www.ijses.net

Performing 1-1 Interventions to Address Mathematics Anxiety – An Intervention Case Study of 3 Brazilian Women Who Believed They Were Stupid in Mathematics

Karina Lumena Alves
Universidade Federal de São Carlos, Brazil

Telma Pará
Fundação de Apoio à Escola Técnica, Brazil

Sue Johnston-Wilder
University of Warwick, United Kingdom

Janet Baker
Arden University, United Kingdom

To cite this article:

Alves, K.L., Pará, T., Johnston-Wilder, S., & Baker, J. (2024). Performing 1-1 interventions to address mathematics anxiety – An intervention case study of 3 Brazilian women who believed they were stupid in mathematics. *International Journal of Studies in Education and Science (IJSES), 5*(4), 354-373. https://doi.org/10.46328/ijses.104

IJSES International Journal of Studies in Education and Science
2024, Vol. 5, No. 4, 354-373 https://doi.org/10.46328/ijses.104

Performing 1-1 Interventions to Address Mathematics Anxiety – An Intervention Case Study of 3 Brazilian Women Who Believed They Were Stupid in Mathematics

Karina Lumena Alves, Telma Pará, Sue Johnston-Wilder, Janet Baker

Article Info

Article History

Received:
23 January 2024
Accepted:
17 May 2024

Keywords

Mathematics anxiety
Mathematical resilience
Growth zone model
Mathematics education
Psychoeducation

Abstract

Mathematics Anxiety is well-researched, but solutions are few. This study shows the potential to provide an affordable solution, one that could ultimately be rolled out across the country and the world. The 1:1 interventions involve inviting the participants to tell their math story and then introducing the Mathematical Resilience Framework and reframing adverse prior experiences as unrelated to intrinsic ability. The framework includes three tools: the hand model of the brain, the growth zone model, and the relaxation response. The intervention participants were Brazilian volunteers living in England from the local and virtual communities. The levels of Mathematics Anxiety were measured before the intervention using the Betz (1978) scale, and narrative records were made. The qualitative data were analyzed using deductive thematic analysis (Braun & Clarke, 2006) through the lens of the Mathematical Resilience Framework. The data indicated the positive impact of performing this kind of intervention.

Introduction

Mathematics anxiety (MA) has been defined as a "feeling of tension and anxiety that interferes with the manipulation of numbers and the solving of mathematical problems in ordinary life and academic situations" (Richardson & Suinn, 1972, p. 551). In Brazil, an operational definition of mathematics anxiety was proposed by Carmo et al. (2019). It consists of the description of three sets of simultaneous reactions, in situations in which mathematical problem-solving skills are required. Carmo et al. (2019) suggest that the first set of reactions involves physiological responses common to all manifestations of anxiety. The most common of these reactions are excessive sweating, increased heart rate, changes in blood pressure, cold body extremities, changes in sleep and stomach pains. The second set of manifestations is composed of cognitive reactions, such as forgetting algorithms and problem-solving steps which are probably related to failures in working memory, as suggested by Ramirez et al. (2013) and Ashcraft and Kirk (2001). This second set of reactions also includes the development of unhelpful beliefs related to mathematics, for example, mathematics is a very difficult subject; boys are better than girls at mathematics; mathematics is for geniuses. In addition, it is quite common for students with mathematics anxiety to develop negative self-attributions in relation to their performance in mathematics, which evidences low self-efficacy. The third set of reactions concerns escape, avoidance, and freeze behavior.

Demand for science, technology, engineering, and mathematics (STEM) professionals is on the rise worldwide. In order to meet this demand, many governments and institutions are stimulating STEM education and promoting training to enhance mathematics and science skills among learners. However, large-scale international assessments (OECD, 2013) suggest that mathematics anxiety must be considered when trying to increase mathematics achievement and STEM career success.

It is well known that mathematics anxiety interferes with performance and mathematics achievement in school (Beilock & Maloney, 2015; Dowker et al., 2016). Research suggests that women tend to experience higher levels of mathematics anxiety compared to men (Hembree, 1990; Maloney & Beilock, 2012; Sokolowski et al., 2019; Vos et al., 2023). This gender difference in mathematics anxiety has been observed across various age groups, from primary and secondary school (Newstead, 1998; Chiu & Henry, 1990; Blatchford, 1996; Dowker, 2005) to university level (Dane, 2005; Núñez-Peña et al., 2013). Hill et al. (2016) sought to map math anxiety comparing males and females, in 1014 children, aged 6-19 years, attending primary and secondary schools in Italy. Although some studies have found no MA difference between genders in primary school, this study found higher math anxiety in females in both primary and secondary schools.

Several factors contribute to the higher levels of mathematics anxiety among women. Social and cultural factors play a significant role in shaping attitudes and beliefs about gender and mathematics. Stereotypes and societal expectations often portray mathematics as a male domain, leading to a lack of confidence and increased anxiety among women when it comes to math-related tasks. Additionally, studies have found that girls tend to receive less encouragement and support in mathematics compared to boys (Kelly, 1988; Gunderson et al., 2012; Mujtaba & Reiss, 2016).

Teachers, parents, and peers may unknowingly reinforce gender biases and create an environment that perpetuates mathematics anxiety among girls. It is important to note that mathematics anxiety is not an inherent trait of women. Rather, it is a learned response influenced by various factors, including societal expectations and educational experiences. Addressing mathematics anxiety requires a multi-faceted approach involving educators, parents, and policymakers. Identifying interventions to reduce negative emotions related to mathematics is also important to raise women's participation in higher mathematics education and support career decisions in STEM disciplines (Ashcraft & Krause, 2007). Such interventions aim to develop abilities and behaviors to face the challenges involved in the learning of math. A related new construct called Mathematical Resilience (MR) can be defined as "a learner's stance towards mathematics that enables pupils to continue learning despite finding setbacks and challenges in their mathematical learning journey" (Johnston-Wilder & Lee, 2010, p. 38). In this study, we introduce the use of the mathematical resilience framework to address mathematics anxiety and build mathematical resilience in three Brazilian women.

One-to-One Interventions

In this study, we performed 1-1 interventions in line with the mathematical resilience framework that incorporates psychological and coaching techniques including re-framing and psychoeducation. The important contribution of

this paper is that the interventions can be conducted by educators.

Reframing can be a valuable cognitive tool in various contexts, including personal growth (Munroe et al., 2022). Reframing is the process of altering the way a participant perceives or interprets a situation, problem, or concept in order to gain new perspectives and potentially find more effective or positive ways of understanding or addressing it (Figure 1). It involves consciously shifting the way something is perceived or interpreted in order to change its meaning or significance. Reframing can lead to new insights, understanding, alternative approaches and potential solutions. The educator offers alternative viewpoints or ways of looking at things that help overcome previous adverse experiences. In this case the frame is shifted from "what is wrong with you?" to "what happened to you?"

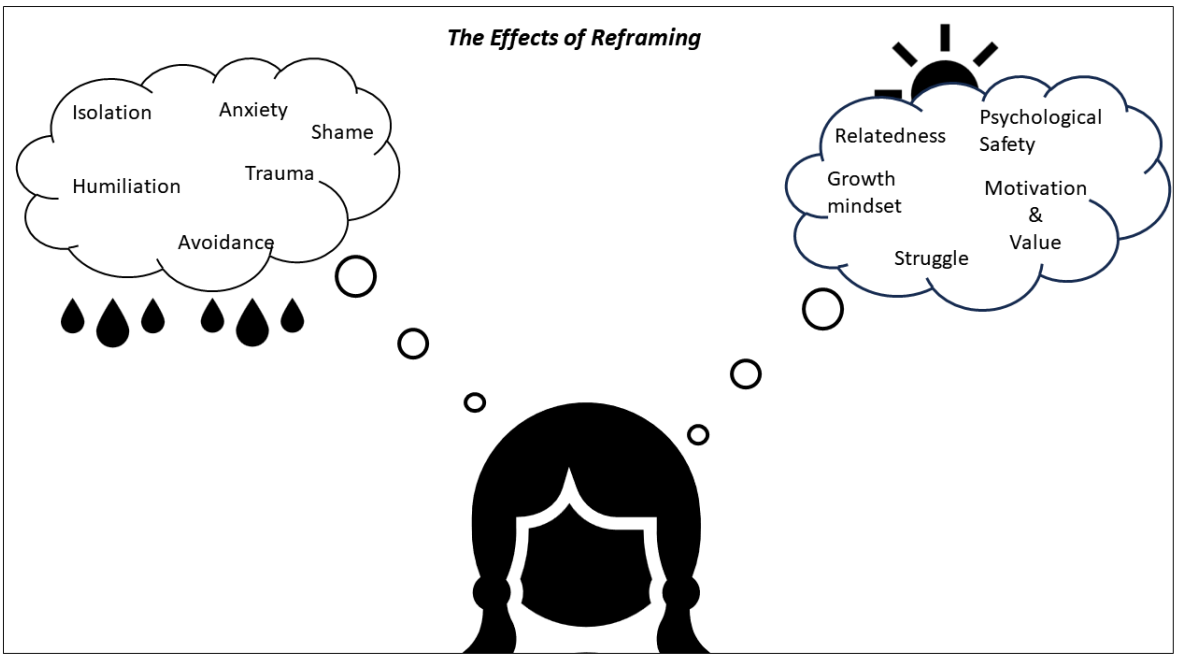

Figure 1. The Effects of Reframing in Mathematical Anxiety Context

Psychoeducation refers to the process of providing education and information about mental health, psychological issues, and related topics to individuals, families, or communities (Fisher et al., 2004; Donker et al., 2009). It aims to increase knowledge, awareness, and understanding of mental health conditions, their causes, symptoms, treatment options, and coping strategies. In this case, the goal of the psychoeducation approach is to promote self-care in the context of learning mathematics, by equipping participants with practical tools, strategies, and resources to maintain their mathematical wellbeing effectively and build their mathematical resilience.

We also seek to empower individuals and families, by increasing knowledge and understanding of how to take an active role in maintaining their mathematical well-being, make informed decisions, and seek appropriate support when needed. It is important to reinforce here that we are not therapists, we are writing as educators. As educators, we sometimes use coaching techniques; in this case we used the skill of feeding back using the participants' own words and picking up on their concerns and experiences.

Tools to Develop MR

Now we present three tools used in the interventions to help participants with mathematics anxiety to reframe their prior experiences of mathematics, and to understand how to reduce its impact, to protect their mathematical well-being from further harm and build resilience.

The Growth Zone Model (GZM)

The Growth Zone Model (GZM) (Lugalia et al., 2013) is a tool for learners to name and communicate their current, otherwise hidden, feelings when learning mathematics. The GZM has three “zones”, as depicted in Figure 2, which represent ways individual learners might experience a situation. The diagram illustrates the difference between being in the "comfort zone" (safe, but without the possibility of personal growth) and being in the "growth zone" (dynamic space in which there is opportunity for growth, for facing challenging situations bravely and effectively) and the need to avoid the overwhelming “anxiety zone”. Mathematical resilience manifests itself in the passage from the comfort zone to the growth zone, and thriving there, being able to leave the anxiety zone when it arises. To support this behavior, we were inspired by the ideas of self-efficacy (Bandura, 1994): the mastery of experiences (sharing the idea that experiencing failure is important so that we can build resilience, facing failure as a learning opportunity) and also that self-efficacy can be developed overtime. In addition, we draw on the ideas of optimistic struggling (Seligman, 1991); we encourage participants to maintain a positive attitude despite difficulties.

Figure 2. Representative Diagram of the Growth Zone Model based on Lugalia et al. (2013)

The Hand Model of the Brain (HMB)

The Hand Model of the Brain is a tool developed by Siegel (2010) that proposes a description of parts of the brain compared to a closed hand to highlight some brain structures and functions responsible for producing thoughts and emotional reactions. Figure 3 presents Siegel's model graphically. When we bend our fingers over the thumb, we have a model of the cerebral cortex, responsible for the production of complex thoughts and symbols, while the thumb illustrates the limbic system involved in the processes of primary emotions and states of alertness. The raised fingers represent the idea that, when faced with perceived threats and dangers, the cerebral cortex is "turned

off" and the fight, flight or freeze responses, typical of anxious states, come into action. This model, although very simple, has been used to explain to participants with mathematics anxiety what happens to their brains when they are faced with situations and contexts that generate mathematics-specific anxiety. It illustrates that the participant is not stupid in mathematics (which is a permanent state) but panicking (which is a temporary state). Understanding these brain activities helps the participant to understand that they need to learn to relax when faced with panic in response to aversive stimuli. The participant can, under encouragement, metaphorically describe the state they are in at any given moment when faced with situations that require the application of some mathematical knowledge. Reactions such as "gone blank", flight, freezing are current physiological responses that need to be brought under control. Hence the need to learn to trigger the relaxation response.

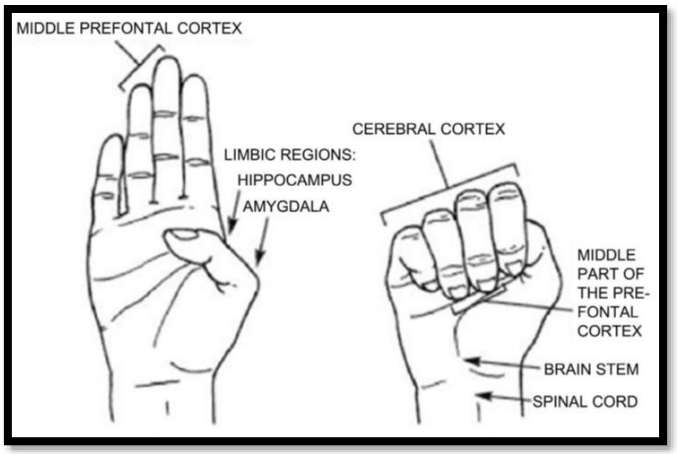

Figure 3. Hand Model of the Brain, adapted from Siegel (2010)

Relaxation Response (RR)

Relaxation is the inverse state of tension, commonly known as ‘rest-and-digest’. The Relaxation Response is a natural innate protective mechanism which allows people to turn off harmful effects from stress that are no longer needed, through changes that decrease heart rate, lower metabolism, decrease rate of breathing, and bring the body back into a responsive state. Participants can learn to trigger the relaxation response. This can be achieved through managing breathing or attention. A study performed in 2013 showed the influence that breathing exercises have on math-anxious students, increasing calmness and enhancing performance in tests. The results suggest that focused breathing exercises can be a useful tool to help to address the negative impacts of math anxiety (Brunyé et al., 2013).

We performed 1-1 interventions in order to address MA using these three tools from the Mathematical Resilience Framework: the Growth Zone Model, the Hand Model of the Brain, and the Relaxation Response (Johnston-Wilder et al., 2020).

The Study

The aims of the project were to: address math anxiety and build mathematical resilience in adults using

interventions based on tools developed at the University of Warwick by Johnston-Wilder and her PhD students; gain further evidence of impact of 1:1 interventions in a new context; give Brazilian colleagues experience of the interventions which they can then use in Brazil at a later date with appropriate ethical approval.

Methods

The study aimed to gather further evidence of the impact of the interventions on participants who have math anxiety, trying to answer the following research questions:

1. Has the Mathematical Resilience Toolkit helped the participants? In which ways?
2. How was the impact of the intervention as a whole on Brazilian participants?

One of the aims of the project was to induct Brazilian colleagues into 1:1 interventions, so that they could take them back to Brazil. Ten members of a chat group of Brazilian residents in the UK expressed interest in taking part, using their home language, Portuguese. The levels of Mathematics Anxiety of potential participants were measured before the intervention using the Betz scale (Betz, 1978); participants with moderate and high mathematics anxiety were recruited. For the purposes of this study, Betz's scores were provisionally categorized as: 10-27 low; 28-32 moderate; 33-42 high (Baker, 2021). For low levels of mathematics anxiety, we considered the intervention may not be needed. For extreme levels of mathematics anxiety, provisionally scores higher than 42, we referred the potential participants to more experienced colleagues as a precaution.

Eight chat group members answered the pre-questionnaire, 2 of whom scored low, 3 scored high (Tania, Amanda, Rita) and 3 scored extremely high. We performed individual interventions with the three participants who scored high; the interventions were two 45-minute sessions each. Ethical approval for this study was gained from the University of Warwick HSSREC committee (HSSREC 86/22-23). Informed consent was sought from prospective participants for their data to be included in the project. Participants were informed about the intended nature of their involvement, and what happened with their data. The methodology was pragmatic. Three forms of data collection were used: recordings of sessions, narrative records and questionnaires. Sessions were conducted, recorded and transcribed on Teams.

The approach we used was firstly developed in English (Baker, 2021) for children (11 years old) and it was adapted for this project into two sessions for adults. The 1:1 intervention was carefully prepared to fit the Brazilian context and language. The tools were well transferable to the Brazilian participants and only one aspect was not understood by the participants during the second session, because it had no correspondence to Brazilian culture. Tables 1 and 2 describe the session schedules. All data was pseudonymised, and participants were reminded that they could withdraw from the research at any time. Thematic analysis was undertaken with the qualitative data. The quantitative data will be discussed in another paper.

In the context of learning, the terms "not yet knowing" and 'being stuck' are not popularized among Brazilians and there is a huge distance between mathematics that is taught in an academic environment and everyday life. However, this fact did not bring prejudice to the development of the adapted Portuguese version of the intervention

as the terms were easily explained. Participants were asked about their prior experiences as well as their current beliefs, attitudes and emotions relating to studying that involves mathematics. The first session involved listening to their experiences of math, talking about their previous relationship towards making mistakes, and explaining the HMB, the GZM and proposed strategies to recover from mathematics anxiety like the RR.

Table 1. Description of Session 1: Timing, Key Points and Rationale for the Session

Timing	**Activity**	**Key Points**	**Rationale**
5min	Introductions	Explain the research, and what to do if feeling uncomfortable.	Creating a comfortable and safe environment.
7min	Your feelings about math	Tell me a little about your feelings about math - the what and the why.	Identifying emotions associated with learning mathematics. (Johnston-Wilder & Lee, 2010)
5min	Neuroplasticity	New technology - Show MRI scans, describe seeing blood flow, show parts of brain on MRI. Explain that knowledge of brain function and growth has changed - ability is not fixed	Growth rather than fixed mindset (Dweck, 2000). Neuroplasticity – learning increases grey matter (Geake, 2009)
5min	Making mistakes	Discussion about feelings when making a mistake. Learning from mistakes - neuronal growth demo – scrumpled paper	Stronger neuronal connections after a mistake – doesn't need to be corrected. (Boaler, 2016; Moser et al., 2011)
7min	Growth Zone Model (GZM)	Sharing the model – explain each part. Identifying feelings for each zone.	Learning to recognise emotions – name it to tame it - (Siegel, 2010) to maximize learning potential. GZM - (Johnston-Wilder & Lee, 2010)
5min	Hand Model of the brain (HMB)	Parts of brain to parts of hand, emotions taking over – flipping your lid. Calming down and taking charge again.	Managing unpleasant emotions and self-safeguarding. (Siegel, 2010)
6min	Recovering from anxiety	Reflection – what pushes you into the anxiety zone? Have you been there recently? What might you do in the classroom if you realized that you were in the anxiety zone? Create a reminder card to prompt appropriate action when in anxiety	Managing unpleasant emotions and self-safeguarding. (Siegel, 2010)
5min	Plenary	What will you try before next week?	Reviewing progress and identifying actions for next week

The second session aimed to reprise the tools, GZM, HMB and RR, remember the importance of identifying feelings/body sensations that refer to each Zone in GZM and focus on talk about strategies to get away from the Anxiety Zone, not hide in the Comfort Zone, and persevere in the Growth Zone. Researchers elicited the participants' stories about the impact of the intervention.

Table 2. Description of Session 2: Timing, Key Points and Rationale for the Session

Timing	**Activity**	**Key Points**	**Rationale**
2min	Overview	Go through overview, ask if participants are happy. Again emphasize that no math is involved.	Participants feel comfortable, knowing the content of the session
3min	Review	Recap GZM and descriptive words. Review experience since last session and track on GZM	Gather more data about recognition and management of emotions. Consolidate Growth learning, address misconceptions, encourage continued use of GZM
5min	Growth zone model	Reminder of GZM model	Learning to recognise emotions – name it to tame it - (Siegel, 2010) to maximize learning potential. GZM - (Johnston-Wilder & Lee, 2010)
5min	Recovering from anxiety	Reflection – what pushed you into the anxiety zone since we last met? What did you do or might you do if/when you realized that you were in the anxiety zone? (If appropriate – to remind of HMB)	Managing unpleasant emotions and self-safeguarding. (Siegel, 2010)
5min	Persevering in growth	How does it feel when you get stuck with math? Is it an absolute disaster?	Finding out participant's attitude to being stuck, feeling incapacitated or not yet knowing how to progress (either in the past or in the future)
5min	Persevering in growth	What could you do if you got stuck or felt confused about some math? What helps when you are wading through treacle?	Strategies for when struggling or stuck. Getting stuck is expected in the growth zone and can be overcome – 'being stuck is an honourable state' (Mason et al., 2010)
2min	Persevering in growth	How useful is a problem that is already solved?	Attitudes to being stuck (Mason, 2015); perseverance (Williams, 2014)

Timing	Activity	Key Points	Rationale
5min	Persevering in growth	Have you ever felt unsure about whether you could do something but kept trying anyway? What helped? Write down strategies on the poster.	MRS – Encouraging self-efficacy (Bandura, 1994), optimistic struggling (Seligman, 1991)
5min	Hiding in comfort	Do you hide in the comfort zone? Do you ever take risks with math, like trying to answer a challenging question?	As emerged from pilot research, possible need to support in process of recovering from learned helplessness (Peterson et al., 1993)
5min	Creeping out of comfort - worst- and best-case scenario	What would happen if you tried something you have been avoiding, like asking a question in class? What would you do if you ended up in the anxiety zone? Could you recover? How? If time - Who helps you learn math? Who else might be a help?	MRR– from Circles of relationship (Walker-Hirsch & Champagne, 1991) to raise awareness of the different kinds of support available.
3min	Looking forward	Look over both sessions. What has been most helpful?	Ensuring that the participant is ready to finish the sessions.

Results

The qualitative data were analyzed using deductive thematic analysis as we were working with subjective experiences and using a pre-existing framework: the Mathematical Resilience Framework. Thus, in our deductive thematic analysis, we looked for evidence of anxiety, experience of math anxiety, lack of relatedness, avoidance, isolation, shame and humiliation and trauma in the first session where we proposed the following questions to be commented on as the participant wanted: How much math do you do in everyday life (including your job)? ; What feelings do you associate with learning math?; What is your best experience of math?; What is your worst experience with math? Would you say that you feel good about math? In the second session, we looked for evidence of psychological safety, growth mindset, motivation and value, struggle, and relatedness.

We present the data from three Brazilian women who took part in the intervention, showing their perspectives on mathematics anxiety and what was the impact of intervention for each one. We found that reassurance that no math would be done was an important aspect of the intervention as a whole. This feeling was illustrated by Rita when she mentions that “I was anxious about this session” and after we talked about no math being done “It has lowered my anxiety a lot now.”

First Session

We observed similar points from each of the three participants. Although they are in different contexts with math

nowadays, there are similarities between their responses. All of them expressed negative feelings when thinking about math learning. When they spoke about their relationships with math, Tania said, “I remember I used to get very nervous when I was going to do a math test, as a child”. Amanda mentioned, “I felt so incapable that I hated studying”, and “It is a tense relationship because I am very careful to not make some mistakes”, and Rita said, “I've always been very insecure about the topic […] An area that I've always had a lot of anxiety about”.

In the beginning of the first session, we presented the aim of the project and explained about Math Anxiety (MA). This is important because many people have never heard about it. When the interviewer asked if they have ever heard about math anxiety, each participant answered “no”. Amanda added “No, it is the first time”. Explaining MA is a social contribution since people get to know the term and that adds to our effort as researchers investigating a way to help people with math and to improve math education in the world.

The participants then had the opportunity to talk about their feelings when learning mathematics. When asked about her previous experiences with math, Tania related: “I remember my steps with math, in primary school”, “I didn't understand math”, “I thought how could he understand and I couldn't?”, “I couldn't do things”, “I remember I used to get very nervous when I was going to do a math test, as a child”, “the result of the test won't be good”. Amanda related: “I cried all the time when I sat with my father to study”, “he was the person who taught us mathematics at home and it was a nightmare”, “I would make mistakes and he would get angry”, “I felt so desperate”. Rita related: “I feel really insecure about math. [...] An area that I've always had a lot of anxiety about, [...] I think I have this irrationally still in my head, that I'm not good at math [...] when I was doing training to also teach mathematics, it was very uncomfortable for me because I felt out of place [...] out of my comfort zone, yeah, it felt like I was a fish out of water.” As Rita had trained to be a teacher, she faced a lot of stress and anxiety during this training especially because she doesn't know the times table. She describes “it was something like torture. It's like somebody's been pulling out my fingernails or whatever, shoving knives in my eyes. [...] when I had to prepare those classes, my preparation was 10 times greater than any other class.”

Relating bad previous experiences was an important way for the participants to remember how they experienced the anxiety in relation to mathematics. We also noticed intense bad feelings in their previous experiences when learning math. For example, Rita related: “I didn't have the pain in my stomach, but it's something in my stomach”, “in the center of my body, it feels like there's a tightness, discomfort”, “that's how my anxiety manifests itself and that tightness keeps getting tighter, tighter”, “Everything inside of me feels tense”. The words “desperate”, “feels tense”, and “I couldn´t do it” show responses of the participants about the bad experiences with math in the past that can affect the way they look at math in their lives. We also could see some other terms that show feelings of humiliation “I felt quite humiliated”, lack of relatedness “I felt out of place…”, and isolation “everyone can do math except me, what is wrong with me?”. Avoidance of mathematics was verified with Rita as she mentioned that “[...] at the first opportunity I had, not to teach math and to do it, to teach something other than math, I jumped out.”

In the second part of this session, the interviewer and participant talked about making mistakes. People who have math anxiety have a big fear of making mistakes. An important aspect that caught our attention was Amanda´s

description of her father's negative reaction when she made a mistake: “I would make mistakes and he would get angry”. Rita declared when she had to prepare her math classes: “My anxiety was absurd, and the fear of making any mistake. It was absurd, so I always had notes, I had everything written down.” So, we believe that talking about what they feel about making mistakes when learning can improve the way they deal with mistakes. To improve their understanding, we showed some concepts of neuroscience like the neuroplasticity of the brain and what can happen in our brain when we make mistakes in the process of learning. We aimed to give them another perspective about making mistakes in learning math, so that they can distinguish the context in which mistakes are acceptable. Note that in “presentation/competition mode” mistakes can be costly. But in the context of learning, errors are part of the process. A learning environment needs to include being able to make and learn from mistakes and to receive growth-promoting feedback.

The interviewer showed the tools, HMB and GZM, then both participant and interviewer tried to understand what kind of strategies would work for participants to get out of the anxiety zone. All the participants had never heard about these tools. An important approach that we used consisted of presenting the GZM, trying to explain the feelings related in each zone, making bridges with their previous particular experiences. We suggest that GZM is ideally introduced this way, encouraging learners to identify relations between the zones and their previous experiences. This is reinforced by Baker (2021), where learners are encouraged to identify which zone of GZM they can best relate to, by recognizing the emotions for each zone in different situations.

We could see immediate positive impacts of showing the tools to them, by changes in their body language: smiling, nodding, a new expression of surprise. After that, the interviewer showed them some strategies, allowing them the opportunity to think and talk about them, helping to find the best strategy that can work for each participant. In relation to strategies that they used to recover from anxiety, Tania related “I just leave the place and go to breathe outside”. She had the opportunity to practice a breathing technique during the second session at a time when she entered the anxiety zone. According to her, after the practice, she was quickly able to relax and get out of the red zone. Rita explained that “With that stress, one thing I do depending on the situation, obviously, if you allow me, I listen to certain types of music, relaxing music, or something like that. It helps me to focus my thoughts better”.

Participants showed further reactions towards the Toolkit in this first session. For example, Tania related “it is very interesting”, “It made me understand some of the things I went through. Because I just felt it but what was the meaning? Why did I feel that?” “You feel it, but you don't understand why you are feeling it [...] how did the [...] Why did it come?” “About what's new too... you brought me neuroscience, explaining this relationship, so I think it was very cool. It was a great learning experience for me.” Amanda related “Well, it's quite interesting to be working in this area, because people don't open their minds to new learning. So, there you are touching this wound, and making the person understand well what happens, with the brain, with the sensations, with the feelings, right?” Rita declared that “[...] I think there are a lot of things that are going to be useful for me in this session. I think as, as I mentioned, I am a teacher, so there are things that I will be able to use in my practice that are not related to mathematics, I think, but in relation to learning and how we react […] For my personal case, I think trying is challenging myself to enter the growth zone in relation to mathematics, right? And instead of

staying in the comfort zone, which is where I try to take refuge all the time."

Second Session

At the beginning of the second session, we asked about what the participants remembered about the first session. All participants remembered important aspects of the HMB and the GZM. Tania related "I remember how the brain works. The hand thing I remember. That every day we can, for sure, learn something. [...] I think in my math test, I was in the red zone. I don't know, but I think it would be in my growth zone, which I talked about in high school when I did well with math". Amanda remembered specifically of the GZM, "It was good, yeah, it was interesting for me to understand anxiety. What revolves around this theme for me even though it may not be me, not that I am not aware of it, right? But internally, I have this anxiety, right? One way or another, it ends up manifesting itself, right? I remember that it had the Growth Zone and the Anxiety Zone". Rita recalled that "I was thinking a lot about this issue of the zone of growth, not only in relation to mathematics, but towards mathematics as well. So, if you came up with mathematics, I would try to enter the growth zone, try not to panic […]. And then [...] does not only apply to mathematics, I think that anything that we have a certain anxiety about, right? But in this specific case, math, which is something I'm anxious about, so I'm calmer now that you tell me there won't be math, but I wasn't. I was bracing myself so I wouldn't panic."

The second part of the second session was dedicated to taking up strategies to get out of the anxiety zone, persevering in the growth zone and not hiding in the comfort zone.

About strategies to get out of the anxiety zone, in the first session, Tania told us she tried to leave the situation and breathe outside. In the second session, she mentioned that she tried not to get frustrated with the negativity. Amanda also mentioned that she tried to breathe slowly and deeply but added "I've been trying. It depends a lot on the level of anxiety, right? Sometimes I don't succeed, but sometimes I do." Rita explained that music was a strategy she used to get out of the anxiety zone. Regarding math tests, Rita declared "There is me in the matter of mathematics. I do this kind of thing a lot, the first tip you have there, changing from one to another question and then going back to the previous question, because sometimes I may not see the way to solve the first question or the second, [...] the fact of distancing myself from that, moving on to another issue, this other issue, can sometimes give me the light I need." Getting support was also used to get out of the anxiety zone, for example when Rita had to face a math teaching situation, she declared that "Talking to my colleague, we sat down, talked and she said, I think it wasn't as bad as you might think, is it? [...] I was suddenly being very critical of the way I was managing behavior in the classroom [...] Yeah, but she gave me some tips too. This I got through the conversation with my friend. I was able to calm down and get better [...] I was able to think more rationally and see that I was suddenly making [...] 'a storm in a glass of water'".

People who have math anxiety can hide in their comfort zone to avoid facing math. So, the researchers showed a math question in order to verify if the participant would try or run away from doing math. We explained that it was not necessary to solve the question. This activity focused on the feelings that could come up when facing math. Tania told us, "I would go to the next question." and mentioned that her heart started pounding. So, we did

some breathing techniques and she could get better quickly. On the other hand, Amanda said, “I will say that I will try”. This showed us that people who report the same level of math anxiety can show different behaviors towards mathematics. Hence, it's important to address strategies both for getting out of the anxiety zone and for not hiding in the comfort zone. Rita stated, “Look, if you had shown me that image in session one [...] I was going to panic, like, what? No idea now. Today I still have no idea where to start, but like this I would, I would read the subject of this question today. I think I would read this question and see. […] if I can figure something out, you know? There are some or several parts of it that I'm probably not going to, are above my math knowledge, right? But there are some things that I can suddenly try to work on, try to understand.” We verified evidence of orange zone in Rita as she declared, “I was going to try, I was probably going to fail, but I wasn't going to be afraid of failing, you know? [...] I doubt that I could answer the whole question, because it has several steps, from what I can see, right? [...] wow, it has a lot of letters. [...] Yeah, but like, it's not scaring me that much, is it, but how am I supposed to tell you? It's not scaring me not because [...] It's the fact that, I know that there are things that are beyond my knowledge [...] I accept this at this moment, understand? I know it has [...] It's the worst thing that's going to happen, the wrong thing. Yes, I could look something up online and stuff.”

Finally, we talked about persevering in the growth zone. The aim was to know if participants felt unsure about whether they could do something but kept trying anyway, to verify what strategies they took, and what helped them.

About persevering in the Growth Zone in relation to mathematics, Tania mentioned that in the recent math test she moved on to the next one. “I cannot solve it, then I come back. It's like, it was taking me a long time to solve a question, I couldn't, I'll move on to the next one, then I'll spend time on this one, you know? Let's see what I know now”. She also mentioned, “I can understand that I am able to do math, but for me if it was a choice, I would not do anything in relation to math. But if I have to do it, I will be open to do it.” This data showed us that she has some trauma that keeps her avoiding math as much as possible. But we can see some growth mindset if it is necessary to do math. Although Amanda told us about her insecurities, she showed a growth impulse, “I am a person who is always trying to get out of comfort zone. I get insecure, but the fact that I can learn something new encourages me to get out of my comfort zone”. And Rita states that, “I think, but in relation to learning [...]. For my personal case, I think trying is challenging myself to enter the growth zone in relation to mathematics, right? And instead of staying […] in the comfort zone, which is where I try to take refuge all the time [...] What 's the worst that can happen? I will be wrong […] But like, my life is not at stake [...] my health is not at stake, there is nothing, you don't know, nobody is going to die because if I make a mistake, if I make a mistake I have to try again.”

The end of the second session was dedicated to talking about the impact of the whole intervention; we could see positive responses. Tania said, “I think I'm not so afraid of math like that. I think you made me see that it's not my best, but math can be a colleague. [...] I found that this model makes me rethink many points in my life in relation to mathematics”. Amanda mentioned, “It's good to understand these zones of comfort, learning and anxiety, because for me I didn't have this distinction. I didn't understand that there is this growth zone and how important it is. [...] I'm finding it super interesting because I hadn't realized a series of things. [...] This feeling of helplessness

has been with me for so long. That all this has made me realize how much I've achieved." When the interviewer asked, "How are you feeling now, after hearing all this and starting to think about it?" Amanda mentioned that she was feeling satisfied and added, "I think this is the feeling that this course brought me to realize. Exactly. Gosh, but it is, isn't it? Wow, I did this, I did that […] I let go of everything. Those frustrations... they are things that until then, maybe I never realized, right?". The impact of the intervention for Rita was huge. For example, she mentions that "So I have to find a way to find a balance that, this zone of growth, where I can grow, I can develop. I can learn something new, but without panicking and running away from the situation, or freezing in the situation, or whatever, right? Acting in a way that will prevent me from learning something new or from growing or developing. I think that's what stayed in my head."

When asked about what was the most useful for the participants, Rita said that "I think the two theoretical parts are very interesting. I really enjoyed understanding. It's this theory of the growth zone, the comfort zone and the anxiety zone. It is to help me in everything. I think almost every aspect of my life, isn't it because then I get it? Today I have this awareness, I get awareness [...] Of conscience, right? That at some point I'm suddenly going to enter the anxiety zone. When I enter the anxiety zone, Oops, this is not an area I should be in and also stay in the comfort zone, is it? Yeah, not the zone I should be in. I have to challenge myself; I have to try to take a little more risk here to be able to learn, develop, but not suddenly, go to the extreme or look for strategies." Finally, Rita stated that, "do you think you benefited from my participation? But I think I'll personally benefit a lot more. It is because of the knowledge that you have brought to my life, I think there is a lot that I will be able to apply and that I will be able to develop to help me with moments of anxiety. It's as much math as it is in other ways, so thank you very much for the opportunity and the conversation."

Discussion

In this study, we use reframing adverse prior experiences towards math as unrelated to intrinsic ability. We are interested in the realization that people with math anxiety are not stupid and changing the perspective (reframing) that "what happened to me is not my fault or a limit on my growth", which is a change of mindset. We used the Mathematical Resilience Framework: (1) identifying evidence of mathematics anxiety; experience of math anxiety; lack of relatedness; avoidance; isolation; shame, humiliation, and trauma; (2) using the Mathematical Resilience Toolkit (HMB, GZM and RR); (3) developing psychological safety, growth mindset, motivation and value, struggle, and relatedness to structure our discussion.

Importantly, these participants are immigrants (adventurers) invited to work in the UK, one a primary teacher, one a mum with a new baby whose husband is working in UK, and the third a quality engineer. We believe that life is already a challenge for all three; they have to understand a new culture, adapt to a new life and face challenging situations. Hence, we observed that they are already experiencing the growth zone outside mathematics. They are risk-takers, they are familiar with the growth zone, and they do not hide in their comfort zone (their need in life is to learn how to get out of the red zone, not to creep out of comfort). Even though there was a strong message from the reframing, the intervention shows that for the particular context of math learning they had an incorrect assumption (of being stupid at math) and did not apply their adventurousness to math.

Evidence of experiencing math anxiety were present in all three participants, especially when relating their previous bad experiences with mathematics. Strong feelings such as anguish, tension and anxiety were experienced by them, also associated with physiological symptoms such as body pains. Quotes that illustrate this math anxiety include: “I didn't have the pain in my stomach, but it's something in my stomach…[...], it feels like there's a tightness, discomfort, that's how my anxiety manifests itself and that tightness keeps getting tighter, tighter”, “Everything inside of me feels tense”. The words “desperate”, “feels tense”, and “I couldn´t do” show responses about the bad experiences with math in the past that can affect the way they relate to math in their lives. Lyons and Beilock (2012) show that for those with high levels of mathematics anxiety, the simple anticipation of a math event can be painful. The authors provide a potential neural mechanism to explain why math anxious people avoid math and math-related situations that lead them to getting away from taking math classes or to pursue a math-related career. Besides, experiencing mathematics anxiety can be the worst experience at school. We identified three main themes that arose from data.

Lack of and/or Low Self-Efficacy in Mathematics

In all three participants’ reports, it was possible to detect lack of and/or low self-efficacy in math. Most of it is a product of a set of bad experiences, traumas and failure in math that generates avoidance and lack of relatedness. Quotes such as “I thought how he could understand and I couldn't?” and “everyone can do math except me” indicate this lack of math self-efficacy. Bad experiences in math have a connection to the way a person deals with it and with the negative self-concepts and beliefs that emerge related to math (Hunt & Malone, 2022).

Impact of the Mathematical Resilience Toolkit

We observed that each participant had their own experience which modeled their behaviors towards math. They experienced the toolkit differently. For example, the Hand Model of the Brain (HMB) had a great impact on Tania. She remembered the tool in the second session as, according to her, the HMB gave a biological explanation for all her bad feelings during math tests in primary school. On the other hand, The Growth Zone Model (GZM) called Amanda´s attention, specifically the Growth and Anxiety Zones. She presented some growth impulse when she told us that she was always eager to learn something new. Getting to know the Growth Zone and the possibility of being in challenging situations without math anxiety was a novelty to her. Conversely, Rita presented a mature and self-knowledge as she understood all the tools and applied the learned techniques. She found herself in a challenging situation in other aspects of her life between the two sessions. She was able to apply the relaxation response and asked for help. In summary, since each participant could learn different aspects of the intervention and as any learning is a process, this experience may be helpful in their future learning journey. Hence, we believe that the tools can be transferred well to Brazilian culture and have a significant impact as shown by the qualitative data.

Impact of the Intervention

We observed positive impact of performing this kind of intervention. The participants could reframe their past

bad experiences with math and they realized that they are not stupid or incapable of doing math. In addition, all of them had the new understanding that their feelings were just a response of their bodies which detected math as a threat, because of their previous bad math experiences. This is a big step in developing mathematical resilience. However, we noticed that the intervention differed for each participant. At the end of the second session, all the participants showed some different mindset in comparison with themselves in the beginning of the first session. Tania focused on the HMB. Amanda focused on the GZM, especially the anxiety zone. And Rita could understand all the tools and showed a big change of behavior by knowing the mathematical resilience toolkit. The three participants showed different impacts from the tools, all of them could understand that the trouble is not with them, that they are not stupid and for Rita, this intervention had more positive impact in comparison with the other participants.

The observed differences may be due to the distinct learning journeys that each woman had and that reflected in their present working context. Each participant showed different emotions and behaviors towards their bad experiences. Amanda had trauma related to her father when learning math and at present is a quality engineer who has difficulties in making mistakes. Tania had bad episodes in school related to specific math content (fractions) and nowadays she always avoids math and everyday mental calculations (bills, age). Rita did not mention bad math experiences in her childhood when she was a teenager, however, she had bad previous moments when working as a primary teacher as she felt ashamed for not knowing the times table. That made her change her job to an English teacher, avoiding math. We observe that both Tania and Rita were avoiding math before the intervention. Hence one participant showed difficulties in family context meanwhile the other two presented difficulties in schooling context. Some people with math anxiety may need a longer intervention. But, we were able to see some points that are important to achieve in this journey of developing mathematical resilience. So we want to add some contributions to the mathematical resilience research about the elements in the journey to develop mathematical resilience, though not every learner encounters the elements in the same order:

1º Reframing - “what is wrong with me?” becomes “what happened to me?” and “how can I stop it from happening again”?

2º Knowing the tools - the hand model of the brain is an argument that the person experiencing mathematics as a threat is not stupid but panicking, and panicking is temporary.

3º Recognizing the feelings/sensations in a real and actual situation - be aware of the difference between red and orange, i.e. threat and challenge.

4º If the person goes more to the Anxiety Zone, recognizing the feelings/sensations and seeing what strategies can help to get out of the Anxiety Zone. If the person stays more in the comfort zone, understanding what helps them get out of the comfort zone.

5º Starting to see and understand the Growth Zone. It is important to try to understand what strategies can help them to persevere in the Growth Zone. But it is also important to understand how the person reacts when faced with challenges and what kind of things can motivate the person to get out of their comfort zone.

6º Living the Growth Zone. To experience what they have learned. To experience trying to use strategies to get out of the red zone and not to hide in the comfort zone in math. This part is important to happen out of the intervention (between the sessions). So, the participant can bring the experiences to the session and talk in a way to organize their feelings and thoughts about what happened.

One of the outcomes of the present study was the power that reframing had in those three women. In particular, we learned that the dialogic approach based on active listening, and then responsive personalization, brought another perspective to the lives of these three women. We also verified that people with high levels of mathematics anxiety will respond differently to the intervention, and some can possibly need a longer intervention. Although each participant benefited from different parts of the intervention, they all related at the end of the intervention that they are not stupid at math as they had believed.

Conclusions, Limitations and Future Prospects

Our intervention proposes a big change of behavior: we felt that Tania had no growth mindset but could understand that it was not her fault, but it was due to her weak math in primary school. Although Amanda had suffered mathematics anxiety, she had a growth impulse, so it was not too hard for her to have a growth mindset towards math. And we verified that Rita already had a growth mindset before participating in this intervention.

The unintended consequence of math pedagogy based on 'you can either do math or you can't' in both Brazil and the UK, is that students don't even reach the moment where they find themselves stuck in a problem or struggling in the orange zone. It is essential that the pedagogy used avoids perpetuating the idea that mathematical ability is fixed, as this can discourage students from persisting in their math learning journey. Math proficiency is not an innate trait that some individuals have, and others do not. It is a skill that can be developed and improved through effective teaching methods, practice, and a positive attitude towards learning. A growth mindset is crucial in understanding that abilities can be cultivated over time.

Limitations of this study include the possible need for a third session depending on the participant characteristics previously verified by use of questionnaires; heterogeneous samples which made it difficult to analyze data (not all participants were from the same context). Although all three participants had the same high level of mathematics anxiety, other aspects interacted with the way they receive the intervention.

For future research we can try to verify before the intervention whether the participant already has some growth mindset in different areas; how he/she reacts when making mistakes and if he/she is a person who takes more risk or prefers not to change. We can try to find some way to measure how prepared and available they are to change something in their lives, and if they already take risks in their lives. We believe it would be interesting to develop some questionnaires or to use a math resilience scale before and after the intervention to provide quantitative evidence of mathematical resilience development. It is desirable to perform future longitudinal studies to verify the persistence of the reframing and the growth mindset.

Acknowledgements

This study was supported by Conselho Nacional de Desenvolvimento Científico e Tecnológico — Brasil (CNPq) Process Number 402626/2022-2.

References

Ashcraft, M. H., & Kirk, E. P. (2001). The relationships among working memory, math anxiety, and performance. *Journal of Experimental Psychology:* General, 130(2), 224–237. 10.1037/0096-3445.130.2.224

Ashcraft, M. H., & Krause, J. A. (2007). Working memory, math performance, and math anxiety. *Psychonomic Bulletin & Review*, 14, 243–248. http://dx.doi.org/10.3758/BF03194059.

Baker, J. (2021) *'You see it differently once you calm down': developing an intervention to support learners to address their mathematics anxiety*. PhD thesis, University of Warwick.

Bandura, A. (1994). Self-efficacy. In R. J. Corsini (Ed.), *Encyclopedia of psychology* (2nd ed., Vol. 3, pp. 368-369). New York, NY: Wiley.

Beilock, S. L., & Maloney, E. A. (2015). Math anxiety: A factor in math achievement not to be ignored. *Policy Insights from the Behavioral and Brain Sciences*, 2(1), 4-12.

Betz, N. (1978). Prevalence, Distribution and Correlates of Math Anxiety in College Students. *Journal of Counseling Psychology*, 25, 441-448.

Blatchford, P. (1996). Pupils' views on school work and school from 7 to 16 years. *Research papers in education*, 11(3), 263-288.

Boaler, J. (2016) Mathematical mindsets: unleashing students' potential through creative math, inspiring messages, and innovative teaching. [online] First edition. edn. San Francisco: Jossey Bass.

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, 3, 77–101. https://doi.org/10.1191/1478088706qp063oa

Brunyé, T. T., Mahoney, C. R., Giles, G. E., Rapp, D. N., Taylor, H. A., & Kanarek, R. B. (2013). Learning to relax: Evaluating four brief interventions for overcoming the negative emotions accompanying math anxiety. *Learning and Individual Differences*, 27, 1-7. https://doi.org/10.1016/j.lindif.2013.06.008

Carmo, J., Gris, G., & Palombarini, L. (2019) Mathematics anxiety: Definition, prevention, reversal strategies and school setting inclusion. In D. Kollosche et. al. (Eds.), *Inclusive mathematics education. State of the art research from Brazil and Germany* (pp. 403–418). Switzerland: Springer.

Chiu, L. H., & Henry, L. L. (1990). Development and validation of the Mathematics Anxiety Scale for Children. *Measurement and evaluation in counseling and development*, 23, 121–127.

Dane, A. (2005). Differences in mathematics anxiety by sex, program, and education of university mathematics students in turkey. *Psychological Reports*, 96(2), 422-424. https://doi.org/10.2466/pr0.96.2.422-424

Donker, T., Griffiths, K.M., Cuijpers, P. & Christensen, H. (2009). Psychoeducation for depression, anxiety and psychological distress: a meta-analysis. *BMC Med* 7, 79. https://doi.org/10.1186/1741-7015-7-79

Dowker A (2005). *Individual differences in arithmetic: implications for psychology, neuroscience and education.* Hove: Psychology Press.

Dowker, A., Sarkar, A., & Looi, C. Y. (2016). Mathematics anxiety: What have we learned in 60 years? *Frontiers in Psychology*, 7. https://doi.org/10.3389/fpsyg.2016.00508

Dweck, C. S. (2006). *Mindset: The new psychology of success*. Random house.

Fisher, P. H., Masia-Warner, C., & Klein, R. G. (2004). Skills for social and academic success: A school-based intervention for social anxiety disorder in adolescents. *Clinical Child and Family Psychology Review*, 7(4), 241-249. https://doi.org/10.1007/s10567-004-6088-7

Geake, J. (2009). *The brain at school: Educational neuroscience in the classroom: Educational neuroscience in the classroom.* McGraw-Hill Education (UK).

Gunderson, E. A., Ramirez, G., Levine, S. C., & Beilock, S. L. (2012). The role of parents and teachers in the development of gender-related math attitudes. *Sex Roles: A Journal of Research*, 66(3-4), 153-166. https://doi.org/10.1007/s11199-011-9996-2

Hembree, R. (1990). The nature, effects, and relief of mathematics anxiety. *Journal for Research in Mathematics Education*, 21(1), 33–46. https://doi.org/10.5951/jresematheduc.21.1.0033

Hill, F., Mammarella, I. C., Devine, A., Caviola, S., Passolunghi, M. C. & Szűcs, D. (2016) math anxiety in primary and secondary school students: Gender differences, developmental changes and anxiety specificity. *Learning & Individual Differences*, 48 45-53.

Hunt, T. E., & Maloney, E. A. (2022). Appraisals of previous math experiences play an important role in math anxiety. *Annals of the New York Academy of Scien*ces, 1515(1), 143-154.

Johnston-Wilder, S., & Lee, C. (2010). Mathematical Resilience. *Mathematics Teaching*, 218, 38-41.

Johnston-Wilder, S., Kilpatrick Baker, J., McCracken, A., & Msimanga A. (2020). A Toolkit for Teachers and Learners, Parents, Carers and Support Staff: Improving Mathematical Safeguarding and Building Resilience to Increase Effectiveness of Teaching and Learning Mathematics. *Creative Education*, 11, 1418-1441. https://doi.org/10.4236/ce.2020.118104

Kelly, A. (1988). Option choice for girls and boys. *Research in Science & Technological Education*, 6(1), 5-23.

Lugalia, M., Johnston-Wilder, S., & Goodall, J. (2013). The Role of ICT in Developing Mathematical Resilience in Learners. In *INTED 2013: 7th International Technology, Education and Development Conference* (pp. 4096-4105). IATED.

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.

Maloney, E. A., & Beilock, S. L. (2012). Math anxiety: Who has it, why it develops, and how to guard against it. *Trends in Cognitive Sciences*, 16(8), 404–406. https://doi.org/10.1016/j.tics.2012.06.008

Mason, J. (2015). On being stuck on a mathematical problem: What does it mean to have something come-to-mind? *LUMAT: International Journal on Math, Science and Technology Education*, 3(1), 101-121.

Mason, J., Burton, L. & Stacey, K. (2010). *Thinking mathematically*. London: Pearson.

Moser, J. S., Schroder, H. S., Heeter, C., Moran, T. P., & Lee, Y. H. (2011). Mind your errors: Evidence for a neural mechanism linking growth mind-set to adaptive posterror adjustments. *Psychological science*, 22(12), 1484-1489.

Mujtaba, T., & Reiss, M. (2016). Girls in the UK have similar reasons to boys for intending to study mathematics post-16 thanks to the support and encouragement they receive. *London Review of Education*, 14, 66-82. https://doi.org/10.18546/LRE.14.2.05

Munroe, M., Al-Refae, M., Chan, H. W., & Ferrari, M. (2022). Using self-compassion to grow in the face of trauma: The role of positive reframing and problem-focused coping strategies. *Psychological Trauma: Theory, Research, Practice, and Policy*, 14(S1), S157. https://doi.org/10.1037/tra0001164

Newstead, K. (1988). Aspects of children's mathematics anxiety. *Educ Stud Math*, 36:53–71.

Núñez-Peña, M. I., Suárez-Pellicioni, M., & Bono, R. (2013). Effects of math anxiety on student success in higher education. *International Journal of Educational Research*, 58, 36-43.

https://doi.org/10.1016/j.ijer.2012.12.004

OECD (2013) Mathematics Self-Beliefs and Participation in Mathematics-Related Activities. In: PISA, ed. PISA 2012 Results: Ready to Learn - Students' Engagement, Drive and Self-Beliefs. *OECD Publishing*.

Ramirez, G., Gunderson, A., Levine, S., & Beilock, S. (2013). Math anxiety, working memory, and math achievement in early elementary school. *Journal of Cognition and Development*, 14(2), 187–202. 10.1080/15248372.2012.664593

Richardson, F. C., & Suinn, R. M. (1972). The Mathematics Anxiety Rating Scale: Psychometric Data. *Journal of Counseling Psychology*, 19, 551-554. https://doi.org/10.1037/h0033456

Seligman, M. (1991) *Learned optimism.* New York: Knopf.

Siegel, D. (2010). *Mindsight: Transform Your Brain with the New Science of Kindness*. Oneworld Publications.

Sokolowski, H. M., Hawes, Z., & Lyons, I. M. (2019). What explains sex differences in math anxiety? A closer look at the role of spatial processing. *Cognition*, 182, 193–212. https://doi.org/10.1016/j.cognition.2018.10.005

Vos, H., Marinova, M., De L´eon, S. C., Sasanguie, D., & Reynvoet, B. (2023). Gender differences in young adults' mathematical performance: Examining the contribution of working memory, math anxiety and gender-related stereotypes. *Learning and Individual Differences*, 102, Article 102255. https://doi.org/10.1016/j.lindif.2022.102255

Walker-Hirsch, L. & Champagne, M.P. (1991) Circles revisited: Ten years later. *Sex Disabil* 9, 143–148. https://doi.org/10.1007/BF01101739

Williams, G. (2014). Optimistic problem-solving activity: enacting confidence, persistence, and perseverance. *ZDM*, 46, 407-422.

Author Information

Karina Lumena Alves
https://orcid.org/0000-0003-2891-0228
Universidade Federal de São Carlos
Rod. Washington Luís, s/n - Monjolinho, São Carlos
Brazil
Contact e-mail: *profkarinalumena@gmail.com*

Telma Pará
https://orcid.org/ 0000-0002-4784-8506
Fundação de Apoio à Escola Técnica
Rua Bartolomeu de Gusmão, 850 – Rio de Janeiro
Brazil

Sue Johnston-Wilder
https://orcid.org/ 0000-0002-1631-6478
University of Warwick
Education Studies Department, Coventry, CV4 7AL
United Kingdom

Janet Baker
https://orcid.org/ 0000-0002-0309-9873
Arden University
Middlemarch Park, Coventry, CV3 4FJ
United Kingdom