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WORKING WITH PRE-SERVICE TEACHERS: DEVELOPING MATHEMATICS AND SCIENCE RESILIENCE WHILE ADDRESSING MATHS AND SCIENCE ANXIETY LEVELS IN SOUTH AFRICAN SCHOOLS

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Abstract

The current performance of students in STEM subjects has not improved to the desired levels in South Africa. Previous research has demonstrated a strong correlation between the acquisition of mathematical knowledge and individuals' attitudes towards mathematics and physical sciences, as well as their emotional responses, such as experiencing maths/science fear. Over time, compelling empirical data has surfaced, demonstrating that maths/science anxiety has a substantial detrimental impact on mathematical and science ability. Remarkably, several studies have demonstrated that maths/science anxiety may be moderated through mechanisms with students' emotions. However, the suggested interventions have mostly concentrated on learners and teachers rather than pre-service teachers. Hence, there is a need for interventions to address math/science anxiety levels among pre-service teachers. The Self-Determination Theory underpin this study. This study employed action research to design cycles of whole class (n=29) intervention based on three tools designed by Johnson-Wilder and the mathematical network team and the emotional grid to support pre-service teachers in building resilience in math/science as they prepare for fieldwork. Data was analysed through thematic content analysis. The findings revealed that pre-service teachers have math/science anxiety and that maths/science anxiety had a substantial detrimental effect on their proficiency in mathematics/science, aligning with previous research. Furthermore, maths/science anxiety may be successfully reduced through the effective use of emotional tools. These findings suggest a new method of utilising the affective domain in teachers' training in South Africa for educational transformation.

Keywords: *Achievement, coaching, maths/sciences anxiety, pre-service teachers, resilience.*

1. Introduction

Education systems globally face the challenge of preparing future teachers to navigate the complexities of teaching mathematics and science effectively, particularly in contexts where anxiety towards these subjects among both learners and teachers persists (Fitriati et al., 2024; Wallace, 2015). In South Africa, as in many parts of the world, the effective teaching and learning of mathematics and science are crucial for the development of a skilled workforce and a scientifically literate society (Jojo, 2019; Lelliott, 2014). However, despite efforts to improve educational outcomes in these subjects, challenges persist, particularly regarding pre-service teachers' preparedness to teach mathematics and science effectively. One significant barrier to successful teaching and learning in these disciplines is the prevalence of math and science anxiety among both students and teachers (Griggs, et al., 2013; Megreya et al., 2021). In South Africa, where mathematics and science education outcomes have long been a concern (Reddy et al., 2020), addressing the anxiety levels associated with these subjects is paramount for enhancing teaching and learning experiences. Pre-service teacher education programs play a crucial role in shaping teachers' competencies and attitudes towards mathematics and science instruction. However, there is a need to ensure that these programs not only equip future teachers with subject knowledge but also foster resilience to confront challenges inherent in teaching these subjects.

Mathematics and science anxiety, characterized by feelings of fear, tension, and apprehension when engaging with mathematical and science concepts, can significantly impede academic performance and professional efficacy. Pre-service teachers who experience high levels of anxiety in mathematics and science may struggle to convey these subjects effectively in classrooms, perpetuating a cycle of anxiety and underachievement among students (Gresham, 2018).

Addressing math and science anxiety among pre-service teachers is therefore paramount for enhancing the quality of mathematics and science education in South African schools. Moreover, cultivating resilience in pre-service teachers can empower them to navigate the challenges associated with teaching these subjects, fostering confidence and effectiveness in the classroom. This study aims to investigate strategies for developing resilience among pre-service teachers while simultaneously addressing mathematics and science anxiety levels in South African schools. By exploring the intersection of resilience development and anxiety mitigation within the context of pre-service teacher education, this study seeks to contribute insights into effective pedagogical approaches and support mechanisms for preparing teachers to excel in teaching mathematics and science.

2. Literature review

2.1. Mathematics and science anxiety

Mathematics Anxiety (MA) is commonly characterised as a state of fear that hinders the ability to work with numbers and solve mathematical problems in many everyday and academic contexts (Richardson & Suinn, 1972). Literature on MA evaluates anxiety in math-related scenarios by employing hypothetical or retrospective inquiries. For instance, they inquire about the level of anxiety one might have in a certain math-related event. Alternatively, they measure anxiety specifically connected to the fear of failure in mathematics, such as how concerned one is while encountering difficulties in math. MA is a concern among students since it can have a detrimental effect on their academic achievement and general mindset towards the subject. Research has indicated that prospective primary school teachers generally demonstrate elevated levels of mathematical anxiety in comparison to pupils studying other subjects (Artemenko et al., 2021). Research supports the need for interventions to mitigate MA and enhance math achievement, particularly during childhood (Barroso et al., 2021).

On the other hand, Science Anxiety (SA), is a noteworthy issue among students that can have a detrimental effect on their academic achievements and entire state of being. SA is characterised by the experience of unpleasant emotions and fear specifically related to studying science courses (Megreya et al., 2021). SA can be influenced by multiple factors, such as self-efficacy in science, teaching methods employed in classrooms, and the general perception of science as a difficult discipline.

2.2. Building Mathematics and Science Resilience to reduce MA and SA

Mathematical resilience refers to the ability to sustain confidence and belief in one's mathematical abilities despite challenges or negative influences on one's mathematical well-being, as described by Johnston-Wilder and Lee (2010). Mathematical resilience (MR) refers to a mindset characterised by confidence and conviction in one's ability to solve challenging mathematical issues without any external assistance. Indicators of this include cognitive patterns, challenges, self-assurance, social support, positive outlook, resilience, and the ability to exercise self-discipline in challenging circumstances (Hakim & Murtafiah, 2020; Johnston-Wilder and Lee (2010).

In the context of science education, resilience refers to students' ability to recover from setbacks, persist in the face of challenges, and maintain a positive attitude towards learning science. Research indicates that implementing resilience-building strategies can assist students in managing SA and improving their academic performance (Elmi, 2020). One effective method to enhance science resilience is by integrating social-emotional learning strategies into science education (Elmi, 2020).

2.3. Theoretical frameworks

Self-determination theory (SDT) is a comprehensive theory of human development that specifically examines motivation, personality development, and well-being (Martela, 2020). According to SDT, human well-being is contingent upon the fulfilment of three fundamental psychological needs: autonomy, competence, and relatedness (Breitborde et al., 2014). The idea highlights the significance of providing autonomy support, promoting competence development, and nurturing relatedness to increase intrinsic motivation and overall well-being. SDT has been utilised in several fields, such as education, to examine motivation, conduct, and well-being. By applying SDT concepts, PSSTs may develop resilience as they help their learners develop a sense of independence and influence over their learning, which can help decrease anxiety and improve self-confidence in mathematics and science.

3. Methodology

The study employed a Participatory Action Research (PAR) approach to design a whole-class intervention (MacDonald, 2012). PAR allows for a high degree of participant engagement throughout the research process, promoting a sense of ownership and commitment among those involved (MacDonald,

2012). This study is an active collaboration of eight lecturers who teach Mathematics, Science and Technology. However, this paper reports on interventions at one rural university where the Growth Zone Model, the Hand Model of the brain and relaxation response model tools (Johnston-Wilder et al., 2021) were embedded into classroom practices to promote math and science resilience among third-year university students. In the first cycle of interventions, a series of training sessions which were embedded into their physical sciences teaching II curriculum were conducted for pre-service teachers focusing on resilience-building strategies and addressing anxiety in teaching mathematics and science. These sessions facilitate discussions and activities aimed at enhancing teaching effectiveness and confidence in the subject they will teach in the future. At the same time, during physics III, chemistry III, and mathematics III content lessons, the lecturers engaged in a series of interventions with the three tools as PSST learned physics, chemistry, and mathematics concepts. All the tools were provided to the students for engagement purposes.

Qualitative data was collected at the end of the first semester through focus group discussions and individual interviews. The qualitative data was analysed using thematic analysis as guided by Clarke and Braun's (2016) framework. Quality assurance measures were established by returning the captured responses to the participants for member checking.

4. Results

4.1. Biographical profile of respondents

The sample consists of nineteen males and ten females. All PSSTs are in their third year at the university, suggesting they have progressed through their academic program and are approaching the completion of their teacher education. While specific ages may vary, PSSTs in their third year at university typically range from their early twenties to mid-twenties, although there may be some variation due to individual circumstances. Each PSST brings unique strengths and qualities to the classroom, whether it be leadership abilities, subject matter expertise, creativity, or a passion for working with children and youth.

Theme 1: Motivation for learning complex concepts in math and science

When asked about their experiences and perspectives on the cycle of interventions, the participants were of the view that the tools helped alleviate their doubt and anxiety with mathematics and science as they prepared for teaching practices. As future teachers, PSSTs require a solid knowledge of mathematics and sciences, and a variety of good and effective mathematics and science teaching methods and practices to be able to influence their future students' learning and meet students' needs. Some participants narrated:

> *"I've struggled with anxiety in math and science for as long as I can remember. The Growth Zone Model has given me a framework to understand that it's okay to feel uncomfortable and that growth happens outside of my comfort zone. It's still a work in progress, but I'm seeing improvements in my confidence and performance* (PSST9).

> *First the first time in my life, I am no longer anxious when I have maths and science tests. I could not belief it when my lecturer announced test dates for Chemistry III and Mathematics III.* (PSST29).

> *Ah, indeed, the GZM has really helped me. I just move my pebbles to appropriate levels during lectures. When I am in my comfort zone, I begin to smile about myself and my achievements. I know within me that I can do this* (PSST18).

Theme 2: Cultivating a sense of confidence

When asked about their confidence in mathematics and science contents after the intervention, participants' responses indicated that the interventions have provided a starting point for their confidence in the subjects as they have developed knowledge of the subject with understanding, and they would be able to assist their future learners to develop confidence in mathematics and sciences as they have acquired knowledge and understanding of student resilience. Two PSSTs responded:

> *The interventions have improved my confidence in math/science. The thought of having "I can do maths" I can do chemistry" lingers in my mind each time the lecturers are teaching complex concepts. I keep saying this to myself to help me get through to each lesson. That has been helpful* (PSST1).

> *My confidence in mathematics, chemistry and physics has improved drastically. Quantum mechanics at the third-year level was very challenging. Now with the relaxation model, I can breathe in and breathe out as if I am releasing too much information out of my system so I can absorb more. But now I'm very confident in myself* (PSS4).

Incorporating mindfulness activities into math/science lessons helped students stay calm and focused on the task at hand. Techniques such as mindful breathing allowed them to approach math with a calm and centred mindset.

Theme 3: Personality development

This theme focuses on the personal development of PSSTs as they use these tools to build resilience. Participants responded:

> *"I've been amazed by the impact of incorporating coping strategies based on the Growth Zone Model, Hand Model of the Brain, and Relaxation Model in our lectures. I have been empowered to approach science and mathematics with a growth mindset, knowing that my abilities are not fixed and that they can improve with effort and perseverance. As a result, I have seen a noticeable reduction in my anxiety levels and a corresponding increase in my academic achievement* (PSST20).

> *The Growth Zone Model has been a game-changer for me in tackling my anxiety around math and science. By understanding that discomfort is a natural part of growth, I've been able to push through challenging concepts with more confidence. It's not about being perfect, but about progressing, and that mindset shift has made all the difference.*"(PSST15).

5. Discussions

Mathematics and science anxiety can be significant barriers to effective teaching and learning among PSSTs. These anxieties not only impact the teachers themselves but also have cascading effects on the confidence and achievement of their future students. To address this issue, it is essential to explore strategies that not only reduce anxiety but also cultivate resilience and motivation in PSSTs towards these subjects. I explored how integrating intervention strategies using the GZM, the Hand Model of the brain and the relaxation response model vis-a-vis informed by the SDT can help reduce mathematics and science anxiety among PSSTs while simultaneously building their resilience towards these subjects.

The SDT posits that when individual needs are satisfied, individuals experience greater intrinsic motivation, well-being, and optimal functioning. Applying the principles of SDT to the context of PSSTs facing mathematics and science anxiety offers a promising avenue for intervention which improves students' learning and reduces anxieties as they work towards building resilience.

The first theme focused on motivation to learn complex concepts in math and science. The study found that the participants were of the view that the tools helped alleviate their doubt and anxiety with mathematics and science as they studied complex concepts in the subjects. This finding is in line with the study by Barroso et al. (2021) who support the need for interventions to mitigate anxiety and enhance math/science achievement,

The second theme focused on cultivating a sense of confidence as they build resilience. The study found that the interventions provided a starting point for their confidence in the subjects as they have developed knowledge of the subject with understanding and would be able to assist their future learners to develop confidence in mathematics and science. Research supports students' emotional well-being and resilience in science education. Some of its indicators include thinking patterns, self-confidence, having support, optimism, perseverance, and being able to have self-control in difficult situations (Hakim & Murtafiah, 2020; Lee & Johnston-Wilder, 2017).

The third theme focused on participants' personality development. The findings show that implementing coping strategies based on the intervention models has been incredibly effective in helping PSSTs manage anxiety in science and mathematics. SDT highlights the significance of intrinsic motivation, autonomy, and competence in fostering positive outcomes in educational settings (Johnston-Wilder et al., 2021). By following a cycle of interventions, PSSTs can effectively integrate the Growth Zone Model, Hand Model of the Brain, and Relaxation Model into their teaching practice to reduce anxiety in science and mathematics topics and build resilience in these subjects.

6. Conclusion and recommendations

This study explores strategies to enhance resilience and reduce anxiety levels among PSSTs in mathematics and science within the context of South African schools. An important issue emphasised in the study is the significance of reducing anxiety levels among PSSTs in mathematics and science. Studies have demonstrated that anxiety may have a substantial effect on both the effectiveness of instruction and the academic achievements of students. Hence, it is important to implement interventions that target the reduction of anxiety levels and the enhancement of resilience in PSSTs to enhance educational practices and optimise student learning experiences.

Nonetheless, the study recommends integrating experiential learning methodologies into teacher training programmes and implementing mentoring programmes and support structures that can play a crucial role in fostering resilience and mitigating anxiety levels among PSSTs. Through the provision of experienced mentors, resources, and advice, PSSTs can receive the necessary assistance to effectively negotiate the difficulties associated with teaching and learning mathematics and science.

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