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Reducing mathematics anxiety in the classroom

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REDUCING MATHEMATICS ANXIETY IN THE CLASSROOM

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Abstract

The purpose of this review was to analyse empirical studies related to reducing mathematics anxiety in the classroom. A scoping process was used to locate literature, and a thematic method was used to analyse and group the data obtained from the studies. A total of 14 articles published between 2014 and 2022, mostly using mixed-methods approaches, were analysed. The data indicated that mindfulness strategies, sustained exposure and support, and addressing affective factors, such as distractions, negative emotions, and motivation, has been shown to reduce mathematics anxiety levels of students. Possible implications for reducing maths anxiety in the classroom and opportunities for further empirical research are presented.

Keywords

Mathematics anxiety; reducing mathematics anxiety; mathematics pedagogy

Introduction

In education, student achievement in maths does not solely rely on the students' abilities, but on their attitudes as well (Maloney, 2016). Succeeding in mathematics (maths, hereafter) is positively related to the enjoyment of the subject (Goetz et al., 2006); clearly, it is important for students to have positive emotions towards maths. However, students' negative emotions towards maths has increased over time (Villavicencio & Bernardo, 2016), which has brought attention to the causes and effects of maths anxiety.

Maths anxiety is considered a global phenomenon and is exhibited by students in many societies (OECD, 2013). Maths anxiety is defined as an adverse emotional reaction and fear of situations involving maths (Ashcraft & Moore, 2009; Richardson & Suinn, 1972). The symptoms of maths anxiety can be physical, such as experiencing sweaty palms; and psychological, such as feeling dread and depressed because of maths (Ma, 1999).

Research has shown that maths anxiety results from the way maths is taught to students and not necessarily the difficulty of the subject (Samuel & Warner, 2021), so teachers play a vital role in addressing maths anxiety in the classroom. Maths anxiety can begin in early childhood, and causes of maths anxiety can be associated with factors that contribute to early development, such as difficulties in numerical and spatial processing (Ramirez et al., 2013). This can lead to lower achievement which, in turn, fuels maths anxiety (Maloney, 2016). The causes of maths anxiety are also linked to the teaching style of maths teachers, as traditional methods involve teachers using direct instruction with the power of authority. This leads to students passively learning methods without questioning the knowledge they are learning (Cates & Rhymer, 2003; Finlayson, 2014). Furthermore, studies determined that maths anxiety could have an effect on maths performance (Karimi & Venkatesan, 2009; Maree et al., 2013), which could result in students having less interest towards the subject (Asanjarani & Zarebahramabadi, 2021). This could contribute to longitudinal outcomes, such as low maths achievement and avoiding career paths that involve substantial amounts of maths (Ashcraft & Moore, 2009; Ma, 1999). Additionally, failing to address maths anxiety in the classroom could lead to maths anxiety in the workplace and everyday applications. For example, research shows that maths anxiety contributes to substandard drug calculation among nurses (McMullan et al., 2012) and difficulty in financial planning (McKenna & Nickols, 1988). Maths teachers and parents could also pass their maths anxiety to their

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students and children; thus, maths anxiety should be identified and addressed as early as possible in a person's academic life (Asanjarani & Zarebahramabadi, 2021).

Aim and positionality

There is limited research that involves finding interventions or treatments to reduce maths anxiety (Maloney, 2016; Supekar et al., 2015). Furthermore, there are no studies that focus on reducing maths anxiety for students in Aotearoa New Zealand, despite the decline in maths achievement in recent years (Caygill & Zhao, 2020). Additionally, statistics showed that students from New Zealand had a greater intensity of negative attitudes towards maths when compared to international counterparts (Caygill & Zhao, 2020). This motivated me to find effective interventions and practices that teachers could apply in their classrooms to reduce maths anxiety which could help improve maths achievement.

I understand that my identity and positionality could have an influence on my analysis. I am an early career maths teacher from the Philippines, who moved to New Zealand at a young age. I experienced different classroom settings in New Zealand and the Philippines but noticed the presence of maths anxiety in students from both countries. As a teacher, I also observed different levels of maths anxiety and its influence on student engagement and maths achievement. By reviewing and analysing developments in pedagogy in the maths learning area, I hope to find effective ways to reduce maths anxiety and apply it in my practice. Therefore, the focus question of this literature review is, "What interventions or practices have been shown to help reduce maths anxiety in the classroom?"

Methodology

A scoping process was used to conduct the review. Quantitative, qualitative, and mixed-method studies were included in the review using Galvan and Galvan (2017) as the basis for selecting and analysing literature for review.

The databases searched for this review included Taylor and Francis, Elsevier, and Google Scholar. The search keyword strings used were, "maths anxiety", "reducing maths anxiety", "overcoming maths anxiety", and "strategies". The total number of identified articles from the searches was 29, and EndNote was used to manage the bibliographic details and citations of the articles. The inclusion criteria for the articles required that they were recent (published post-2012) peer-reviewed journal articles that were relevant to the focus question: "What interventions or practices have been shown to help reduce maths anxiety in the classroom?" After critical reading against the inclusion criteria, the final number of articles included in the review was 13.

Data presentation and findings of analysis

A thematic method was used to group the data based on Braun and Clarke (2006). The six phases in the thematic method were used as a guide when analysing the articles. This includes familiarising with the data, generating initial codes, searching for themes in the data, assessing the relevance of each theme, defining the themes, and producing the report. Thematic maps were used as a tool to analyse the data, and a total of five themes were identified at the initial stage of the review. The data was organised into three sections for analysis. In the first section, the research approach and the themes found in the thematic maps were analysed. In the second section, the articles were organised by country and publication date. The dates of the articles were categorised by the following: 2014–2016, 2017–2019, and 2020–2022. In the third section, the reviewed studies were organised by study duration and sector level. The study duration was categorised by the following: less than one month, between one month and one year, and greater than a year.

The themes were reviewed by assessing the relevance of each theme regarding the focus question. Braun and Clarke's (2021) recent publication was used to develop and revise the themes. The final number of themes included in the review was three which includes mindfulness, addressing affective factors, and sustained exposure and support.

Results and discussion

Most of the analysed articles were conducted in the United States of America (69.2%). Other locations included Taiwan, Iran, Italy, and New Zealand. Furthermore, most of the studies were published from 2020–2022 (54%), followed by 2017–2019 (31%), and 2014–2016 (15%). This indicated that the number of studies that involve reducing maths anxiety levels have increased over time.

The majority of the studies were conducted over a period of less than one month (46.2%). This is followed by a study duration of between one month and one year (38.5%), and then greater than a year (15.4%). Study duration was analysed to determine if the length of the study had an influence on reducing maths anxiety levels. Most of the studies were carried out in the primary sector (38.5%), followed by other participants (30.8%), and secondary sector (30.8%). Other participants included teachers, family members, and tertiary students that have a mean age that were close to the age of secondary students. The difference between sectors was analysed, as different interventions may be required for different age groups; thus, the studies may have different influences on reducing maths anxiety, depending on the sector level.

It can be seen in Table 1 that a mixed-method approach was used in the majority of the studies (61.5%), followed by quantitative (23.1%), and then qualitative methods (15.4%). Additionally, Table 1 shows that the three themes that have been shown to reduce maths anxiety were mindfulness, addressing affective factors, and sustained exposure and support. Each of the three themes are described and categorised into different elements and then each theme followed by a brief summary discussion.

Table 1. Reviewed Studies by Research Approach and Theme

	Mindfulness	Sustained exposure and support	Addressing affective factors
Qualitative (15.4%)			Instructor misbehaviors and maths anxiety (Kelly et al., 2020) Maths anxiety in secondary school female students: Issues, influences and implications (Mann & Walshaw, 2019)
Quantitative (23.1%)	The role of expressive writing in maths anxiety (Park et al, 2014) Evaluating the effectiveness of cognitive-behavioral therapy on maths self-concept and maths anxiety of elementary school students (Asanjarani & Zarebaramabadi, 2021)	Evaluating the effectiveness of cognitive-behavioral therapy on maths self-concept and maths anxiety of elementary school students (Asanjarani & Zarebaramabadi, 2021) Remediation of childhood maths anxiety and associated neural circuits through cognitive tutoring (Supekar et al, 2015) Disassociating the relation between parents’ maths anxiety and children’s maths achievement: Long-term effects of a maths app intervention (Schaeffer et al, 2018)	Remediation of childhood maths anxiety and associated neural circuits through cognitive tutoring (Supekar et al, 2015)

Mixed-methods (61.5%)	<p>"I can maths!": Reducing maths anxiety and increasing maths self-efficacy using a mindfulness and growth mindset-based intervention in first-year students (Samuel & Warner, 2021)</p> <p>The impact of mindfulness-based cognitive therapy on maths anxiety in adolescents (LaGue et al, 2019)</p> <p>Neural evidence for cognitive reappraisal as a strategy to alleviate the effects of maths anxiety (Pizzie et al, 2020)</p>	<p>The impact of mindfulness-based cognitive therapy on maths anxiety in adolescents (LaGue et al., 2019)</p> <p>Evaluation of maths anxiety and its remediation through a digital training program in maths for first and second graders (Ng et al, 2022)</p> <p>Co-development of maths anxiety, maths self-concept, and maths value in adolescence: The roles of parents and maths teachers (Wang et al., 2021)</p>	<p>Anxiety is not enough to drive me away: A latent profile analysis on maths anxiety and maths motivation (Wang et al., 2018)</p> <p>The mediating role of attention in the association between maths anxiety and maths performance: An eye-tracking study (Li et al., 2022)</p> <p>Neural evidence for cognitive reappraisal as a strategy to alleviate the effects of maths anxiety (Pizzie et al, 2020)</p>
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Mindfulness

Several studies showed that mindfulness techniques reduce maths anxiety in both primary and secondary sectors.

Controlled breathing

One of the mindfulness techniques explored by the studies was controlled breathing. In the study of Samuel and Warner (2021), controlled breathing exercises were carried out at the start of every lesson for 40 first-year tertiary students for a semester in New York, USA LaGue and their colleagues (2019) also used this technique as part of the Mindfulness-Based Cognitive Therapy (MBCT) sessions during a six-week intervention in a secondary school in the USA (LaGue et al., 2019). Both studies determined that controlled breathing helped students become present in their surroundings, which reduced their stress towards attempting maths problems and helped decrease their maths anxiety levels.

Becoming aware of emotions

Another mindfulness technique explored in a study by Park and her colleagues (2014) was expressive writing. In the intervention, tertiary students who had different levels of maths anxiety were assigned to a control group or expressive writing group. Students in the expressive writing group were instructed to write for seven minutes about their thoughts and emotions towards the maths exam they were about to participate in. The results of the control group exhibit that students with high levels of maths anxiety scored lower in the test in contrast to students with low levels of maths anxiety. On the other hand, the results of the expressive writing group showed that the error rates of highly maths anxious students did not differ from the scores of students with low levels of maths anxiety (Park et al., 2014). This study found that expressive writing improved the maths performance of students who had high levels of maths anxiety because it freed up working memory which helped students to become aware and understand how they feel, allowing them to regulate their emotions. This related to LaGue et al.'s (2019) MBCT intervention, which helped students use their senses to be fully present in their surrounding environments. This included sensory-based practices, such as body scans, mindful movement activities, and visualisation practices (LaGue et al., 2019). Both studies confirmed that helping students become

aware of their emotions through expressive writing and MBCT allowed students to understand their emotions; hence, reducing their maths anxiety levels.

Another method that supported students to become aware of their emotions was observed by Asanjarani and Zarebahrabadi (2021) in a study carried out in Iran. Students were taught coping skills, such as thought awareness and the acronym KICK, which stood for ‘Knowing I’m nervous, Calm thoughts, and Keep practicing’, as a part of Cognitive-Behavioural Therapy (CBT) (Asanjarani & Zarebahrabadi, 2021). After 12 sessions of CBT, Asanjarani and Zarebahrabadi (2021) found that the maths anxiety of students decreased when the pre- and post-test results were compared. CBT helped students become aware of their maths anxiety which allowed them to restructure their thinking when facing stressful situations in the classroom (Asanjarani & Zarebahrabadi, 2021).

Positive affirmations

Additionally, studies found that the mindfulness technique of saying positive affirmations reduces maths anxiety (Asanjarani & Zarebahrabadi, 2021; Samuel & Warner, 2021). In Samuel and Warner’s (2021) study, students were instructed to recite five positive affirmations derived from growth mindset principles, such as “I am capable of understanding maths” at the start of each lesson. Verbally saying positive affirmations was also part of the CBT intervention in the study by Asanjarani and Zarebahrabadi (2021). Both studies concluded that positive affirmations had a significant impact on the students’ beliefs, which helped decrease their maths anxiety levels (Asanjarani & Zarebahrabadi, 2021; Samuel & Warner, 2021). Therefore, saying positive affirmations during lessons could be a possible technique that teachers can apply to their practices to reduce maths anxiety in the classroom.

Discussion

In summary, the studies suggested that controlled breathing, expressive writing, Cognitive-Behavioural Therapy (CBT), cognitive reappraisal, and positive affirmations could be possible strategies to reduce the maths anxiety levels of students. As well as reducing maths anxiety, the techniques used in these studies were also associated with improvement in other areas such as maths achievement (LaGue et al., 2019; Park et al., 2014; Pizzie et al., 2020) and self-confidence (Asanjarani & Zarebahrabadi, 2021; Samuel & Warner, 2021) in the primary, secondary, and tertiary sectors.

Mindfulness can be applied in the classroom by allocating time for students to use the techniques that the analysed studies suggested. Possible times could be at the beginning of each lesson, in the middle of a lesson as a “brain break”, or before completing a difficult task.

Addressing affective factors

Several studies found that addressing affective factors, such as confidence and motivation, has been shown to reduce maths anxiety (Kelly et al., 2020; Li et al., 2022; Mann & Walshaw, 2019; Pizzie et al., 2020; Supekar et al., 2015; Wang et al., 2018). Affective factors were defined as psychological factors that influence student learning (Bao & Liu, 2021).

Negative emotions

Two studies addressed negative emotions through cognitive restructuring, which is a strategy that helps regulate emotions. This reduced the negative emotions of students towards maths, thus, decreasing their maths anxiety (Pizzie et al., 2020; Supekar et al., 2015). Additionally, Supekar and their colleagues (2015) determined that cognitive restructuring addressed negative emotions because it regulates the brain activity in the amygdala nuclei, which mediates reactivity to negatively valenced stimuli (Supekar et al., 2015).

Motivation

One study addressed motivation, which was an affective factor that had a significant effect on maths anxiety of secondary students in the USA (Wang et al., 2018). Wang and her colleagues (2018) found through cognitive tests and self-report measures that highly motivated students were more likely to be associated with higher maths achievement, thus, experiencing lower maths anxiety. Additionally, the students who had high levels of maths anxiety had low motivation with their maths learning. Therefore, Wang and her colleagues (2018) emphasised that maths motivation should be addressed to reduce maths anxiety, as they are on the opposite ends of a continuum (Wang et al., 2018).

Attention

The role of attention was investigated by Li and his colleagues' (2022) study, which was an affective factor shown to contribute towards reducing maths anxiety (Li et al., 2022). The study involved primary students from a school in the USA answering maths problems on the computer with different distractions that are both relevant and irrelevant to the task. Relevant distractions were included as daily classroom items could also be distractors during maths lessons and exams. It was observed that students with high levels of maths anxiety had an attentional bias towards both relevant and irrelevant distractors when answering the maths problems. This resulted in less accuracy and slower performance in contrast to students with lower maths anxiety levels. Therefore, Li and his colleagues (2022) suggested that educators should be aware of possible distracting information they are presenting and consider classroom practices that could be disruptive as it was shown that distractions have significant effect on maths anxiety levels (Li et al., 2022).

Low quality practices

A study by Kelly and her colleagues (2020) investigated the relationship between low quality teaching practices and maths anxiety (Kelly et al., 2020). Kelly and her colleagues (2020) categorised low quality practices as incompetence, disrespectful practices, and refusing to form connections with students. The study found that low quality practices increased maths anxiety levels of the students (Kelly et al., 2020). This finding was consistent with Mann and Walshaw's (2019) study, which explored maths anxiety issues, influences, and implications through surveys and focus group interviews of secondary students in New Zealand (Mann & Walshaw, 2019). The student data indicated that high quality teaching practices have been shown to reduce the maths anxiety levels of students. It was emphasised by Mann and Walshaw (2019) that teachers should provide comprehensive explanations of mathematical concepts and provide multiple ways to solve problems (Mann & Walshaw, 2019). They recommended that educators should continuously find strategies to improve and refine their practice, which could help reduce maths anxiety levels of students.

Discussion

The studies suggested that negative emotions, motivation, attention, and teacher practices were important affective factors that teachers could address in their classrooms to reduce maths anxiety. A possible strategy to address affective factors in the classroom is by engaging students in their learning, which is suggested by Kelly and her colleagues (2020). This could include using digital tools, such as Google Forms and Padlet, or through physical surveys that students could complete. Students could be asked questions such as:

- Which part of the unit are you finding most challenging?
- What helps you learn?
- How can the teacher support you better?
- What would you like the teacher to know about you?

Engaging students in their learning allows teachers to identify the affective factors, such as motivation, negative emotions, or distractions, that could be addressed in the classroom which could help them construct effective strategies that can reduce the maths anxiety of their students. This could also reduce the negative emotions of students towards maths because they are able to express their opinions and be involved with their learning. Furthermore, teachers can form connections with their students as they become aware of their students' interests and needs. Therefore, engaging students with their learning could be a possible strategy to address affective factors in the classroom.

Sustained exposure and support

An intervention that has been shown to reduce maths anxiety was sustained exposure to maths through one-to-one tutoring and continuous support from parents and teachers (LaGue et al., 2019; Ng et al., 2022; Schaeffer et al., 2018; Supekar et al., 2015; Wang et al., 2021).

Sustained exposure-based interventions

Using the evidence from previous studies of exposure-based interventions for treating anxiety, Supekar and his colleagues (2015) investigated the effect of one-to-one cognitive maths tutoring on the maths anxiety levels of primary students in the USA for eight weeks (Supekar et al., 2015). Supekar and his colleagues (2015) suggested that one-to-one maths tutoring could reduce maths anxiety, as it repeatedly exposes students to mathematical stimuli and social situations that require them to problem solve for mathematical solutions (Supekar et al., 2015). It was stated that sustained exposure to what the students fear can help them feel more in control of situations that involve maths problems, which could reduce their maths anxiety (Supekar et al., 2015). This finding is consistent with the study conducted by Ng and their colleagues (2022) which resulted in a reduction of maths anxiety levels of primary students in Taiwan after six weeks of intensive digital training (Ng et al., 2022). The study suggested that it was the sustained exposure to maths that helped reduce the negative emotions of the students towards maths, as it eliminates the expectation of an association between the source of anxiety and aversive outcomes (Ng et al., 2022).

Similar results were obtained through a different approach by Samuel and Warner (2021), as the study involved two mindfulness interventions that were carried out at different durations (Samuel & Warner, 2021). One duration was over a semester while another duration was for the whole academic year. The findings determined that the intervention that was conducted for the whole academic year decreased the maths anxiety levels of the students more when compared to the intervention that was carried out for a semester (Samuel & Warner, 2021). The study by LaGue and their colleagues (2019) supported this finding as sustained cognitive therapy for six weeks reduced maths anxiety levels of students (LaGue et al., 2019). It was suggested that sustained exposure over a long period is required because cognitive therapy happens in three different phases: the opening phase, the middle phase, and the termination phase (LaGue et al., 2019). Therefore, multiple sessions would be required to significantly reduce the maths anxiety levels of students.

Support from parents and teachers

Two articles found that sustained support from parents and teachers reduced the maths anxiety levels of students (Schaeffer et al., 2018; Wang et al., 2021). In the study by Wang and her colleagues (2021), the roles of parents and teachers were investigated through questionnaires that were answered by secondary students from a school in the USA (Wang et al., 2021). The study found that higher encouragement and support from parents and teachers correlated with lower maths anxiety levels (Wang et al., 2021). This finding was consistent with the study of Schaeffer and her colleagues (2018) that used a different approach to investigate the effect of parental support on the maths anxiety levels of primary students (Schaeffer et al., 2018). The study involved a digital maths application intervention where students were required to work with their parents at home and answer problems using an iPad

mini for over the whole academic year. Parental involvement was found to have an important role in the maths anxiety levels of their children because students who sustained their use of the application intervention with their parents experienced lower maths anxiety levels by the end of the year when compared to students who did not consistently use the application (Schaeffer et al., 2018). This suggested that changes in parents' expectations and involvement could play a vital role in reducing maths anxiety and improving maths achievement (Schaeffer et al., 2018).

Discussion

The findings exhibited consistent results, which involved using sustained exposure-based interventions and teacher and parental support to reduce maths anxiety.

It is important to acknowledge that most of the studies that had a duration that was greater than one month were carried out in the USA (71.4%), which indicated that some countries may have more resources or funding to conduct studies over a longer period. However, exposure-based interventions were observed to reduce maths anxiety of students from Iran and Taiwan, which demonstrated how exposure-based interventions were also effective in other countries.

A possible strategy that involves sustained exposure to maths is asking students to report how they use maths in everyday life. This could be carried out through a class project intervention or by using digital tools that are similar to the methods used by Ng and their colleagues (2022). Similar to the approach used by Schaeffer and her colleagues (2018), parental support could be used in this strategy by asking parents to help their children determine how they are using maths at home. Teachers could also help parents become aware that they have a role in their child's mindset about maths and that their influence has an impact on the maths anxiety levels of their children.

Conclusion

This review examined articles about reducing maths anxiety in the classroom. Outcomes of this review illustrated that studies that explore interventions to reduce maths anxiety have increased since 2014. Additionally, the data indicated that the majority of the studies were carried out in the primary sector, showing a large focus is on remediating maths anxiety during its early stages before it becomes detrimental and more difficult to remediate.

Based on this review, effective teaching practices that have been shown to reduce maths anxiety were organised into three themes: mindfulness practices, addressing affective factors, and sustained exposure and support. The review of literature which involves reducing maths anxiety in the classroom has limitations. One of its limitations is the keywords I used to find articles to use as data for the review. There is a possibility that using other words as search strings may lead to more articles that explore interventions and teaching practices that reduce maths anxiety.

Another limitation is that there is a possibility that social and cultural factors of different countries may influence the interventions. In Aotearoa New Zealand context, studies determined that some teachers have lower expectations in maths achievement of Māori and Pasifika students (Caygill & Zhao, 2020). Additionally, the maths self-concept of students from Aotearoa New Zealand are negatively impacted by socialisation of stereotypical gender beliefs and social comparison. Interventions suggested by this review may require modification to meet the needs of Aotearoa New Zealand learners. Nevertheless, this review provides a summary and discussion of interventions that educators could use as a framework to develop practices that could help reduce maths anxiety in the classroom.

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