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Maths Anxiety

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Abstract

This paper considers the impact of maths and statistics anxiety on students in higher education. It provides a definition of maths anxiety and the impact of maths anxiety. It then discusses the possible causes of maths anxiety and strategies for reducing maths anxiety. Finally, it suggests strategies for tutors supporting students with maths anxiety to improve their maths and statistics skills, as well as a strategies for students coping with maths or stats anxiety.

Keywords: maths anxiety, statistics anxiety, strategies, SpLD tutors, maths resilience, strategies, SpLDs and maths, supporting maths learning.

Introduction

Maths anxiety has been described as *"feelings of tension and anxiety that interfere with the manipulation of numbers and the solving of mathematics problems in a wide variety of ordinary life and academic situations"* (Richardson & Suinn, 1972). Related to this is statistics anxiety, which is the *"specific feelings of anxiety students experience when they encounter statistics, for example, gathering, processing, and interpreting data"* (Cruise, Cash, & Bolton, 1985). Maths anxiety and statistics anxiety share similar symptoms as they are both situation-specific anxiety disorders, but they are often incorrectly considered to be the same construct. Students can be anxious around maths, yet comfortable around statistics, and vice versa. There is evidence that the cognitive processes involved with statistics anxiety may be different from mathematics anxiety because statistics is more closely related to verbal reasoning than mathematical reasoning (Baloglu, 2004).

According to Onwuegbuzie & Wilson (2003), as many as 80% of graduate students experience uncomfortable levels of anxiety around statistics, and Jones (2001) found that 25.9% of 9,000 American students had a moderate to high levels of maths anxiety. Students with high anxiety are thought to practice maths avoidance (Hembree, 1990), often choosing subjects they think will not include maths or statistics, or avoiding studying until close to coursework and exam deadlines. Equally, Ashcraft & Moore (2009) found that the higher the anxiety, the less likely a student was to seek further maths courses. The impact of this for students in higher education is that students may select out of courses and modules containing maths or statistics, thus restricting course choice, and possibly employment opportunities.

Causes of maths anxiety and its impact on students

There is a strong case that maths anxiety is rooted in negative learning experiences. For example, Finlayson (2014) reported that maths anxiety is usually linked with the kind of teaching styles experienced in the classroom, in particular the use of memorisation and rote recitation. Cornell (1999) listed a number of pedagogical practices that can contribute to maths anxiety, as follows.

- The view that mathematical processes and procedures were inherently simple and self-explanatory;
- Use of mathematics terms without an explanation of terminology being used;
- Overuse of 'skill and drill' exercises which do not lead to understanding;
- The sequential nature of mathematics instruction leading to students becoming confused if grasp the procedures or concepts being taught;
- Mathematics tended to be taught in isolation, as opposed to using real life examples.

This is more likely to be the case when teachers have had negative learning experiences of maths. Karp (1991, p. 369) supports this, stating *"teachers with negative beliefs about mathematics influence a learned helplessness response from students, whereas the students of teachers with positive beliefs about mathematics enjoy successful mathematical experiences that result in their seeing mathematics as a discourse worthwhile of study."*

Maths, therefore, can trigger negative thoughts and memories, which could lead to students avoiding subjects or modules they think contain maths (including statistics) or in situations where they have to study maths, and avoid studying until the last minute. Poor preparation leads to poor performance which is another negative maths experience, making the student more anxious as it reinforces their view that they are bad at maths. These processes are encapsulated in the maths avoidance cycle (Fig. 1).

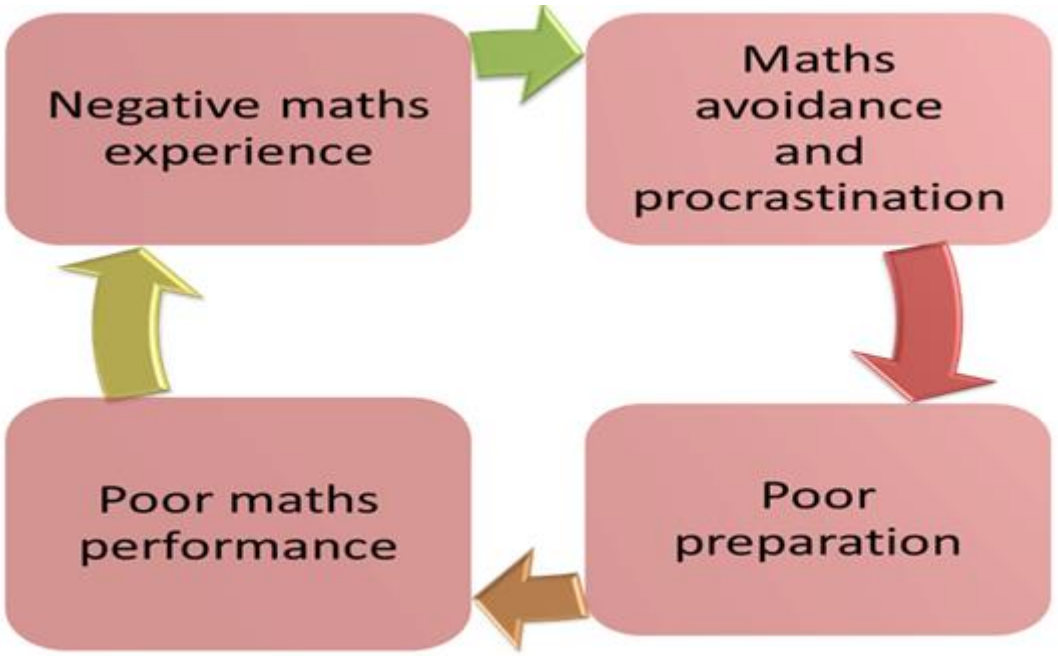

Fig 1. The maths avoidance cycle. The cycle begins with negative experiences in learning mathematics.

Negative experiences aversively condition the student away from maths and the brain learns to view maths as a threat and something to be avoided. This is demonstrable in brain scans (fMRI), in that regions of the brain associated with pain processing are activated when thinking about maths (Lyons & Beilock, 2012). Importantly, this only occurs when *thinking* about the maths, but does not occur when actually *doing* maths, thus maths anxiety is a purely anticipative fear that is learned through negative experiences in primary or secondary maths education. Furthermore, maths anxiety negatively impacts on working memory, wasting working memory resources thinking about failing or doubting oneself that could otherwise be used for solving mathematical problems (Young, Wu, & Menon, 2012). This means that whilst the student is in a state of anxiety, they will struggle to understand the maths being taught and avoid asking questions or attempting problems because they are preoccupied with anxious thoughts. Finally, the brain has an “idling network” when it is not actively engaged in a task, e.g. daydreaming or quiet wakefulness. When there is a cognitive task to perform, this “idling network” disengages and other networks become activated to process the task at hand. In students with maths anxiety, this “idling network” does not disengage, which could explain why students report they “don’t know where to start” or “cannot switch on to maths” (Pletzer, Kronbichler, Nuerk, & Kerschbaum, 2015).

Tutor strategies for reducing anxiety

University classes often cover a lot of material in a short space of time and therefore do not provide time for the asking of questions (Finlayson, 2014). Providing students with relaxing, non-threatening maths experiences in a supportive environment, and teaching at a slower pace, allows enough time for inquiry and individual development (Woodard, 2004). One-to-one support is therefore an effective method for overcoming maths anxiety. One reason for this is that one-to-one sessions offer the opportunity to tailor sessions to the individual, allowing enough time for inquiry and conceptual development (Woodard, 2004). By

progressing very slowly through increasingly-difficult problems, and encouraging students to practice these techniques at home, students can become desensitised to maths anxiety (Sheffield & Hunt, 2006). Similarly for statistics, spending more time on producing and interpreting graphs, which is something most people can already do, before moving slowly onto harder techniques should help increase students' confidence.

One-to-one sessions are most beneficial when they allow students to work at their own pace and avoid students feeling embarrassed in front of their peers. It is therefore important to consider the location of the one-to-one sessions, as providing a quiet, relaxed, and supportive study area can help reduce maths anxiety (Patel & Little, 2006). Unfortunately, it is estimated that 33% of students who have maths anxiety do not use available one-to-one support (O'Sullivan, Mac an Bhaird, Fitzmaurice, & Ni Fhlionn, 2014). Encouraging the use of such a service at regular intervals during the course ought to encourage attendance, but this is often not enough (Marshall et al., unpublished observations). Due to the anticipative nature of maths anxiety, the same maths avoidance behaviours apply to booking the first appointment with the maths support centre and often results in the student not utilising the maths support centre. Thus it is strongly recommended that SpLD tutors accompany the student to their first visit at the support centre and introduce them to named maths support tutors.

An important principle for reducing maths anxiety is for tutors to help students develop awareness of their maths anxiety (Uusimaki & Kidman, 2004). Students are not usually aware that maths anxiety is a known condition that impacts upon their learning. Making students aware of how maths anxiety affects memory and cognitive processes, along with coping strategies for overcoming maths anxiety can help students recognise that they are able to develop their maths and statistics skills. Providing formative feedback and encouraging students to explain simple sections and commenting on the parts they got right can also develop confidence. It also reduces the time needed for students to reach a desired level of understanding (Anderson, Conrad, & Corbett, 1989), which particularly reassures the maths-anxious student as faster progress than expected demonstrates to the student that their abilities in maths are greater than they expected. Indeed, in an evaluative study of a formative assessment system, exam grade scores are correlated with 'perceived usefulness of feedback', but not with maths anxiety scores, thus providing the correct form of feedback is a crucial factor in addressing maths anxiety (Núñez-Peña, Bono, & Suárez-Pellicioni, 2015).

Counterintuitively, low-stakes testing is a factor in reducing maths anxiety. Whilst having only one opportunity to test knowledge at the end of a course (high-stakes testing) has a very negative impact on students with maths anxiety, untimed unassessed tests (low-stakes testing) actually reduce anxiety as well as increasing confidence (Simzar, Martinez, Rutherford, Domina, & Conley, 2015/4). Short online tests allow students to check their progress without the fear of peers finding out their score. A test-retest approach allows students to take a similar test several times, which helps students deal with past feelings of failure, as they are being exposed to many test scenarios and can observe their performance improving (Juhler, Rech, From, & Brogan, 1998). Online tests in which the questions stay the same but the numbers change are ideal, as this ensures that the students are engaging with the questions, as opposed to memorising the solutions.

Student strategies for reducing anxiety

There are a number of strategies that students can use to reduce anxiety during of one-to-one sessions to the math support centre. Peer learning has been found to be beneficial in reducing anxiety. Research suggests that collaborative learning in which groups work together to construct their own methods for approaching problems and receive feedback from their peers increases confidence, develops skills, and reduces anxiety (O'Donnell & King, 2014).

Self-efficacy is the belief that one is capable of successfully performing a task and several studies have shown that high scores of self-efficacy are related to good exam performance. Tyler-Smith (2006), found that learners with higher levels of self-efficacy and self-concept were more likely to be persistent when faced with educational roadblocks, and more likely to enrol in future courses. Perry (2004) argued that 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. Encouragement and feedback from lecturers and one-to-one tutors increases their self-belief (Wisker, Exley, Antoniou, & Ridley, 2013).

It is recommended that a student be taught strategies for reducing anxiety in particular situations, such as pre-exam anxiety. Ramirez and Beilock (2011) have found that 10-15 mins expressive writing about pre-exam anxiety before a test allows the brain to concentrate on writing rather than thinking about the exam, as the latter only serves to ruminate on worrying thoughts rather than extinguishing them. This technique is thought to work because expressive writing increases the availability of working-memory resources, which would otherwise be consumed by anxious thoughts (Yogo & Fujihara, 2008).

Strategies for improving maths skills

Scaffolding learning, which is a process in which students are given support until they can apply new skills and strategies independently (Rosenshine & Meister, 1992), can provide a useful framework to support students with maths anxiety. Whilst students may believe that they cannot do maths, everyone can do some maths or statistics, and this foundational knowledge can be built upon. In sessions, therefore, the tutor can start with what the student knows and work from there to develop knowledge. This can be supported with the use of concrete real life problems that students can relate to. This can be achieved by making the sessions project-related, or by using manipulatives, which are objects designed so that a learner can perceive a mathematical concept in order to move from concrete to abstract concepts, whilst building confidence along the way (Bartolini & Martignone, 2014), see example in Fig. 2. Vinson (2001) reported that using hands-on manipulatives as part of a mathematics methods course resulted in a significant reduction in maths and statistics anxiety.

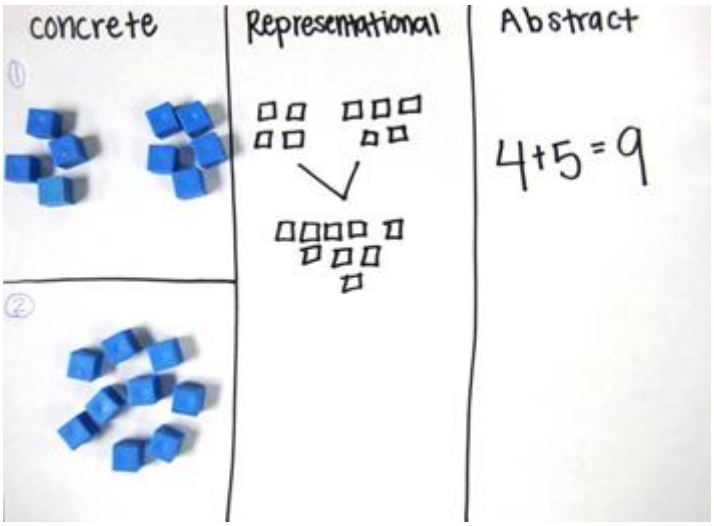

Fig 2. This image demonstrates the use of manipulatives to move from concrete to abstract representations ("Concrete-Representational-Abstract Instructional Approach," 2008).

Encouraging students to construct their own systems of understanding is also a useful strategy to improve maths skills. This can be achieved through *"mathematizing the real world through analysis, organization, synthesizing, and construction of situations based on their level of understanding"* (van den Heuvel-Panhuizen, 1996). Similarly, students benefit from time for discussion and practice rather than memorisation and rote recitation. Some lecturers are using a 'flipped classroom' approach, in which students study the material online and then teaching time concentrates on group activities to cement learning (Charles-Ogan & Williams, 2015). Online or distance learning is thought to be beneficial as students don't have the fear of being called upon in class to answer questions or worry about looking stupid in front of peers (Taylor & Mohr, 2001).

Conclusion

In conclusion, maths anxiety can have a large impact on students in higher education: it can influence degree choice, module choice, and ultimately, career choice. By discussing maths anxiety and its impact on learning, tutors can instil a sense of self efficacy in students and reduce maths avoidance. It must be underlined that students with the highest levels of maths anxiety are unlikely to attend the maths support centre of their own accord: it is strongly recommended that SpLD tutors accompany the student to the maths support centre to meet named tutors for at least their first visit.

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