By introducing specific strategies as part of our day to day teaching and learning on Maths, we have already seen a positive impact in our children in terms of their resilience to keep going when faced with a challenging problem"* [5.5a]. Indeed, self-reported maths anxiety was significantly lower following the implementation of strategies in the school. Thus, MARG research led to improvements in educational practices and outcomes. The UoD and MARG research also supported the school's strategy for engaging with parents on the topic of maths, which saw approximately 50 parents attend a talk on maths anxiety and the maths curriculum [5.5a]. Feedback from parents was very positive, including statements such as: "*really useful to listen all about maths anxiety, especially finding out about some strategies I can use at home with my child*"; and, "*it really helped me change my thoughts of maths so that I can help my child more*" [5.5a].

MARG research [3.4] also informed the content of 'Noodle's Maths Challenge', one of a series of children's books co-authored by D. Petronzi (09-2019) [5.6], which is selling well across the UK. Based on MARG research, the book was devised to help children understand aversion to numbers and to promote a challenge mind-set. This approach encourages discussion of feelings and issues surrounding maths (as well as solutions), in a format that facilitates reflection for younger children.

The UoD ran a staff development workshop for (approximately 20) teachers on maths anxiety at an Academy in Burton (2017) along with a workshop for 40 students to teach ways to reduce maths anxiety, specifically targeting pupils identified using the Mathematics Anxiety Scale UK [5.5b]; this led to maths anxious children improving on their earlier mock exam performance by almost half a grade. They also outperformed the general cohort by 0.41 of a grade [5.5b]. This work contributed to publications to support maths education nationally [5.7a].

The UoD (06-2018) worked in partnership with a Pupil Referral Unit, giving workshops to teachers on the topic of maths anxiety and helping to produce a workbook that teachers can use with their pupils to support them in overcoming maths anxiety, with one teacher stating: "*Making sure that our students now have the opportunity to talk about their relationship to Maths has made a big impact on some students' attendance, their ability to focus on harder problems and resilience in general. We have trialled giving students a book where they can record important milestones in their relationship to maths learning. Some very positive statements have been made in these. E.g. one student learnt breathing techniques to get through and pass a functional skills exam (after repeated, worsening failures)*" [5.5c].

The UoD delivered workshops on strategies to reduce maths anxiety to approximately 450 local school pupils (03-2019–04-2019). Reflecting on a workshop, a UoD Widening Access Officer noted how the session was excellently received by staff, while: *"Students mentioned [that] they found the 'reducing maths anxiety' session valuable as it provided 'good advice' and it enabled them to 'feel more confident'"*; particularly in relation to the possibility of achieving grade 4 [5.5d]. This feedback aligns with the findings in the National Numeracy report [5.3b] that a growth mindset is hugely important.

Bower Grove School in Kent adopted the MARG's scales [3.1, 3.2]. Measurement in approximately 200 pupils enabled teachers to support their pupils and to plan effectively. The scales are also used in CPD sessions in the school, in addition to measuring maths anxiety in formal planned interventions, supporting the effective reintegration of pupils back into class. For example, one pupil was identified as maths anxious by the scales and interventions were put in place to improve her maths attainment. As a consequence: "…[her] *attitude changed and her behaviour improved. Subsequently she moved to the satellite provision and is thriving there*" [5.5e]. The scales are regarded as inclusive and accessible and have been shared with the maths departments of all 19 Special Schools in Kent [5.5e]. Internationally, using Research England GCRF pump-prime funds, UoD have worked with a range of schools in Nevsehir, Turkey (02-2019) [G3.2] and Masaka, Uganda (03-2020) [G3.3]. Workshops were delivered to teachers and students to raise their awareness and understanding of maths anxiety and provide them with strategies to reduce maths anxiety. Feedback from teachers, based on implementation of the intervention with approximately 300 pupils in Turkey, was very positive, indicating improved attitude and confidence in maths [5.5f].

Our research heavily influenced the formation of an official University partnership with Vretta Inc (a global company specialising in technology for maths education, with bases in Canada, Luxembourg, the USA and the UK) to embed pre and post measures of maths attitudes into their maths training software. In 2019 and in collaboration with Ovidiu Bagdasar in the UoD Maths Hub

in the School of Computing and Engineering, 10 numeracy training courses were developed that are now available to 8,000 NASBTT teacher trainees, 2,000 staff and students at UoD and 180 universities in the UK [5.8]. Following this, the UoD became Vretta's first academic hub in the UK to support success in mathematics. Research by UoD has, "*enabled Vretta to implement innovative approaches into the design of its cutting edge products*", such as the EMM 2.0 platform that featured modules inspired by UoD research which, "*proved to engage students in learning and reduce maths anxiety*" [5.8].

Our research contributed to the Pearson Education #PowerofMaths campaign and subsequent publication on tackling maths anxiety [5.7a]. A Pearson representative has confirmed that the research and the collaboration with MARG had helped to initiate and sustain the ambition to build more confident and resilient learners of maths [5.7b]. The *Guide to Tackling Maths Anxiety* (10-2019), which has been downloaded and viewed 1,500 times (as of 15-07-2020), has also been featured in key educational publications, including *SecEd* (May 2020), *Primary School Management* (January 2020), and *SEN Magazine* (August 2020) [5.7c]. This has resulted in widespread dissemination and requests for our maths anxiety scales from teachers from Kent to the Shetland Islands. The campaign highlighted the importance of UoD research in recognising and identifying maths anxiety.

An open-access online short course on maths anxiety [5.9a] was created by the UoD Mathematics Anxiety Research Group (03-2020) and this has already been accessed by over 200 people, including teachers. The course raises awareness of maths anxiety and provides some practical solutions to help address it. In particular, one maths teacher emphasised how informative they found the course and that they will try to implement the suggested strategies to support their students [5.9b].

5. Sources to corroborate the impact (indicative maximum of 10 references)

5.1 Factual statement (FS) from Health Education England (02-2020).

5.2 FS from Derbyshire County Council Educational Psychology Service (05-2019).

5.3 National Numeracy evidence group: (a) FS from National Numeracy (11-2019); **(b)** National Numeracy Building a Numerate Nation report (11-2019); **(c)** National Numeracy blogs.

5.4 British Dyslexia Association evidence group: (a) British Dyslexia Association Policy, 'Research, Identification and Intervention for Maths Learning Difficulties and Dyscalculia', p. 4 (03-2015); **(b)** FS from the Dyscalculia Committee Chair, British Dyslexia Association (02-2020).

5.5 Schools evidence group: (a) FS from the Acting Deputy Head Teacher at Ridgeway Infant School, Littleover, Derby (05-2019); **(b)** FS from the Head of Mathematics at Paget High School, Burton-upon-Trent, Staffordshire (06-2019); **(c)** FS from Kingsmead Pupil Referral Unit, Derby (09-2019); **(d)** FS from Widening Access Office, UoD (09-2019); **(e)** FS from Bower Grove School, Kent (06-2020); **(f)** FS from Altinyildiz Middle School, Turkey (12-2019).

5.6 Screenshot of the research informed children's book on maths anxiety.

5.7 *Pearson Guide to Tackling Maths Anxiety* evidence group: (a) *Pearson Guide to Tackling Maths Anxiety* (10-2019); **(b)** FS from Pearson Ed. Ltd (12-2019); **(c)** Publications referring to the Pearson roundtable event and *Guide to Tackling Maths Anxiety*.

5.8 FS from Vretta Inc (09-2019).

5.9 Maths anxiety online short course evidence group: (a) Screenshot of the UoD online short course on maths anxiety; **(b)** FS from school teacher regarding the short course (05-2020).