

Mathematics Anxiety



DESCRIPTION AND ANALYSES OF THE TOPIC

“Many people think of mathematics as one of the most logical, most impersonal branches of knowledge, yet it inspires more emotion than any other school subject” (Zaslavsky, 1994, p.5).

THE BIG PICTURE: MATHEMATICS ANXIETY AS AN IMPORTANT ISSUE IN MATHEMATICS

Teachers of English, Art and other disciplines would argue with Zaslavsky that their content also inspires a range of emotions in students. However, there is a difference for mathematics that Zaslavsky alludes to – the emotion is often negative and can be extreme.

Mathematics anxiety, the worry and tension felt when anticipating or completing mathematical tasks, is reported widely by Australian students (Thomson, DeBortoli & Buckley, 2013).

This Mathematics Monograph is focussed on helping teachers and school leaders gain a better understanding of:

How mathematics anxiety negatively impacts learning and teaching.

- The symptoms, causes and companions of mathematics anxiety.
- The difference between reducing mathematics anxiety directly and indirectly.
- Strategies that can identify and address mathematics anxiety in students and teachers.

The Monograph is intended to present information for reflecting and planning how mathematics anxiety can be reduced and regulated in classrooms and in the school community.

KEY TERMS AND DEFINITIONS

Working memory

Part of the memory system that is crucial for mathematical learning as it allows information to be temporarily stored, maintained and manipulated (Ashcraft & Kirk, 2001; Clements, Sarama & Germeroth, 2016).

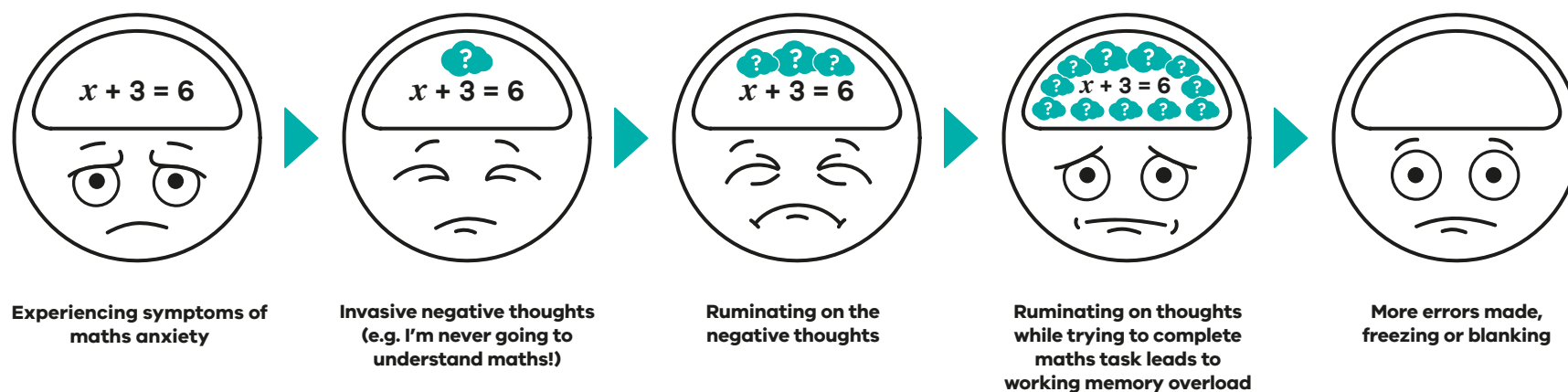
Emotion regulation

The process of changing the way that an emotion is experienced by altering things like its strength, how it is expressed or its type (e.g. reframing a negative emotional experience to become positive) (Davis & Levine, 2013).



Figure 1. The impact of mathematics anxiety on mathematics performance

Completing a maths task



THE EVIDENCE BASE OF MATHEMATICS ANXIETY

Mathematics anxiety is widely studied for its negative impact on learning.

Research has demonstrated that mathematics anxiety can interrupt working memory leading to more error-making and reducing the capacity to successfully participate in mathematics (see Figure 1; Ashcraft & Kirk, 2001; Eden, Heien & Jacobs, 2013; Ma, 1999).

Individuals who consistently experience mathematics anxiety when engaging with mathematics are more likely to avoid mathematics subjects, courses and careers.

Therefore, mathematics anxiety is a problem for short-term learning as it compromises performance and a problem for long-term learning as it leads students away from mathematics opportunities and career pathways (Buckley, Reid, Good, Lipp & Thomson, 2016).

Compounding the problem even further, mathematics anxiety is a common phenomenon in mathematics classrooms. For instance, in the 2012 cycle of PISA, 25% of Australian 15-year-old students reported feeling helpless when doing a mathematics problem (Thomson, DeBortoli & Buckley, 2013).

Mathematics anxiety can also be an obstacle for mathematics teaching. Teachers who experience higher levels of mathematics anxiety are less confident and more likely to avoid teaching mathematics when given the option (Gresham, 2018). While no population-level studies have been conducted, researchers estimate anywhere between 6–17% of the population experience mathematics anxiety (Dowker, Sarkar & Looi, 2016).

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PISA 2012: Thomson, DeBortoli & Buckley, 2013

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One way to better understand mathematics anxiety is to think about it having symptoms, causes and companions. The symptoms and causes have different impacts on learning and need different strategies to address them (Buckley, Reid, Good, Lipp & Thomson, 2016), while the companions are things often experienced alongside mathematics anxiety (see Figure 2).

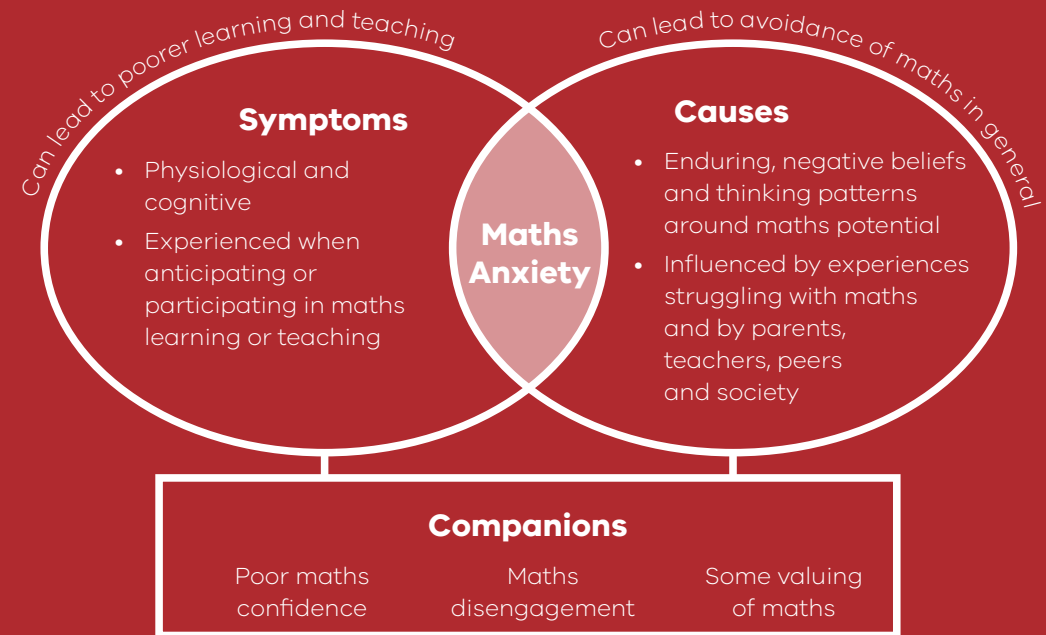


Figure 2. Symptoms, causes and companions of mathematics anxiety

The symptoms of mathematics anxiety:

- Are physiological (including increased heart rate and breathing rate) and cognitive (invasive negative thoughts or worries, e.g. 'I am never going to understand maths').
- Are felt when anticipating or completing a mathematics task.
- Are the part of mathematics anxiety that can lead to poorer performance on mathematics tasks; however, this depends on how the symptoms are managed. Research suggests that students who use emotion regulation skills to moderate the symptoms of their mathematics anxiety are able to eliminate or reduce the negative impact of those symptoms on their mathematics performance and learning (Ramirez, Shaw & Maloney, 2018).

The causes of mathematics anxiety:

- Revolve around a fixed mindset or belief about mathematics performance and learning – "I am no good at maths"; "My parents were bad at maths and that's why I am too"; "I'm just not a maths person". All of these statements illustrate a belief that mathematics potential cannot change. Students who believe that their mathematics potential is fixed are unlikely to think that effort or practise in mathematics is going to improve their mathematics learning.
- Are beliefs that are long-standing and formed through experiences with parents, teachers and peers. They are also influenced by previous experiences struggling with mathematics (Buckley, Reid, Good, Lipp & Thomson, 2016).
- Can be addressed by changing and challenging negative beliefs about mathematics ability (Paunesku, Walton, Romero, Smith, Yeager & Dweck, 2015).

The companions of mathematics anxiety include:

- Poor mathematics confidence.
- Mathematics disengagement.
- Some type of valuing of mathematics.

You cannot be anxious about something unless you value it and value can come in different forms. Value could be liking or enjoying mathematics, it could be seeing mathematics as useful for life or career options, or it could be thinking that mathematical knowledge is related to general intelligence.

ISSUES AND CHALLENGES IN ADDRESSING MATHEMATICS ANXIETY IN SCHOOLS

CULTURAL CHALLENGES

Negative perceptions and attitudes towards mathematics in the community mean that mathematics anxiety has become an accepted emotional response in reaction to mathematics content (*Wilkins, 2000*).

Peer relationships, networks and social identities, particularly in early adolescence, can be based around openly disliking and avoiding mathematics (*Frenzel, Pekrun & Goetz, 2007*).

Parental attitudes can also be the source or reinforce a fixed mathematics mindset. One of the ways to address negative mathematics culture is by highlighting role models in the community or in fiction that challenge negative stereotypes about mathematics. For example, some that could be discussed are Tony Stark (aka Iron Man) or Michael Jordan who studied mathematics at university.

CONCEPTUAL CHALLENGES

Mathematics anxiety is a popular topic of discussion in mathematics teaching for good reason; however, this discussion always centres on the negative qualities of anxiety. A way to reframe mathematics anxiety is to acknowledge its positive and constructive qualities.

One of these has already been discussed and that is recognising that mathematics anxiety can only be experienced by someone who values mathematics in some way; someone who does not value mathematics feels apathy and not anxiety. The other positive quality to appreciate is that moderate levels of anxiety are associated with optimal levels of performance. When it is emphasised to students that moderate anxiety actually leads to performance improvement, research has shown that students do better on mathematics tasks (*Jamieson, Peters, Greenwood, Altose, 2016*).

Throughout this mathematics monograph there is discussion of reducing and regulating mathematics anxiety. This phrasing is intentional and designed to challenge educators to think that the objective is not to remove all mathematics anxiety but to reduce and regulate anxiety so that it is operating at a level that leads to the best mathematics performance and learning.



Mathematics anxiety can only be experienced by someone who values mathematics in some way

PEDAGOGICAL CHALLENGES

In many classrooms, the way that mathematics anxiety is targeted is indirect. Educators often aim to reduce anxiety by improving mathematics confidence and building students' mathematical understanding. The assumption is that after confidence improves, anxiety will decrease. However, this does not work for all students and when it is effective it does not always reduce mathematics anxiety in the long-term. Research suggests direct or psychological strategies should be used in combination with indirect or educational strategies to successfully reduce mathematics anxiety (*Bursal, Paznokas, 2006; Maloney, Schaeffer & Beilock, 2013*).

This idea may seem counter-intuitive but it links to a symptoms-and-causes model of mathematics anxiety:

- The symptoms of mathematics anxiety should be addressed by helping students improve their emotion regulation skills to remove anxiety as a barrier to mathematical learning.
- The causes of mathematics anxiety should be addressed by using pedagogical practices that foster a growth mindset, challenge negative thinking about mathematics and provide students with the opportunity for personal mathematics accomplishment.



Q&A

Q: Why should I spend time teaching students emotion regulation skills? The way to reduce maths anxiety is to make maths more meaningful for students and give them an opportunity to use their skills and develop confidence.

A: Yes, that is part of the solution. But it is also important to give students the tools to reduce the symptoms of their maths anxiety immediately. The last thing that a highly maths anxious student wants to do is maths. Help your students use emotion regulation skills like deep breathing or expressive writing to reduce the physical and cognitive symptoms of their maths anxiety. Then your efforts to improve their mathematical understanding and develop confidence will be even more successful because they will be more likely to engage with the ideas. Maths anxiety is not a 'life sentence'; it can be addressed in different ways so that it can be reduced and regulated.



REFERENCES, TOOLS AND RESOURCES

<https://www.youcubed.org/>

<https://fuse.education.vic.gov.au/?YR8NB4>

WHAT DOES ADDRESSING MATHEMATICS ANXIETY LOOK LIKE IN PRACTICE?

First steps: what do schools need to do about mathematics anxiety?

To target any barrier to learning you must first identify where it occurs. Then you can use strategies to **reduce** any negative effects on learning.

IDENTIFYING MATHEMATICS ANXIETY IN STUDENTS

Create mathematics metaphors with your students (*Brady & Winn, 2014*). Explain to students the concept of a metaphor and then ask them to create their own mathematics metaphor by getting them to:

- Describe mathematics.
- Describe the feelings they experience when doing mathematics.
- Identify what things best represent how they think of mathematics.

These metaphors will illustrate the types of beliefs, patterns of thinking and emotions your students experience in relation to mathematics.

IDENTIFYING MATHEMATICS ANXIETY IN TEACHERS

Conduct an online anonymous staff survey to gauge levels of mathematics anxiety in your school. Make sure the items or questions forming the survey will not compromise staff anonymity. For example, if you are surveying a group of staff and there is only one member in the group who identifies as male, then do not include an item on gender.



SOME TIPS ON HOW TO CREATE A SURVEY FOR STAFF

- 1** Have a clear picture of what you want to investigate. Make sure your survey will collect data that will help you conduct this investigation. You might want to examine teaching confidence as well as mathematics anxiety.
- 2** Make sure the wording of your survey items is clear and concise. Measure one concept per item. For example:
 - I feel nervous when teaching maths.
 - I worry more about my teaching of maths than other subjects.
 - If I can avoid teaching maths, I do.
 - Anxiety about maths stops me from asking for help with my maths teaching.
- 3** If you want to measure change over time (e.g. change in levels of mathematics anxiety before and after implementing engagement activities), make sure you conduct the survey before and after staff complete the activities. Ensure that the items that you are using to monitor change are the same in the before and after versions of the surveys.
- 4** Make the rating scale consistent across items.

REDUCING MATHEMATICS ANXIETY

REDUCING MATHEMATICS ANXIETY IN YOUNGER STUDENTS

Bibliotherapy

Bibliotherapy is the practise of helping an individual address negative emotions through reading and discussion (Wilson, 2009). It is a strategy that can help students, particularly younger students, understand their mathematics anxiety as it encourages them through reading to empathise with a character who is experiencing similar challenges to those that occur in the mathematics classroom. This empathy supports students to identify their own ways of overcoming these challenges as they observe how the character in the book approaches the problem.

There are many texts that address mathematics anxiety topics including the following examples:

- *The Neverending Math Test: Working to Understand Our Strengths and Limitations* by Tosca Killoran, Jeff Hoffart, Riva Zietsoff
- *The Monster Who Did My Math* by Danny Shnitzlein
- *Math Curse* by Jon Scieszka
- *Donavan's Double Trouble* by Monalisa Degross
- *I'm Trying to Love Math* by Bethany Barton
- *When Sophie Thinks She Can't* by Molly Bang

When using these texts in class or with students individually, it is important to engage in follow up discussions and activities with students to draw out the key experiences of the characters and link these to the emotions that students may be feeling.

Additionally, reading books with students prior to or as part of the process of teaching mathematical concepts, whilst not technically bibliotherapy, can also help to reduce negative emotional responses and illicit more positive reactions towards mathematics instruction.

The Mathematical Association of Victoria provides a summary of available picture books organised by age level and many with reviews on their website at:

<https://www.mav.vic.edu.au/Resources/Primary-resources/Picture-books>

REDUCING MATHEMATICS ANXIETY IN OLDER STUDENTS AND ADULTS

Two techniques that help improve emotion regulation skills are deep breathing exercises and expressive writing. Both techniques will reduce the negative impact of the symptoms of mathematics anxiety on performance and learning.

Deep breathing exercises can be short, are very effective and can easily form a part of a lesson.

Expressive writing requires the individual to privately write down all their negative emotions in relation to mathematics without judgement.

Deep breathing

<https://www.verywellmind.com/how-to-reduce-stress-with-breathing-exercises-3144508>

Expressive writing

<https://www.psychologytoday.com/au/blog/nudging-ahead/201804/why-your-students-should-journal-test>

Mathematics Anxiety

SUPPLEMENTARY MATERIALS

Activities and reference material

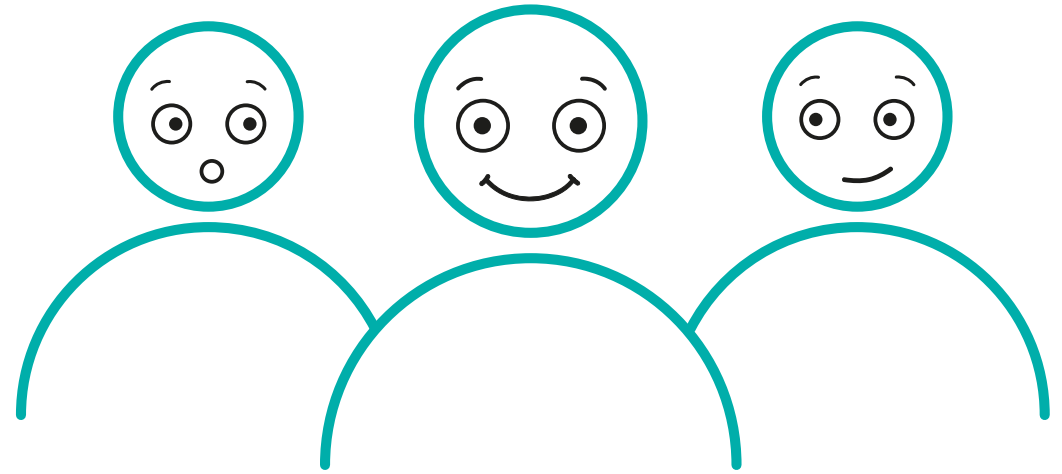
ENGAGEMENT ACTIVITIES

Team-Based Activity

STIMULUS: 10 MINUTES

Watch the following video:

<https://www.youtube.com/watch?v=7snnRaC4t5c>



ACTIVITY: APPROXIMATELY 1 HOUR

- 1** After watching the video, break into small groups or discuss with a colleague your history with mathematics anxiety whether that be your own experience of mathematics anxiety or anxiety you have seen experienced by students, friends or family members.
- 2** Reflect either individually or with your colleagues on how this video and the model for mathematics anxiety represented in Figure 2 resonates with your context:
 - a** Where do you see evidence of mathematics anxiety? With students, staff, parents?
 - b** What aspects of the video and the data it presents about mathematics anxiety did you already know and what was new?
 - c** What are some ways of identifying mathematics anxiety and negative beliefs about mathematics in students and the wider school community?
 - d** What could you, as a school, do to support all students, staff and parents to see the value of mathematics and numeracy and to build self-confidence across the system?
- 3** From your reflection, identify ways you can support all students, staff and parents to see the value of mathematics and numeracy and to build self-confidence across the system. Describe how these things will help to promote positive beliefs about mathematical learning and mathematics potential.

ENGAGEMENT ACTIVITIES

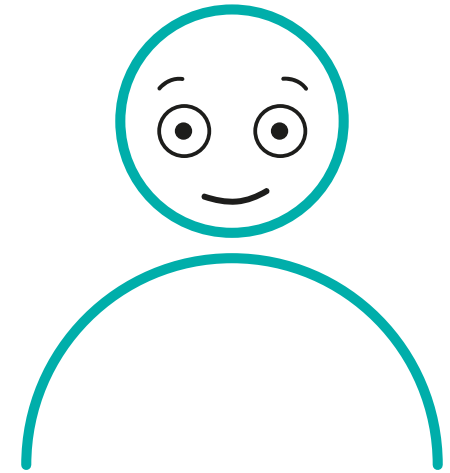
Individual activity

STIMULUS: 10–20 MINUTES

Choose one of the following articles to read:

<https://www.psychologytoday.com/au/blog/nudging-ahead/201804/why-your-students-should-journal-test>

<https://www.apa.org/pubs/journals/features/xap-0000013.pdf>



ACTIVITY: APPROXIMATELY 40 MINUTES

- 1 Reflect on your current practice, your attitudes towards mathematics, ideas about teaching mathematics and the mathematical beliefs of your students.
 - a For **mathematics teachers**: Think about your students and consider if you are aware of their feelings toward mathematics. Could some students that appear disengaged actually be avoiding mathematics because of anxiety? What kinds of beliefs do your students hold about mathematics potential? Do the students in your class value mathematics? In answering this question, remember that anxiety is always connected to some type of mathematics value and value can come in different forms – it could be enjoyment, it could be considering mathematics useful or it could be thinking that it is linked to ‘being smart’.
 - b For **non-mathematics teachers**: What types of beliefs do you have about mathematics? How are they reflected in the way that you talk about mathematics? How might the way you talk about mathematics influence your students’ attitudes.
- 2 Link your reflection to the reading on expressive writing.
 - a For **mathematics teachers**: How do you typically help a student who is mathematically anxious? Have you ever tried helping a student who is mathematically anxious without discussing mathematics or by suggesting ways to reduce the symptoms of their anxiety? How could you incorporate expressive writing into a lesson plan and what type of lesson would work best?
 - b For **non-mathematics teachers**: Try developing your own mathematics metaphor (see above) to highlight beliefs and patterns of thinking that you have about mathematics.
- 3 Discuss how the ideas in the reading and your reflection will impact on your future classroom practices.
 - a For **mathematics teachers**: Could modifying your language around mathematics help to encourage more positive mathematical beliefs? What changes will you make to your teaching practice to prevent or reverse the development of mathematics anxiety in your students? Endorsing a growth mindset in the mathematics classroom does not mean that you believe that every student will become a high-level mathematician. It means that you believe that every student can improve with practise and effort.
 - b For **non-mathematics teachers**: Could modifying your language around mathematics help to encourage more positive mathematical beliefs? How can you better demonstrate to students the importance of mathematics and numeracy in your subject area?

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