"The question is … are feelings as important as learning?" Assessing mathematics anxiety in young learners.

Janet K. Baker

University of Warwick

Mathematics anxiety is a prevalent, distressing and debilitating problem which increases through secondary education. Causes of mathematics anxiety are well researched and the implications for teaching are widely discussed; however, the age at which it becomes debilitating is less clear. I report on the first stage of my doctoral research. I assessed the level of mathematics anxiety in year 7 pupils at a large secondary school in the English Midlands. Mathematics anxiety was measured through a paper-based questionnaire, adapted from the Betz Mathematics Anxiety Scale. 223 eleven-year olds took part. The data was analysed using commercial software. This research develops knowledge of the extent to which young learners are affected by mathematics anxiety, including issues related to prior mathematics achievement and gender.

Mathematics anxiety, secondary education, emotion.

Introduction

This article describes the first stage of doctoral research. The aim of the broader study is to develop an effective intervention to support young learners who already experience mathematics anxiety in overcoming their feelings and improving their learning experience, to answer the research question 'How can an intervention scaffold year 7 students in learning to manage and overcome their mathematics anxiety?'. This paper describes the first stage, where the sub question 'What is the level of mathematics anxiety in the cohort?' was addressed. In order to assess the prevalence of mathematics anxiety in the target age group (eleven to twelve-year olds) and identify possible future research participants, a quantitative approach was adopted. Design-based research is used in the second stage of the research to develop the intervention.

Mathematics Anxiety

The description of mathematics anxiety as "feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematical problems" (Richardson & Suinn, 1972, p.551) resonates with my experience, as many learners of all ages describe to me the same feelings in the same situations. These learners are children and adults who want to improve their mathematical ability but need help to manage the emotions which arise from previous experiences. Mathematics anxiety is recognised as domain specific (Hill et al., 2016), being a particular phenomenon for mathematics related to test anxiety and other forms of academic anxiety (Dowker, Sarker, & Looi, 2016). Mathematics anxiety inhibits learning (Foley et al., 2017) and affects education and career choices (Dowker et al., 2016). It is prevalent across the globe (OECD, 2013) although, as Dowker et al. (2016) note, a comparable measure is yet to be agreed. The fact that mathematics anxiety increases through adolescence

(Dowker et al., 2016) suggests that a timely point for an intervention would be the beginning years of secondary school, after the transition from primary school.

A useful way of appreciating the inhibiting effect of mathematics anxiety on learning is to use the metaphor of a handbrake on a car (Johnston-Wilder, personal communication). Trying to drive a car when the handbrake is engaged is an unsatisfactory experience which most drivers rectify as soon as they notice the problem. This action results in a marked improvement in driving performance. In a similar manner, removing the barrier of mathematics anxiety by enabling the learner to manage their feelings can result in a marked improvement of learning (Johnston-Wilder & Lee, 2017). Mathematics anxiety is preventable (Lyons & Beilock, 2012) and much recent research concerns itself with this important task (for example, Findon & Johnston-Wilder, 2017). However, many learners already suffer from mathematics anxiety; interventions which help them to alleviate the anxiety and overcome the learning barrier it creates are much needed (De Corte, Depaepe, Op't Eynde & Verschaffel, 2011; Lyons & Beilock, 2012).

A key foundation of this research is the recognised link between cognition and affect, which is well expressed by Roth and Walshaw: "intellect is one of the consequences of the affective nature of an organism's life" (2019, p.112). It is important to note that, according to Roth and Walshaw, affect is an integral part of the learning process rather than just a consequence of problems or unhelpful circumstances.

Neurological support for the integral involvement of affect in learning includes fMRI scans to assess brain function when individuals anticipate a mathematics task (Lyons & Beilock, 2012), where evidence of anticipatory anxiety was found in those suffering from maths anxiety. A useful model of the relationship between cognition and affect is the Hand Model of the Brain (Siegel, 2010), where brain areas are represented by the palm, thumb and fingers. The use of this image has helped learners to appreciate that the sensation of their mind going blank is normal and understandable (Johnston-Wilder & Lee, 2017). Reassurance comes from learners coming to understand that feelings of brain freeze or mind blankness are protective and temporary.

Alleviating Mathematics Anxiety

Research into interventions that help alleviate the negative impact of anticipatory mathematics anxiety include a comparison of chemical and behavioural strategies (Brunye et al., 2013), where different breathing strategies were evaluated against a dose of Theanine, one of the active chemicals in black tea. Whilst a cup of tea is a widely used panacea, a short episode of focused breathing was found to be the most effective strategy. Another approach, which can be used before, during and after any mathematics activity is the Growth Zone Model (Johnston-Wilder & Lee, 2017). Mathematics anxiety can be addressed through enhancing learners' awareness of their emotional state, and then helping them to manage their emotions so that they are ready to learn.

The Growth Zone Model (Johnston-Wilder & Lee, 2017) consists of three zones arranged as concentric circles. These zones represent different emotional states. Once learners have identified their current emotional state they are then encouraged to move to or stay in the growth zone, which is the most productive place to learn. If learners recognise that they are in the anxiety zone, they are encouraged to take appropriate action to recover and move to the growth zone, for example through the use of focused breathing. If they recognise that they are in the comfort zone, they are challenged to make an effort to move to the growth zone by searching out and engaging in learning opportunities.

Research Question and Methodology

As a precursor to testing an intervention, I set out to find the level of mathematics anxiety in the year 7 cohort of the participating school. The overall research design had a mixed methods structure. To answer the first sub-question a quantitative approach was adopted, through a questionnaire to assess the extent of the problem and identify possible participants for the second part of the research. To answer the second and third sub questions, a qualitative approach involving design-based research was adopted. These proceedings report on the findings for the first, quantitative part of the research.

The participating school is a co-educational non-selective academy with 1300 pupils aged from eleven to eighteen on roll. Located in a market town in the West Midlands, it was graded as ‘good’ by the most recent Ofsted inspection. The inspection report recognised good student progress but identified a need for further development to strengthen numeracy skills.

A paper-based questionnaire was administered to each year 7 teaching group by their mathematics teacher. Anonymity was preserved as learner names were not gathered. The questionnaire consisted of two parts. The first gathered contextual information such as age, gender, and teaching group. In addition, the learners were asked to recall their year 6, end of primary school mathematics score. The second part of the questionnaire was based on the Betz (1978) Mathematics Anxiety Scale (MAS), adapted for 10 to 12-year olds by simplifying the wording and then checking the reading age. The MAS asked the learners to report their feelings in various mathematical situations. The MAS has acceptable internal consistency and test – retest reliability and measures mathematics anxiety with appropriate levels of validity (Pajares & Urdan, 1966). The ten questions are answered through the use of a 5-point Likert scale where a high score indicates a high level of mathematics anxiety.

As noted in the introduction, a variety of measures have been used to assess mathematics anxiety, and different criteria have been used to identify levels of mathematics anxiety. In order to move towards a consistent approach, previous research (Johnston-Wilder et al., 2014) was followed in using the criteria identified by Mahmood & Khatoon (2011) to separate the Betz MAS scores into different levels of mathematics anxiety. Mahmood and Khatoon suggest that scores above 32 should be seen as visibly high mathematics anxiety, while scores above 27 should be seen as a sign of mathematics anxiety that is not externally observable.

Results

The end of primary maths scores have an average of 100 and range from 80 to 120. The 223 learners were asked to recall their score, and 213 were able to do so. Whilst these scores were not verified against records, they were judged to be plausible as they all fell within the 80 to 120 range. The average score for this sample was 104, which is 4 points above the national average. The Kolmogorov-Smirnov test indicated that the distribution fell within normal parameters.

Figure 1 shows the distribution of reported mathematics anxiety for the sample. As the MAS contains ten questions and the points on the Likert scale range from 1 to 5, a score of 10 represents the lowest level of reported mathematics anxiety and a score of 50 represents the highest level of reported mathematics anxiety. Figure 2 shows the occurrence of scores in each of these three groups. 55% of the year 7 learners surveyed demonstrated low levels of mathematics anxiety. 20% of the learners surveyed demonstrated moderate levels of mathematics anxiety, and 25% of the learners demonstrated high levels of mathematics anxiety. These proportions are higher than expected from much of the literature (see Dowker et al., 2016 for a summary). However, much of this literature is dated and more recent publications recognise an increase in mathematics anxiety in primary school years (for example Carey et al., 2019).

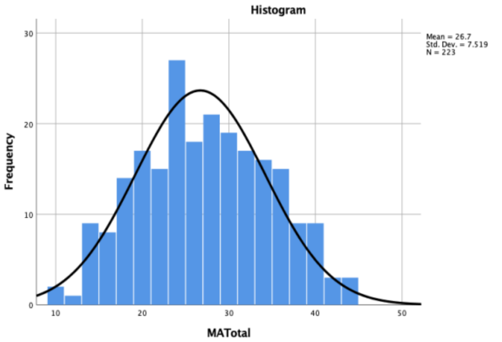

Figure 1 – Distribution of mathematics anxiety

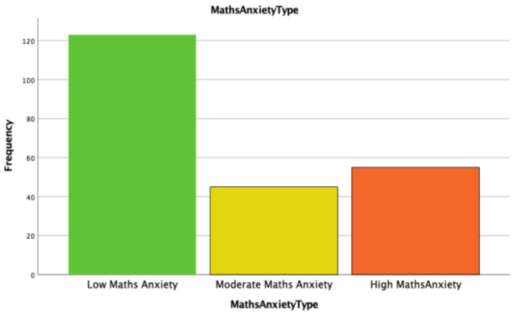

Figure 2 – Grouped mathematics anxiety

Once these findings are arranged into levels of mathematics anxiety by gender, it can be seen that generally females report more mathematics anxiety (a mean of 27.73) than males (a mean of 25.59). This difference is not statistically significant. Hill et al. (2016) found that there was no evidence for gender differences before the age of 12 and Dowker et al. (2016) that gender differences increase through adolescence.

Gathering information about participant gender is a straightforward and reliable procedure, but the trends it reveals may be representative of personality differences which are also gendered to an extent. Personality type may be more significant than gender in terms of a tendency to experience mathematics anxiety, for example the identification of ‘feelers’ rather than ‘thinkers’ by the Myers-Briggs Type Indicator, or ‘empathisers’ rather than ‘systemisers’ by Baron-Cohen, Richler, Bisarya, Gurunathan & Wheelwright (2003), or the orchids rather than the tulips and dandelions identified by Lionetti et al. (2018). All three of these different forms of personality categorisation describe a personality type more sensitive to feedback and encouragement, or lack of it, and so could explain why some learners develop mathematics anxiety whilst others who have similar experiences do not. The possible benefits of analysis of the data using these typologies was not fully appreciated in the planning stages of this doctoral research, and so this data was not gathered. However, it is hoped that these perspectives will inform the qualitative analysis of the second stage of the research, and also future iterations of quantitative research.

Each learner’s mathematics anxiety score was plotted against their reported end of primary mathematics score, to show distribution of mathematics anxiety by previous achievement. The best-fit line on figure 3 shows that there is a slight negative correlation between achievement and anxiety. This result is statistically significant ($p<0.001$) and is predicted by the literature. However, it is important to note that there is evidence of high levels of mathematics anxiety across the attainment span and even in the learners with the highest attainment.

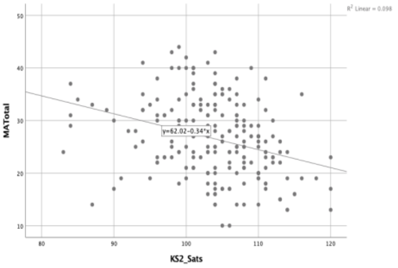

Figure 3 – mathematics anxiety plotted against previous achievement

Discussion

The study described is the first stage of doctoral research. It provided information on the prevalence of mathematics anxiety in first year students in a typical comprehensive school in the West Midlands.

A high level of mathematics anxiety was reported by 25% of the year 7 learners, which is predicted to have a noticeable impact on their attitude towards learning mathematics. Another 20% of the learners reported moderate levels of mathematics anxiety, which indicates a tendency to be anxious when learning mathematics but without clear signs of distress. These levels are slightly higher than those predicted by the literature (Dowker et al., 2016). To have this level of mathematics anxiety already present in the first year of secondary education is certainly worthy of attention. As discussed above, the negative impact of this anxiety is substantial but the barrier to learning that it causes can be reversed to a large extent, just like releasing the handbrake on a car. Key staff members of the participating school are sufficiently aware to appreciate this problem and have the will to address it. However, it is highly probable that other secondary schools have similar levels of mathematics anxiety in their young learners, which is currently not appreciated or addressed.

A negative correlation between previous achievement and mathematics anxiety emerged from the data, as was expected from the literature. This relationship is not necessarily one of simple cause and effect, however. Once anxiety is experienced in a mathematical context, the individual tends to avoid further mathematical experiences to avoid further unpleasant experiences, an approach which limits learning and dulls potential progress in a negative spiral (Dowker et al., 2016). The evidence that some high achievers still report high mathematics anxiety should also be taken into consideration, as an intervention to support them with their mathematics anxiety would arguably result in continued mathematics study.

Conclusion

These findings add to the knowledge regarding the prevalence of mathematics anxiety in the early years of secondary school. They indicate that 45% of learners in the sample school could benefit from an intervention. The benefits of a successful intervention could arguably include higher achievement, increased retention in further mathematics study and most importantly, improve wellbeing. Similar benefits could be gained in other secondary schools; it is recommended that an assessment of current levels of mathematics anxiety is conducted as a starting point.

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