

**MATHEMATICS ANXIETY OF GRADE 11 LEARNERS IN TRIGONOMETRY
IN VHEMBE WEST DISTRICT, LIMPOPO PROVINCE**

by

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Mathematics Anxiety of Grade 11 Learners in Trigonometry in Vhembe West District, Limpopo Province

I declare that the above dissertation is my own work and that all the sources that I have used or quoted have been indicated and acknowledged by means of complete references.

I further declare that I submitted the dissertation to originality checking software and that it falls within the accepted requirements for originality.

I further declare that I have not previously submitted this work, or part of it, for examination at Unisa for another qualification or at any other higher education institution.

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Dedication

This thesis is dedicated to my son, Uakona Kharendwe Sivhada. With this I am planting a seed within you to develop quest and hunger for greater achievements in life. Walk in my footsteps, aim beyond the sky, strive for excellence and conquer the world. I believe in you, God bless.

Abstract

Mathematics anxiety is a significant problem to learners' academic performance and engagement, particularly in topics such as trigonometry. In grade 11 classrooms, these challenges are often intensified, yet limited research has examined factors influencing learners' experiences. This study explored mathematics anxiety among Grade 11 learners studying trigonometry, focusing on personal, environmental, and behavioral factors. Data were collected using a pragmatic paradigm and an exploratory sequential mixed-methods approach, (both qualitative and quantitative). The research involved 40 learners and two mathematics teachers from two schools. Data collection instruments included researcher-developed questionnaires, interviews, classroom observations, and a diagnostic test. Qualitative data were analyzed thematically, while quantitative data were processed using Microsoft Excel. Findings indicated that mathematics anxiety manifested through behavioral, emotional, and social responses such as fear, task avoidance, and low classroom participation. Key contributing factors included socio-emotional reactions, performance-related challenges, and teacher-centred instruction. However, strategies like learner-centred teaching, positive teacher-learner relationships, and supportive classroom environments were found to help reduce anxiety. The study recommends professional development for teachers and increased support from the Department of Basic Education to promote anxiety-reducing learning environments and improve learners' performance in mathematics.

Keywords: Mathematics anxiety, worry, Trigonometry, cognitive, environmental factors, behavioural factors, personal factors, pragmatism, mathematics teachers, Grade 11 learners

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Abbreviations and Acronyms

2D	Two-Dimensional
ARCS	Attention, Relevance, Confidence and Satisfaction
ATMI	Attitude Towards Mathematics Inventory
ATMI-Short Form	Attitudes Towards Mathematics Inventory Short Form
BAU	Business As Usual
BEd	Bachelor of Education
UNISA CEDU	UNISA College of Education
CAPS	Curriculum and Assessment Policy Statement
CG	Control Group
CPD	Continuing Professional Development
DBE	Department of Basic Education
ECDOE	Eastern Cape Department of Education
EG	Experimental Group
FET	Further Education and Training
FIQ	Family Involvement Questionnaire
GED	Gauteng Education Department
GLM	GeoGebra Learning Module
ICT	Information and Communications Technology
IMMS	Instructional Material Motivational Scale
JSSII	Junior Secondary School Two
LPDoE	Limpopo Province Department of Education
MAAS	Mathematics Activities Attitude Scale
MAI	Mathematics Anxiety Inventory
MARS	Mathematics Anxiety Rating Scale
MARS-A	Mathematics Anxiety Rating Scale for Adolescents
MARS-E	Mathematics Anxiety Rating Scale of Elementary Students
MARS-SV	Mathematics Anxiety Scale Short Version
MAS	Mathematics Anxiety Scale
MASESS	Mathematics Anxiety Scale for Elementary School Students
MAT	Mathematics Achievement Test
MMS	Mathematical Motivation Scale
MPT	Mathematics Performance Test
MSEA	Mathematics Self-Efficacy and Anxiety

MSEAQ	Mathematics Self-Efficacy and Anxiety Questionnaire
MSEO	Municipal Secondary Education Officer
MSES-R	Mindfulness-Based Self Efficacy Scale – Revised
MSLQ	Motivated Strategies for Learning Questionnaire
MST	Mathematics Success Test
MT	Mathematics Test
NSC	National Senior Certificate
PBL	Problem-Based Learning
Revised-FSMAS	Revised Fennema-Sherman Mathematics Anxiety Scale
RMARS	Revised version of the Mathematics Anxiety Rating Scale
SCT	Social Cognitive Theory
SEMA	Scale for Early Mathematics Anxiety
SES	Socio-Economic Status
SMAT	Students' Mathematics Achievement Test
SSII	Senior Secondary School Two
STAQ	Students' Trigonometry Attitude Questionnaire
STEM	Science, Technology, Engineering and Mathematics
SPSS	Statistical Package for the Social Sciences
T&L	Teaching and Learning
TASQ	Trigonometry Attitude Scale Questionnaire
TOMRA	Test of Mathematics-Related Attitude
TPT	Trigonometry Performance Test
TRT	Trigonometry Retention Test
UiTM Kedah	University in Bedong, Malaysia
WASSCE	West African Senior School Certification Examination

Chapter 1: Introduction

1.1 Background

Mathematics is necessary in every aspect of life, as numeracy skills are required to function successfully in everyday life (Gafoor & Kurukkan, 2015). It helps to develop mental processes that enhance logical and critical thinking, accuracy, and problem solving that will contribute to decision-making, as well as enabling learners to think creatively (DBE, 2011a). Mathematics encourages participation and success in many fields of study, particularly those in the fields of Science, Technology, Engineering, and Mathematics (STEM) (Ferguson et al., 2015). Thus, mathematics is an essential subject that every high school graduate should pass in order to pursue further studies at the tertiary level.

Within the Further Education and Training (FET) phase in South Africa, which includes Grades 10 to 12, mathematics is regarded as a key learning area (DBE, 2011a). Success in mathematics is critical for access to tertiary education, particularly in STEM disciplines. Trigonometry is one of the important topics in mathematics, and it contributes approximately 27% towards mathematics final examinations in Paper 2 (Department of Basic Education [DBE], 2011a). It integrates algebra, geometry, functions, and spatial reasoning, requiring learners to manipulate trigonometric ratios, graph trigonometric functions, work with identities, and apply angle measures in problem settings. These cognitive demands are high and often expose gaps in learners' prior knowledge. Reports indicate that learners struggle to attempt trigonometry questions in the National Senior Certificate (NSC) exams because of poor algebraic skills, lack of fundamental competencies, and gaps that can be traced back to Grades 8 and 9 (DBE, 2017; Eastern Cape Department of Education [ECDOE], 2019, 2020).

At the same time, learners' emotional and affective responses to mathematics, especially mathematics anxiety, have a substantial impact on performance. Mathematics anxiety is a negative emotion a person experiences when trying to solve a mathematical problem (Mutlu, 2019). It manifests as tension, fear, or worry that interferes with cognitive processing such as working memory, reduces confidence, and may lead to avoidance of challenging tasks or under-preparation. From my experience as a teacher, trigonometry is one of the mathematics topics that learners

do not like because of the perception that it is too difficult. For example, when they struggled with the topic. It was also observed that some learners were absent during tests, which may be interpreted as signals of mathematics anxiety.

South Africa's recent diagnostic reports provide context. According to the NSC Diagnostic Report (DBE, 2023), while the overall Mathematics pass rate improved from 55.0% in 2022 to 63.5% in 2023 at the 30% threshold (and from 36.0% to 43.6% at the 40% threshold), trigonometry questions (Questions 5, 6, 7) had significantly lower average scores ($\approx 40\%$, $\approx 30\%$, $\approx 20\%$, respectively) compared with other topics in Paper 2. The 2024 Diagnostic Report indicated a continued improvement in the overall Mathematics pass rate, with the percentage of learners passing at the 30% threshold increasing from 63.4% in 2023 to 69.1% in 2024, and those passing at the 40% level rising from 43.6% to 47.9%. However, trigonometry remained one of the poorest-performing areas, especially in non-routine questions. Similarly, the Universities South Africa report (2023) noted that learners often struggle with trigonometry when moving from high school to university, suggesting that gaps and anxiety around these topics are widespread.

Recent studies reveal that mathematics self-efficacy, which is closely related to anxiety, is strongly associated with learners' achievement among Grade 9 learners (Hannan et al., 2024). Other studies on Grade 11 learners suggest that moderate levels of anxiety correlate negatively with performance. Internationally, mathematics is considered one of the most difficult subjects due to its abstract nature and interconnected learning processes, where lack of understanding in earlier grades creates further difficulties later (Azizah & Suhendra, 2020; Haase et al., 2019). In trigonometry, learners often show procedural knowledge but lack conceptual understanding (Chigonga, 2016; May & Courtney, 2016). These trends suggest that while many learners are meeting minimum performance thresholds, performance in challenging topics remains weak, and affective barriers such as anxiety remain a concern.

1.2 Rationale of the Study

I identified learners who seemed to have experienced mathematics anxiety during my years of teaching. However, I was unaware of what was happening, as those learners were otherwise confident and engaged in other subjects. In mathematics, they would avoid mathematical problems, become extremely nervous and show an evident lack of self-belief in their abilities. According to Garcia et al. (2016), learners with low belief in themselves about learning mathematics tend to be more anxious about their learning and refrain from learning opportunities when they come up. Numerous research studies have been conducted on Mathematics anxiety, for example, Alanazi (2019), Anouti et al. (2018), Estonanto and Dio (2019), Hill et al. (2016), Kesici and Bindak (2019), Ramirez et al. (2016), Shishign (2018), Skagerlund et al. (2019), Yuliani et al. (2019), and Zhang et al. (2019). These studies focused on mathematics anxiety and its links with mathematics performance (Alanazi, 2019; Anouti et al., 2018; Hill et al., 2016; Skagerlund et al., 2019; Zhang et al., 2019). Some scholars focused on mathematics anxiety and its effect on mathematics achievement (Ramirez et al., 2016; Shishign, 2018).

There is persistent underperformance in trigonometry in NSC diagnostic reports from 2022 to 2024 (DBE, 2022, 2023, 2024). Trigonometry questions are often among the weakest performing in Paper 2 of Mathematics, particularly when questions require non-routine thinking, multiple steps, or conceptual reasoning. While diagnostic reports identify weaknesses in content knowledge, they do not usually quantify and deeply probe how learners' affective factors, such as anxiety, contribute to these outcomes. Research exists on mathematics anxiety in lower grades and in mathematics generally, but there is less focused research in South Africa on how it plays out in Grade 11 within a specific topic such as trigonometry, which is high stakes and demanding (Maphutha, Maoto & Mutodi, 2023). The concept of self-efficacy from Bandura's (1997) Social Cognitive Theory has been shown to mediate or moderate performance in mathematics. Given the links between anxiety and self-efficacy, targeting these might offer ways to improve results. Understanding the role of anxiety can help inform teacher training, learning support programmes, and the design of assessments and classroom practices that reduce negative emotional responses.

There is still a paucity of research on mathematics anxiety within the specific focus of this research. Those studies that do exist are inadequate to address issues such as signs of mathematics anxiety in Grade 11 learners when learning trigonometry; factors that contribute to anxiety in Grade 11 learners when learning trigonometry; and how the problem of anxiety in Grade 11 learners when learning trigonometry can be resolved for higher achievement. It was therefore the aim of this study to investigate how mathematics anxiety manifests in Grade 11 learners when learning trigonometry.

1.3 Statement of the Problem

Many studies have been published on factors contributing to the high failure rate in mathematics (Mabena et al., 2021; Sundai & Sheriff, 2015). Among the causes, mathematics anxiety appears to be a common problem, and it escalates in the secondary school when mathematics becomes more challenging. Evidence shows that mathematics anxiety significantly hampers the progress of learners in mathematics (Radišić et al., 2015). Existing studies suggest that the anxiety is partly caused by a negative attitude towards mathematics by learners, loss of interest in the subject, and low pass rate (Bekele & Yalew, 2023; Rajab & Motileng, 2024). There is limited research in the South African context regarding how teachers and their teaching methods contribute to mathematics anxiety.

Despite improvements in the overall NSC pass rates in 2023 for Mathematics Grade 12 (with the pass rate rising to 82.9%), the performance on trigonometry questions in Paper 2 remains significantly lower, particularly in non-routine items that require higher-order reasoning. Many Grade 11 learners continue to struggle with trigonometry content in the NSC curriculum. These struggles likely stem not only from cognitive and content gaps but also from affective factors, particularly mathematics anxiety, which may inhibit learning, reduce performance, and lead to avoidance behaviour. The confidence and competence which is a specific aim of the Curriculum and Assessment Policy Statement (CAPS) (DBE, 2011b) seem not to be realised for many learners in this content area. However, the current body of research in South Africa has not sufficiently examined the specific relationship between mathematics anxiety and performance in trigonometry among Grade 11 learners, nor how error types, prerequisite knowledge, teacher practices, and self-efficacy interact with anxiety in this context. The problem addressed in this study is that Grade 11 learners

in South Africa continue to demonstrate low achievement in trigonometry. Although mathematics anxiety may be associated with this pattern of performance, there is insufficient clarity regarding the nature, degree and underlying processes of its influence on learners' engagement and performance in this topic.

1.4 Aim of the Study and Objectives

The aim of this study was to investigate mathematics anxiety among Grade 11 learners studying trigonometry by identifying its signs, its causes, and measures that teachers use to curb or address it.

The study had three specific objectives:

- a) To identify signs of mathematics anxiety among Grade 11 learners learning trigonometry.
- b) To examine factors that contribute to mathematics anxiety.
- c) To determine measures that can help address or reduce mathematics anxiety in learning trigonometry.

1.5 Research Questions

The main research question was: How does mathematics anxiety manifest in Grade 11 learners when learning trigonometry?

To answer the main research question, the study addressed the following sub-research questions:

- a) What are signs of mathematics anxiety among Grade 11 learners when learning trigonometry?
- b) What factors contribute to mathematics anxiety when learning trigonometry?
- c) What measures can help address or reduce mathematics anxiety to promote higher achievement?

1.6 Theoretical Framework

To provide a conceptual lens for understanding the factors influencing learners' experiences and performance in trigonometry, this study draws on Albert Bandura's Social Cognitive Theory (SCT) (1986) as its theoretical framework which posits that learning is shaped by a triadic reciprocal interaction among personal factors,

environmental factors, and behavioural factors. In the context of mathematics anxiety in Grade 11 trigonometry, SCT helps clarify how these interact:

- Personal factors: Learners' self-efficacy in trigonometry (beliefs about their ability to perform trigonometric tasks), emotional states such as anxiety, prerequisite cognitive knowledge in algebra, geometry, and related areas.
- Environmental factors: Teacher support and feedback, classroom climate (whether mistakes are treated as punishable or as learning opportunities), assessment design (routine versus non-routine items), opportunities for scaffolding and modelling, peer interactions, and availability of resources.
- Behavioural factors: Learners' engagement with trigonometry, such as practice, avoidance, help-seeking, error correction, persistence, and risk-taking when solving difficult problems.

According to Bandura (1986), within this triadic reciprocal interaction, self-efficacy is central, and high self-efficacy tends to reduce anxiety, promote persistence, and encourage coping strategies; while low self-efficacy may increase anxiety, lead to avoidance, and poor performance. Emotional arousal (such as anxiety) can also reduce working memory capacity and impair problem solving. Observational learning (seeing others succeed) can strengthen self-efficacy, and social persuasion (encouragement from teachers or peers) also support it.

Reciprocal determinism suggests that feelings of anxiety can lead to avoidance behaviours and minimal effort, which result in poor performance, reinforcing the cycle of anxiety. However, with positive environmental factors such as supportive teaching and constructive feedback, this cycle can be disrupted.

Thus, SCT guided the analysis and interpretation of how mathematics anxiety, self-efficacy, prerequisite skills, error types, and instructional environment interact to influence learners' engagement, coping strategies, and performance trends in Grade 11 trigonometry.

1.7 Significance of the Study

This study is significant to learners, teachers and curriculum developers. The findings may motivate learners to overcome fear and become active participants in mathematics. Positive attitudes can help learners develop a sense of efficacy and confidence about their ability to perform well in mathematics. Once learners are

confident in their ability to succeed, they are more likely to persist in learning and recognise that mathematics is part of daily life, an indispensable tool for problem solving, and a subject worth engaging with rather than avoiding.

The findings may also help teachers to understand how mathematics anxiety is manifested and recognised in their classrooms on an individual basis. When teachers are aware of the forms of mathematics anxiety their learners experience, they can take steps to reduce it.

In addition, the study can contribute to raising awareness of mathematics anxiety in secondary school classrooms and promote support strategies for affected learners, leading to possible reductions in mathematics anxiety. The strategies identified for reducing mathematics anxiety may assist teachers in creating an atmosphere in which learners feel in control and confident about their ability to succeed. This will also help teachers to become more aware of anxiety-related behaviours and emotions and how to respond constructively.

Finally, the findings may assist curriculum designers in making the curriculum more responsive to learners' needs and concerns. A curriculum that allows learners to build mathematical concepts actively, based on prior knowledge, can reduce anxiety-provoking situations in mathematics classrooms. Moving towards a learner-centred and problem-centred curriculum design may also encourage formative assessment and diversity instructional methods.

1.8 Methodology

This section presents the research paradigm, research design and approach, sampling procedures, data collection instruments, data analysis techniques and ethical considerations employed in this study.

1.8.1 Research Paradigm

The study followed a pragmatism paradigm. This paradigm was chosen because I wanted to incorporate both qualitative and quantitative methods. Pragmatism is widely recognised as an appropriate philosophical foundation for mixed-methods research because it prioritises the research problem and supports the use of multiple methods to generate a comprehensive understanding of complex phenomena (Creswell & Plano Clark, 2018). Rather than adhering strictly to either positivist or constructivist assumptions, pragmatism allows the researcher to draw on both

objective and subjective perspectives, depending on what is most suitable for addressing the research questions.

Furthermore, scholars such as Tashakkori and Teddlie (2010) argue that pragmatism provides a practical and flexible framework for integrating qualitative and quantitative approaches within a single study. In the context of this research on mathematics anxiety in Grade 11 trigonometry, the pragmatist paradigm enabled the combination of quantitative measures (e.g., levels of anxiety and performance trends) with qualitative insights (e.g., learners' experiences and perceptions), thereby facilitating a more holistic understanding of the phenomenon under investigation.

1.8.2 Research Design

An exploratory sequential mixed-methods design was used in this study to guide data collection and interpretation. This design was used as the research tool adopted to generate data required for the participants to answer the stated questions. According to Creswell and Plano Clark (2018), this design involves an initial qualitative phase followed by a quantitative phase, where the latter is used to test, refine, or generalise the findings derived from the former. This design is particularly suitable when a phenomenon requires in-depth exploration before it can be measured systematically.

The selection of this design was informed by the complexity of mathematics anxiety and learners' experiences in trigonometry. The qualitative phase enabled an in-depth exploration of learners' perceptions, challenges, and coping strategies, while the subsequent quantitative phase facilitated the identification of patterns and relationships across a larger sample. As noted by Tashakkori and Teddlie (2010), such sequential designs enhance the validity of research findings by allowing one phase to inform the development of the next.

Therefore, the exploratory sequential mixed-methods design provided a systematic and theoretically grounded framework for generating and analysing data, ensuring that the study effectively addressed the stated research questions.

1.8.3 Sampling

Aspects relating to sampling are discussed briefly in the methodology chapter, including the criteria for participation in the study. Purposive sampling was used to select participants from the two classrooms (one classroom per school) consisting of 20 Grade 11 mathematics learners and their mathematics teachers from two selected secondary schools (one educator per school). The schools were approximately 2 kilometres apart. The participants were chosen on the basis that they were Grade 11 mathematics learners, as the study aimed to explore mathematics anxiety among Grade 11 trigonometry learners. Grade 11 teachers were included because they teach mathematics, including trigonometry, and have observed and taught the Grade 11 learners.

1.8.4 Data Collection Instruments

This study used semi-structured interviews, questionnaires, classroom observation and test questions. The use of multiple instruments is consistent with mixed-methods research, as it facilitates triangulation and enhances the credibility and comprehensiveness of findings (Creswell & Plano Clark, 2018).

Semi-structured interviews were utilised to collect in-depth qualitative data regarding learners' experiences, perceptions, and coping strategies related to mathematics anxiety in trigonometry. This approach allows for flexibility in probing participants' responses while maintaining a consistent line of inquiry across interviews (Cohen, Manion, & Morrison, 2018).

Questionnaires were used to obtain quantitative data on learners' levels of mathematics anxiety, self-efficacy, and attitudes towards trigonometry. Their structured format enables efficient data collection from a larger sample and supports statistical analysis of relationships among variables (Creswell & Plano Clark, 2018).

Classroom observations were conducted to capture real-time instructional practices, classroom climate, and learners' behavioural responses, such as engagement or avoidance during trigonometry lessons. Observational data provide contextual insights that complement self-reported data and help to validate findings (Denscombe, 2014).

In addition, the diagnostic test was administered to assess learners' conceptual understanding and performance in trigonometry. This assessment enabled the

identification of common error patterns and allowed for the examination of the relationship between learners' performance, anxiety levels, and self-efficacy.

The integration of these instruments ensured a comprehensive and nuanced understanding of the research problem by capturing multiple dimensions of learners' experiences and outcomes.

1.8.5 Credibility and Trustworthiness (Validity and Reliability)

It is very important that a research study be credible and trustworthy and that the readers should be able to believe and trust the information that will be reported. To ensure credibility and trustworthiness, the study used transferability, dependability and confirmability.

1.8.6 Data Analysis

In this study, two types of data were analysed, that is, qualitative and quantitative data. Qualitative data—collected using questionnaires, semi-structured interviews and classroom observations—were analysed using the thematic analysis method. Quantitative data were analysed by Microsoft Excel.

1.8.7 Ethical Considerations

I was ethically responsible for protecting the welfare of schools and learners by ensuring confidentiality of participants' identity and privacy. A consent form was required from parents of minors who were interviewed as part of the data collection process. Ethical clearance included obtaining authorization from the Limpopo Department of Education (LPDoE) to conduct the study in selected schools. Schools were informed about the legal aspects of the study, and how it aimed to improve the quality of trigonometry learning in Grade 11 Mathematics.

1.9 Definition of Term

Mathematics anxiety: This refers to a sense of excessive frustration or helplessness regarding one's ability to do mathematics, and it is an emotional response to engaging with arithmetic (Kumari, 2015).

1.10 Summary of Chapter

As the introductory chapter of the thesis, this chapter presented the background of the study, as well as its research aims and design. The remainder of the thesis is structured so that each chapter focuses on a specific dimension of the research

process. An overview of the literature on mathematics anxiety among Grade 11 learners in trigonometry is provided in Chapter 2. Hereafter, a detailed report of the research design and methodology is contained in Chapter 3. The findings from the data collection process, as well as a discussion of the research findings, is presented in Chapter 4. Chapter 5 contains concluding remarks on the research findings, recommendations for both learners and teachers in mathematics. limitations and strengths of the study; and suggestions for future research.

Chapter 2

Literature Review and Theoretical Framework

2.1 The Phenomenon of Mathematics Anxiety

By definition, the term anxiety describes a feeling of unease about something, especially that which will likely have an uncertain outcome (Oxford Learner's Dictionaries, 2023). Therefore, mathematics anxiety is described as unease or a negative feeling or reaction towards performing the subject (Dossel, 2016). Although this phenomenon is commonly reported in learners that perform poorly in mathematics, it equally affects adults in homes, at work, and at universities. With regard to learners, this anxiety may be caused by fear of mathematics or a history of poor performance in mathematics. Overall, mathematics anxiety has negative consequences on a learner's in-class performance and as well as their future career choices (Maloney et al., 2013).

2.2 Factors Contributing to Mathematics Anxiety

This section presents factors that contribute to mathematics anxiety among learners:

2.2.1 Personal Factors

The connection between mathematics anxiety and various personal factors, such as self-efficacy, emotional factors, motivation, confidence, and attitude, significantly impacts the academic achievements of students, especially in the subject. In this section, I provide an in-depth review of how these factors are associated with mathematics anxiety, and how each determines the overall mathematics proficiency of students.

2.2.1.1 Self-Efficacy and Mathematics Anxiety

Self-efficacy is a concept that has been defined by various scholars; however, Bandura (1986) refers to it as individuals' perceptions of their abilities to organise and execute the actions necessary to attain specific performances. Findings generated through educational research reveal that, in most cases, secondary school learners tend to exhibit a low level of mathematics self-efficacy and high levels of mathematics anxiety. The inverse relationship shown between efficacy and anxiety of students studying mathematics can mean that self-efficacy stems from their self-belief in their mathematics competence.

Amiruddin et al. (2022) carried out a quantitative study in the Philippines to examine the mathematics-related self-efficacy and anxiety levels of 138 Form 1 to Form 4 learners enrolled in open and distance learning programmes. Data were collected through mathematics experience questionnaire, mathematics self-efficacy questionnaire, and anxiety questionnaire, and were analysed using a Statistical Package for the Social Sciences (SPSS). The findings indicated that learners had moderate levels of anxiety and a moderate level of self-efficacy. Interestingly, the findings also revealed variations in self-efficacy across different levels of study, whereas such a trend was not observed in anxiety levels. This suggests that self-efficacy fluctuates as students' progress from lower to higher levels of study. Additionally, the study indicated that exposure to more mathematics classes or instruction from multiple mathematics teachers might alter these self-efficacy and anxiety patterns.

Supporting this perspective, Riboroso et al. (2018) investigated mathematics self-efficacy, anxiety, and mathematics performance of the 354 elementary education students—131 second year, 102 third year and 121 fourth year students—enrolled at the University of Northern Philippines during the first semester of the 2015-2016 school year. The study utilised the descriptive correlational design. Data were collected through mathematics experience questionnaire and the Mathematics Self-Efficacy and Anxiety Questionnaire (MSEAQ). The results showed that students experienced average self-efficacy and moderate anxiety.

2.2.1.2 Emotional Factors and Mathematics Anxiety:

Mathematics students experience self-efficacy and anxiety as they engage in mathematics exercises or participate in mathematics activities, and undergo assessments. Notably, efficacy and anxiety associated with mathematical emotions differ among low-achieving and high-achieving learners. Those facing challenges in mathematics often exhibit negative emotions, attributed to a pervasive sense of negativity towards the subject (Namkung et al., 2019).

In a comprehensive review conducted by Schukajlow et al. (2017), they examined published literature focusing on theoretical approaches and empirical findings related to mathematics students' emotions and motivation. The authors highlighted that emotional reactions and negative feelings towards mathematics may lead some

learners to perceive the subject as unimportant, undermining their emotional investment and efforts. Moreover, the review emphasised that when students experience anxiety and enjoyment in relation to mathematics, it creates a stark contrast in emotions—anxiety being a negative and unpleasant response, and enjoyment representing a positive and pleasurable emotion.

Expanding on this, Pekrun (2006) interpreted the control-value theory of achievement emotions and outlining its implications for educational research and classroom practice. He argues that learners' positive and negative emotional experiences have profound effects on their learning processes and performance outcomes. Understanding the intricate interplay between emotions, self-efficacy, and academic achievement is crucial for developing effective mathematics education strategies.

2.2.1.3 Motivation and Mathematics Anxiety

The motivation of learners is one of the crucial factors determining their performance in most subjects, including mathematics. Additionally, it has a direct impact on mathematics anxiety. Chirimbana et al. (2022) examined the factors contributing to poor problem-solving skills among Grade 8 mathematics learners in three combined schools within the Ongha Circuit of the Ohangwena Region in Northern Namibia. Employing a qualitative case study design, the researchers focused on a population of 19 Grade 8 mathematics teachers, from which a purposive sample of six teachers was selected. Data were gathered through semi-structured interviews guided by an interview schedule. The findings revealed that insufficient motivation and limited support undermined learners' confidence when approaching mathematical problems. Furthermore, the study showed that learners who received educational and psychological support demonstrated stronger problem-solving performance compared with those who lacked such support.

Studies (e.g. Adao et al., 2015; Akbar, 2015; Suren & Kandemir, 2020; Suren & Kandemir, 2015) have shown an interesting relationship between learner motivation and mathematics anxiety and, in the main, the findings seem to be largely contrasting. It is important that motivation in mathematics is influenced by other role players and/or factors. These factors include the emotional influences of parents, friends, society, and teachers. For example, (Li, Cho, Cosso & Maeda, 2021) meta-analysis examined the association between K-12 students' motivation to learn

mathematics and mathematics anxiety, including different motivation measures, dimensions of mathematics anxiety, students' developmental stages, and cultural contexts. It was conducted with 73 articles and a total of 142 effect sizes. The results indicated a moderate, negative correlation between students' motivation for mathematics and mathematics anxiety. Among their major findings, the authors showed a direct link between learners' motivational beliefs and their mathematical anxiety.

Another study, conducted by Sumantri and Whardani (2017), examined the relationship between achievement motivation and professional competence in public elementary schools in Central Java. The study used a quantitative correlation method. The population was composed of elementary school teachers in Bekasi, West Java. The samples of the study were drawn from the three elementary schools in cluster 2 and resulted in a total of 250 respondents. Data were collected through questionnaires on achievement motivation techniques, professional competence and the job performance of teachers. The results, obtained through a quantitative method, revealed that elementary school teachers exhibited a significant relationship between achievement motivation and their work performance. This suggests that higher levels of achievement motivation are closely associated with improved professional practice, reinforcing the importance of motivational factors in enhancing teacher effectiveness. Despite some studies showing a moderate correlation between learners' motivation and mathematics anxiety, most studies indicate a negative correlation (Ali & Hassan, 2019; Li et al., 2021; Malik & Manaf, 2018; Tella et al., 2007)

Suren and Kandemir (2020) examined the extent to which motivation and anxiety influence students' mathematics achievement from middle school through high school. Their study involved a sample of 777 eighth-grade learners from a province in the Aegean region of Turkey. Data were gathered using several instruments, including the Mathematical Motivation Scale (MMS) and the Mathematics Anxiety Scale for Elementary School Students (MASESS). The researchers used these measures to determine the relationship between students' levels of motivation, their anxiety, and their overall mathematics performance.

According to Tella et al. (2007), learners who achieve high marks in mathematics tend to be less anxious than those who do not. However, the opposite is true for mathematics learners who score lower in the subject. Furthermore, the author found mathematics anxiety significantly affected motivation. These findings are not surprising since scholarly studies (Adao et al., 2015; Akbar, 2015; Suren & Kandemir, 2020) have demonstrated that mathematics anxiety is strongly correlated with motivation. Consequently, students who show a greater degree of mathematics anxiety tend to be less motivated in the subject.

Wang et al. (2015) sought to address the limited focus on the complex interaction between emotion and cognition within mathematics learning research by examining the relationships among mathematics anxiety, motivation, and cognitive performance. Their study drew on two samples: one comprising 262 pairs of adolescent twins and another consisting of 237 adult college students. Data were collected using the Mathematics Anxiety Rating Scale for Elementary Students (MARS-E) alongside additional questionnaires. The findings showed a negative relationship between mathematics anxiety and mathematics performance, whereas mathematics motivation was positively associated with performance.

The study by Ali and Hassan (2019) identified differences in mathematics anxiety and mathematics motivation based on gender, and also investigated the relationship between mathematics anxiety and mathematics motivation among students in the Faculty of Science of a public university in Malaysia. The sample consisted of 104 (23 males and 81 females) undergraduate students in the Faculty of Science. Mathematics anxiety level and mathematics motivation were measured by Mathematics Anxiety Rating Scale (MARS) and Motivated Strategies for Learning Questionnaire (MSLQ). The results showed a significant moderate correlation between mathematics anxiety and mathematics motivation. The results also revealed that there were significant gender differences between male and female in mathematics anxiety and mathematics motivation.

To summarise, motivation and mathematics anxiety play a complex and multifaceted role in academic performance. In spite of the fact that some studies indicate a moderate correlation between motivation and mathematics anxiety, the prevailing trend suggests a negative correlation. External support, societal influences, and

gender dynamics also contribute to this intricate relationship, which ultimately influences students' experiences and outcomes in mathematics.

2.2.1.4 Confidence and Mathematics Anxiety

Confidence primarily revolves around self-confidence and is described as a feeling of trust an individual places in their own abilities (Psychology Dictionary Online, 2018). In the context of this study, confidence relates to a mathematics learner's capacity to carry out their academic activities. Self-confidence plays a significant role throughout a learner's academic journey because it is concerned with their ability to overcome challenges and achieve passing grades (Welford, 2013). In a study conducted by Irhamna et al. (2020), an analysis involving 235 junior high schools in the Kuala Simpang City Sub-district in the province of Aceh, Indonesia, aimed to explore the simultaneous impact of anxiety, learning motivation, and self-confidence on students' ability to solve mathematical problems. The study also assessed the extent to which mathematics anxiety, learning motivation, and self-confidence individually contributed to partial mathematical problem-solving abilities. The data were collected ex-post facto from a sample of 235 students who were all in junior high schools in Kuala Simpang City Sub-District. The population of the study were all students of class IX in Kuala Simpang City Sub-District, consisting of two state junior high schools and two state private junior high schools, totalling 570 students. Quantitative data were obtained through tests of mathematical problem-solving abilities, questionnaires on mathematical anxiety, learning motivation, and self-confidence. The findings revealed several significant aspects: (1) Mathematics anxiety, learning motivation, and self-confidence collectively contributed to the ability to solve mathematical problems simultaneously; (2) These factors also played a role in the partial ability to solve mathematical problems; (3) Together, mathematical anxiety, learning motivation, and self-confidence accounted for 26% of the variance in the ability to solve mathematical problems simultaneously; (4) Breaking it down further, mathematical anxiety contributed 8.5%, learning motivation contributed 15.8%, and self-confidence contributed 16.7% to mathematical problem-solving abilities.

Arslan (2020) examined the relationship between test anxiety and mathematics anxiety and to determine whether certain variables influenced differences in test anxiety and mathematics anxiety scores among 5th, 6th, 7th, and 8th grade students. The study was conducted with 337 students in two middle schools in Istanbul, selected through a random sampling method during the 2016-2017 academic year. The data were collected using the Test Anxiety Scale for Children, the Mathematical Anxiety Scale and a personal information form. Results showed that the average of middle school students' mathematics anxiety and test anxiety scores increased according to grade level but were unchanged according to gender. At the same time, there was a positive relationship between students' mathematics anxiety and test anxiety.

2.2.1.5 Attitude, Mathematics Performance and Mathematics Anxiety

Attitude, defined as the reflection of one's thoughts and feelings towards a specific subject or topic (Eagly and Chaiken, 1993), is an important aspect explored in this study, particularly in its connection to performance and anxiety in mathematics. Human nature allows individuals to develop either negative or positive attitudes towards various aspects of life. Syyeda (2016) conducted a multi-modal case study to investigate the attitudes of 11- and 15-year students towards mathematics in East Midlands, England. The aim of the study was to understand students' emotions, perceptions, beliefs and vision about mathematics, and also to investigate the factors which influence their attitudes. The study used focus group interviews, a closed (Likert scale) questionnaire, an open-ended questionnaire, and pictures drawn by participants. The study collected data related to aural or spoken information, scale-based data, textual or written data, and visual data. The results revealed a mixture of positive and negative attitudes. Despite most students acknowledging the importance of mathematics, a significant number showed negative emotions and aversion towards the subject. Attitudes were associated with gender and achievement level, with boys and high-ability learners generally having more positive attitudes. The relationship between positive attitudes and high achievement, however, remains unclear. Learners of low ability expressed a desire to learn, but had a low self-concept, which required constant motivation. Girls, even those in high-ability groups, expressed uncertainty and a lack of confidence in their abilities in mathematics. Furthermore, the study explored the effects of age, socioeconomic status, and

linguistic background on attitudes. While attitudes were not significantly influenced by age, differences were observed based on socioeconomic status and linguistic background. The attitudes of students from well-off families and those with bilingual or multilingual backgrounds were more positive.

Of concern is the prevalence of negative attitudes towards mathematics subjects by learners, which has been shown to have a direct and positive link with a low pass rate as well as mathematics anxiety. For instance, a study by Haciomeroglu (2017) examined the reciprocal relationship between anxiety and attitude towards mathematics in elementary students. Using two standardised measures: Attitudes Towards Mathematics Inventory Short Form (ATMI-Short Form) and the Revised Fennema-Sherman Mathematics Anxiety Scale (Revised-FSMAS), the study gathered data from 310 fourth-grade elementary students in three elementary public schools in Northwest part of Turkey. The findings indicated that elementary students had a higher level of positive attitude towards mathematics in comparison to their mathematics anxiety level.

Ngussa and Mbuti (2017) employed a case study exploring how the use of humour as a pedagogical strategy affects secondary school learners' attitudes and their academic performance Arusha City, Tanzania. The study involved 412 Form 3 students and used questionnaires to collect data. Their findings indicated that increased incorporation of humour in mathematics instruction was associated with more positive student attitudes and improved mathematics achievement. Clearly, the study by Haciomeroglu (2017) and other scholarly studies (Dowker & Sheridan, 2022; Mutengi et al., 2021) demonstrated reciprocal relationship between students' attitude and their performance in mathematics, where positive attitude tends to correlate with better achievement, while a negative attitude often leads to poorer outcomes.

Akin and Kurbanoglu (2011) investigated the associations among mathematics anxiety, attitudes toward mathematics, and self-efficacy in a sample of 372 university students enrolled in Sakarya University, in Turkey. Using the Revised Mathematics Anxiety Rating Scale, the Mathematics Attitudes Scale, and the Self Efficacy Scale, the researchers found that mathematics anxiety was negatively associated with positive attitudes and self-efficacy, but positively associated with negative attitudes. Their analysis also showed that positive attitudes toward mathematics were positively

related to self-efficacy and inversely related to negative attitudes. Moreover, self-efficacy was a positive predictor of positive attitudes and negative predictor of negative attitudes. Both self-efficacy and positive attitudes predicted lower levels of mathematics anxiety, whereas negative attitudes predicted higher anxiety. In summary, this body of research emphasises the interconnection between attitudes and mathematics performance. It highlights the need to address negative attitudes to improve students' performance.

2.2.1.6 Mathematics Performance and Anxiety

It can be said that, in general, the performance of learners in mathematics is determined by their attitude and extent to which they can be affected by mathematics anxiety. Both these factors are interconnected. Samante and Alave (2021) investigated the levels of mathematics anxiety and mathematics performance among Grade 4 learners, employing a descriptive–correlational research design to examine the relationship between these variables. The study involved Grade 4 pupils from a public elementary school in the Division of Bacolod City, Philippines. Data were collected through a standardised 12-item mathematics anxiety questionnaire. Findings indicated a significant relationship between pupils' levels of mathematics anxiety and their mathematics performance when grouped according to sex and class section.

Mutengi et al. (2021) employed correlational research design to assess the relationship between mathematics anxiety, attitude, and performance of secondary school students studying mathematics. The study involved 367 students from 55 public secondary schools in Kenya were selected to take part in the study. Data were collected through Mathematics Anxiety Scale (MAS) and Attitude towards Mathematics Inventory (ATMI). Results indicated a significant relationship between mathematics anxiety and mathematics attitude. Specifically, mathematics anxiety was classified as low, moderate, or high, while attitude towards mathematics was categorised as either positive or negative. The interconnection between the anxiety and attitude associated with the subject suggests that a negative attitude towards mathematics correlates with high mathematics anxiety, while a positive attitude towards mathematics correlates with moderate or low mathematics anxiety. The attitude portrayed by learners towards a subject can have a significant effect on their

performance outcomes in that particular subject. With regard to attitude and anxiety associated with mathematics, the latter has a significant impact on learners' performance. It has been shown that learners who exhibit anxiety towards mathematics actively avoid mathematical lessons, which results in an overall decline in their performance (Buckley et al., 2016).

Marianne et al. (2016) determined the relationship between the level of mathematics anxiety and the academic performance of the students at the Naval State University in the Philippines. The study employed descriptive research design. The data were gathered through a questionnaire administered to 200 student participants. The findings revealed no significant relationship between the level of mathematics anxiety of the students and their age profile, high school mathematics grades, teaching approaches used by teachers, their performance in mathematics and the family's monthly income. However, a study conducted by Buckley et al. (2016) found that mathematics anxiety tended to discourage learners from attempting to practise problem-solving in mathematics lessons, ultimately leading to poor performance. In summary, this body of research highlights the interconnection between mathematics anxiety and mathematics performance. It emphasises the need to address negative attitudes to improve students' performance.

2.2.1.7 Mathematics Attitude and Anxiety in Specific Topics

In their study, Awang et al. (2013) showed that the attitudes of students taking science subjects such as mathematics were related to how they solved problems, accessed ideas, and made right decisions. The authors used the Test of Mathematics Related Attitude (TOMRA) to determine the attitudes of students across four criteria: normality of mathematics, attitudes towards mathematics inquiry, adoption of a mathematics attitude, and enjoyment of mathematics lessons. The study involved computer science and quantitative science students who enrolled in a Calculus course at the University in Bedong, Malaysia (UiTM Kedah). Findings showed two criteria that influenced students' attitude towards mathematics, namely, normality of mathematics, which had 11 sub-criteria, and enjoyment of mathematics, with eight sub-criteria.

Using analytical and descriptive research design, Chama et al. (2023) adopted a questionnaire to examine whether the perceptions and attitudes of 400 learners

affected their learning of calculus in senior secondary school in the Northern Province in Zambia. Of the participant learners, the majority perceived calculus to be an important subject as it encouraged them to think deeply; thus, improving their ability to make daily life decisions. Consequently, they had a positive perception of calculus and an equally positive attitude towards it. On the other hand, Estonanto and Dio (2019) used a mixed method approach and qualitative techniques to investigate factors that caused students to experience mathematics anxiety in calculus from five sampled senior high schools in a province of Southern Luzon, Philippines. Sixty-nine participants completed the Mathematics Anxiety Inventory (MAI). The results revealed that almost all of the participants showed either high or moderate levels of mathematics anxiety.

Simbulas et al. (2023) investigated how online teaching competencies and attitudes toward mathematics influence the academic achievement of Grade 10 geometry students in Davao City, Philippines. The study also sought to determine the most appropriate model for explaining achievement in geometry. Participants were private school learners, and data were collected using questionnaires. Utilizing a quantitative, descriptive–correlational design, the researchers found that students exhibited high levels of online teaching competencies, moderately high attitudes toward mathematics, and low academic achievement in geometry.

In another study, aimed at evaluating how anxious students felt about geometry during their final three years of high school, Mamiala et al. (2021) adopted a mixed method approach following the convergent parallel sequential design with data collected using the Johnsons' Geometry Students Self-Efficacy questionnaire with open-ended questions from 390 Grade 10-12 mathematics students in Mpumalanga and North West provinces of South Africa. The results revealed that students were worried and concerned about their poor performance in geometry—more than half (61%) of them felt inadequate with regard to geometry, and 71% indicated that they were worried that they might give a wrong answer when asked questions.

Kagenyi (2016) examined the pedagogical factors influencing mathematics learning in secondary schools in Gatundu North District, Kiambu County, Kenya. The study employed a descriptive survey design, using multiple data collection instruments, including questionnaires for mathematics teachers and students, interviews with

heads of mathematics departments, and the Flanders Interaction Analysis Categories. The findings revealed that learners generally exhibited negative attitudes toward mathematics; many showed only moderate interest in trigonometry, while others expressed no interest at all. Trigonometry was widely perceived as a difficult topic, which in turn adversely affected learners' motivation to learn. Makofane and Maile (2019) investigated whether anxiety is a determinant of poor performance in Grade 12 Mathematics from Bohlabela cluster in Sekhukhune district of Limpopo province, South Africa. Through the use of a qualitative research approach, the authors concluded that trigonometry ranked among the topics that caused fear in learners, largely due to lack of resources.

In another related study, Chigonga (2016) sought to find out the problematic concept(s) and errors that learners had in solving trigonometry equations in Malamulele West Circuit schools in Limpopo province, South Africa. Data were gleaned using an open-ended questionnaire and interviews with 10 Grade 12 Mathematics teachers. The study found that the learners committed errors in solving trigonometric equations and teachers had difficulties in teaching the same content. It was found that many schools did not have appropriate teaching and assessment time for topics such as trigonometry. As a result, learners had an irrational fear of trigonometry (e.g. trigonometric equations) and did not regard it as a favourite topic. In summary, this body of research emphasises the interconnection between mathematics anxiety and different topics in mathematics. It stresses the need to address negative attitudes to improve students' performance in different mathematics topics.

2.2.1.8 Influence of Attitudes on Mathematics Anxiety

Soni and Kumari (2017) examined the antecedents and outcomes of mathematics anxiety and attitudes toward mathematics among students in Southwest Punjab, India. The study involved 595 students aged 10 to 15 years (grades 5–10) and one parent (mother or father) of each student. Mathematics anxiety in both students and their parents was assessed using the Mathematics Anxiety Scale Short Version (MARS-SV), the Mathematics Anxiety Scale for Elementary School Students (MARS-E), and the Mathematics Anxiety Rating Scale for Adolescents (MARS-A). The findings revealed that parents' mathematics anxiety and attitudes served as

predictors of their children's mathematics anxiety and attitudes, which, in turn, affected the students' mathematics achievement.

As already detailed in the dissertation, Mutengi et al. (2021) found that learners with negative attitudes toward mathematics tended to experience higher levels of mathematics anxiety, whereas those with positive attitudes exhibited low to moderate anxiety levels.

Similarly, the study by Haciomeroglu (2017) (which has already been discussed in Section 2.2.1.5) also demonstrated that a positive attitude towards mathematics predicted a lower level of anxiety. Therefore, there was a significant relationship between anxiety and attitude towards mathematics.

Many studies (Dowker & Sheridan, 2022; Haciomeroglu, 2017; Mutengi et al. 2021) have also found a correlation between mathematics anxiety and other negative attitudes towards mathematics, which are associated with poorer performance in mathematics. Zhang et al. (2019) explored whether mathematics anxiety and mathematics performance were linked. The study used a literature search for studies on mathematics anxiety and mathematics performance from January 2000 to December 2018 using electronic databases that explored the mathematics anxiety-performance link. Their results indicated a robust negative mathematics anxiety-performance link. On the other hand, Abín et al. (2020) examined how cognitive, motivational, and emotional factors predict mathematics achievement in high school students, taking into account gender and age. The study involved a large sample of 2,365 Spanish students aged 12 to 16 years. The findings indicated differences in achievement across gender and grade levels. Contrary to expectations, motivational and affective factors, such as anxiety and negative attitudes, appeared to have a limited role in predicting performance. Nevertheless, the study underscores the reciprocal relationship between mathematics anxiety and achievement, highlighting the importance of addressing negative attitudes to enhance student performance.

2.2.2 Environmental Factors

The experience that is reported and/or associated with environmental factors occurs due to the influence of external parties (Maloney et al., 2015). In particular, learners that perform well are those that do not experience pressure from friends, parents, family members, peers, teachers and instructional practices, teaching and learning

resources, and the socioeconomic status of learners (Hoferichter et al., 2021). With regard to the influence of parents, they often compare the achievements of their children to those of other children, which is one of the reasons why learners feel burdened and worried, especially when their results are not as good. All the mentioned environmental factors play a significant role in the teaching and learning of trigonometry.

2.2.2.1 Role of Friends or Colleagues and Mathematics Anxiety

Students' mathematics performance is significantly influenced by their friends and classmates, who can either exacerbate or alleviate mathematics anxiety. The perceived value that peers place on academic achievements in mathematics plays a crucial role in determining the impact of mathematics anxiety on students. Garba et al. (2020) explored the influence of peers on mathematics anxiety among secondary school students in Sokoto State, Nigeria, using a photovoice approach. The study involved twenty students identified with high mathematics anxiety. The data were gathered from the interviews and photos. The study revealed that negative peer behaviour, such as disruptive actions by poor-performing students and the dominance of intelligent students in the classroom, as well as negative speech—including frightening and discouraging statements—directly intensified mathematics anxiety. Conversely, positive peer behaviours, such as the achievement of peers and engaging in group discussions, along with positive speech and advice, were found to minimise mathematics anxiety among students.

Similarly, Moliner and Alegre (2020), examined the effects of peer tutoring on mathematics anxiety among 420 middle school students in Grades 7–9. Employing quantitative design and MAS to collect data. The findings indicated that peer tutoring reduced mathematics anxiety, regardless of students' gender or grade. Additionally, a negative relationship was found between peer influence and mathematics achievement and the relationship between peer influence and learner engagement.

Bakar et al. (2021) investigated the relationships among student achievement, engagement, parental involvement, and peer influence in mathematics learning. The study collected data from 284 undergraduate students enrolled at a private university in Malaysia using questionnaires as the primary data collection tool. The findings revealed a negative relationship between increased peer influence and deteriorating

mathematics achievement and learner engagement. Roberts and Spangenberg (2020) conducted a study whose purpose was to report on Grade 12 peer tutors' views on their role in motivating Grade 8 and 9 learners to learn mathematics in Gauteng Province of South Africa. From a population of 15 Grade 12 tutors, 10 peer tutors (six female and four male participants) were purposively selected to participate in the study. The study followed a qualitative approach through which pre- and post-interviews were used to collect data. The findings showed that peer tutors understood their role to motivate Grade 8 and Grade 9 learners to learn mathematics. In summary, the research points to a correlation between mathematics anxiety and peer influence. It emphasises the necessity to address negative peer behaviours and speech that can worsen mathematics anxiety among students. It also highlights the positive impact of peer achievements, group discussions, and positive advice that can alleviate mathematics anxiety among students.

2.2.2.2 Role of Parents (Family Members) and Mathematics Anxiety

Education ideally starts at home, but for children with uneducated parents or guardians, this is not the case. Munje and Mncube (2018) conducted a qualitative study to examine the role of parental involvement in learners' education, educators' perspectives on parental non-involvement, factors contributing to disengagement, and the impact of parental absence on learner experiences and performance in a disadvantaged community within the Metro South Education District in Cape Town, South Africa. Data were collected through individual and focus group interviews, involving three principals and twelve teachers. The findings indicated that many parents were not fully aware of why their involvement in their children's schooling was necessary.

Chirimba et al.'s (2022) as previously discussed, also highlighted that lack of parental involvement in children's education, alongside factors such as language problems, lack of resources, lack of mathematical pedagogical knowledge, lack of motivation and support, and lack of training and workshops, contributed to poor mathematical problem-solving skills. Parental involvement is crucial in academic activities, including assisting learners with homework and providing recommended resources or those that could enhance a learner's understanding of a subject.

McNeal's (2014) theoretical model highlighted the positive impact of parent-child interaction on academic activities.

Fantuzzo et al. (2000) conducted a quantitative study in a large urban school district in the Northeast of the United States to examine the impact of parental involvement on students' mathematics performance. Data were collected using the Family Involvement Questionnaire (FIQ), a multidimensional scale of family involvement in early childhood education. The study found that parental involvement, particularly in helping with assignments and projects, positively influenced students' responsibility and completion of schoolwork.

Mutodi and Ngirande (2014) conducted a quantitative study to ascertain how parental involvement in South African schools affects the academic performance of students in mathematics, collecting data using a questionnaire administered to parents of 114 students. The findings indicated that home and family support significantly contributed to a learner's performance in mathematics. Findings also revealed an increase in overall mathematical performance with parental involvement, depending on the parents' education level and gender.

Mabena et al. (2021) carried out a qualitative case study in the Kwagga West Circuit, South Africa, to assess the factors that contribute to poor performance of students in senior phase mathematics. The study used observation and semi-structured interviews with a sample consisting of three school management team members, six teachers, nine Grade 9 learners, and three parent representatives from the school governing body. The results revealed that parents' failure to assist with homework and assignments negatively impacted learners' perception that mathematics is difficult.

Deringöl (2022) explored how mathematics anxieties of parents contributed to the teaching of mathematics using the Mathematics Anxiety Scale for Parents, Parents' Contribution to the Mathematics Education Scale, and a parent form to collect data in Istanbul, Turkey. The study found that parents with low mathematics anxiety were more willing to participate in their children's mathematics education, emphasising the importance of parental involvement. In a related context, Ayub et al. (2021) conducted a quantitative investigation with 284 undergraduate students at a private university in Malaysia to examine the relationship between student achievement,

student engagement, parental involvement, and peer influence in mathematics learning. Data were collected by means of questionnaires. Their findings revealed a negative relationship between peer influence and mathematics achievement, highlighting the importance of parental involvement. In summary, this body of research highlights the interconnection between mathematics anxiety and the roles of parents. It emphasises the need for parental involvement because it improves students' performance.

2.2.2.3 Professional Development of Teachers and Mathematics Anxiety

As highlighted earlier, the role of a mathematics teacher is crucial in addressing mathematics anxiety in learners. The ability of teachers to navigate and mitigate mathematics anxiety is significantly influenced by their professional development environment. Van Damme (2015) emphasises the importance of incorporating innovative programmes and practices in the professional development of teachers to prevent situations where mathematics teachers exacerbate mathematics anxiety. This suggestion is informed by the observation that, so far, there seem to be fewer initiatives that meet desirable standards (Glover et al. 2016).

Mabena et al.'s (2021) as previously discussed further found that mathematics teachers often faced challenges in the classroom due to insufficient and unresponsive training received from the DBE. Preconceived notions developed during the teachers' training stages could further impact their effectiveness in addressing learner needs. In a separate research study, Mizala et al. (2015) examined the influence of pre-service elementary school teachers' expectations and beliefs on student achievement. The study, based on a survey-experimental methodology with 208 pre-service elementary school teachers from Chilean universities, revealed that some teachers, during their pre-service training, anticipated lower mathematics achievement for female students compared to male students. Apart from training to understand the learners, they should be trained to comprehend concepts relating to some branches of mathematics such as trigonometry.

2.2.2.4 Socio-Economic Environment on Learners and Mathematics Anxiety

In their study, Gegbe et al. (2015) investigated factors contributing to the poor mathematics performance among students. In their research, Gegbe et al. (2015)

used a descriptive survey approach and collected data from 100 West African Senior School Certification Examination (WASSCE) candidates and 15 mathematics teachers in the Kenema District of Sierra Leone. Data were collected through student, and teacher questionnaires. The study found that most parents or caregivers did not have stable sources of income. The low socio-economic status of parents was associated with limited resources, contributing to lower academic achievement. Importantly, socio-economic status emerged as a factor affecting the mathematics achievement of learners.

In another study, Adimora et al. (2015) investigated the influence of socio-economic status and classroom climate on the mathematics anxiety of pupils in Nsukka Local Government Primary Education Authority of Enugu State, Nigeria. The participants were 432 Primary Five pupils. An ex post facto research design was employed and the instrument used for the study was a questionnaire. It was found that socio-economic status and classroom climate significantly influenced the pupils' mathematics anxiety. Similarly, Kumar and Aurora (2017) examined the association of student achievement in mathematics and the household environment. The study involved 500 tenth-grade students (250 boys and 250 girls) from government and private schools in the Jalandhar district of India. Findings revealed significant differences in mathematics performance between students from high and low socio-economic status (SES) backgrounds. Moreover, maternal employment was positively associated with student achievement, whereas parental education levels did not significantly impact mathematics achievement.

Hernandez (2014) investigated the relationship between the mathematics scores of public middle school learners in Miami-Dade County in the USA, and learners' socio-economic status. Participants included students from 59 public middle schools and employed Florida's standardised test and the Florida Comprehensive Assessment as data collection instruments. The results indicated a strong correlation between socio-economic status (SES) and standardised test mathematics scores.

The study by Mahigir et al. (2012) determined the effect of parents' socio-economic background on mathematics anxiety and academic achievement in high school students. The study sampled 540 students (268 boys and 272 girls) from 8th, 9th and 10th grades in Karnataka, Kerala and Tamil Nadu states in India. Data were collected

using the MAS and a questionnaire on parents' socio-economic background. Results revealed a negative correlation between parent's education and mathematics anxiety. Additionally, multivariate regression suggested a combination of age, income and education could predict mathematics anxiety. The study also found a significant positive correlation between parents' income and parents' education with regard to mathematics anxiety. Furthermore, multivariate regression suggested a combination of parents' socio-economic background could predict mathematics anxiety.

In summary, research reveals a consistent association between lower socio-economic status and decreased academic achievement or increased mathematics anxiety, emphasising the importance of addressing socio-economic disparities in educational outcomes.

2.2.2.5 Environmental Factors in the School and Mathematics Anxiety

Shamaki (2015) determined the influence of the learning environment on learners' academic achievement in mathematics at senior school level. The study employed a descriptive survey design as well as an experimental design. A sample of 337 SS II students was taken from a population of 1,682 students in Potiskum LGA, Yobe state, Nigeria. Data were collected through structured questionnaire and achievement test. The study found a significant difference between the mean performance of students taught in an ideal learning environment and that of students taught in a dull learning environment. Environmental factors in schools arise due to the influence of external parties. These include instructional practices (teaching methodologies), teachers' attitudes, anxiety and beliefs, teaching resources in trigonometry, overcrowding in mathematics classrooms and the language used during instruction. All these environmental factors play a significant role in daily trigonometry lessons because if they are not well organised, they can increase mathematics anxiety among learners during trigonometry lessons.

2.2.2.6 Instructional Practices

Bottge et al. (2014) conducted a study investigating the effects of blended instructional models on mathematics performance within multiple middle schools across the United States. This pretest-posttest cluster-randomised trial involved 31 middle schools and 335 students with disabilities, examining the effects of combining

explicit and anchored instruction specifically on fraction computation and problem-solving skills. The results, obtained through standardised and researcher-developed tests, showed that students exposed to the blended units outperformed their counterparts in Business As Usual (BAU) classes.

The study by Amedume et al. (2022) investigated the effect of the problem-based learning (PBL) approach on learners' achievement in trigonometry in senior high schools in the Hohoe Municipality of the Volta region in Ghana. Employing a mixed method approach, the researcher utilised a quasi-experimental non-equivalent comparison group design, comparing the achievements of learners exposed to a PBL approach with those using the traditional approach. This included 94 students, with 45 in the comparison group and 49 in the experimental group. Data collection involved questionnaires, trigonometric achievement tests, and semi-structured interviews. Results revealed that classroom dynamics differed markedly between the two approaches. The traditional approach tended to dominate interaction activities in classrooms, limiting students' opportunities to actively engage with concepts and share ideas. Furthermore, with the traditional approach, learners were expected to play a more passive role, with teachers providing substantial information without encouraging meaningful contributions from students, effectively hindering the development of conceptual understandings.

2.2.2.7 Teachers' Attitudes, Anxiety and Beliefs, and Mathematics Anxiety

In mathematics, attitudes, anxieties, and beliefs of both teachers and students play an important role in shaping the learning experience. Researchers have found that learners who excel in mathematics often develop a positive attitude towards that subject. On the other hand, when mathematics teachers express a negative attitude toward the subject or specific branches within it, it may lead to increased anxiety among learners, ultimately resulting in poor performance. A study conducted by Atnafu (2014) examined the attitudes of secondary school mathematics teachers in Addis Ababa. The survey involved 148 participants and employed a combination of both quantitative and qualitative research methods. The study found that most teachers exhibited a negative attitude toward teaching mathematics, with motivation for teaching identified as the most significant factor influencing their overall attitude. In a related study, Sinyosi (2015) investigated reasons behind poor mathematics

outcomes among Grade 12 learners. The study gathered data through group discussions with 20 learners and through semi-structured interviews conducted in person with six teachers and four school management team members in the Nzhelele East Circuit. The study made an important observation: teachers who perceived mathematics to be a set of rules and algorithms emphasised the rote memorisation of procedures rather than promoting a deeper understanding of the subject matter. This negative approach was associated with poor mathematics performance and the development of unfavourable attitudes towards the subject among learners.

In summary, teachers' attitudes, anxiety, and beliefs significantly influence learners' mathematics performance, highlighting the need to address these factors to create a positive and effective learning environment

2.2.2.8 Teaching Resources in Trigonometry and Mathematics Anxiety

Chirimbana et al.'s (2022) study as previously discussed also revealed that a lack of textbooks and visual aids negatively affected teacher and learner motivation. This shortage also compromised the overall quality of mathematics instruction and directly affecting learners' performance.

Building on this, Mpiti and Wambu (2023) investigated the determinants of under-performance of Grade 12 learners in mathematics. Adopting a qualitative case study approach involving three mathematics teachers and nine Grade 12 learners in the Eastern Cape Province, South Africa. The data were gathered through interviews. The findings revealed that limited access to textbooks and practical learning resources contributed to poor performance in mathematics. The study emphasised the pivotal role of resources' availability in influencing learner performance. Similarly, Kagenyi's (2016) study as previously discussed revealed the need for unique teaching aids, such as cardboard, for effective teaching of trigonometry and also noted that the unequal distribution of resources in South Africa, particularly between rural and town schools, affected the availability of trigonometry teaching aids.

2.2.2.9 Overcrowding in Mathematics Classrooms and Mathematics Anxiety

Ojonubah (2015) investigated how overcrowded mathematics classes influence learners' academic achievements. A sample of 62 students and four mathematics teachers was drawn from tertiary institutions, secondary schools and primary schools

in Nigeria. Data were collected through test questions and questionnaires from the students and their teachers. The results of the analyses showed that overcrowded mathematics classes negatively affected students' learning in mathematics.

On the other hand, Aluyor and Matibemu (2022) examined the effect of classroom overcrowding and social distance among secondary school students in Edo State, Nigeria. The study adopted a survey research design. The population of the study comprised all public secondary schools in Edo State, and a sample of 100 students was drawn using simple random sampling techniques. Data were collected through questionnaire designed with a 4-point Likert scale. Results showed that classroom overcrowding affected effective teaching and learning. It had a negative impact on learners' academic achievement, and teachers found it difficult to impart knowledge to the learners effectively. In addition, the study by Likuru and Mwila (2022) assessed how overcrowded classrooms affected the teaching and learning process in Ilemela Municipality, Mwanza, Tanzania. The study adopted a mixed research approach and convergent parallel research design. The sample consisted of 110 respondents, including a Municipal Secondary Education Officer, a Quality Assurance Officer, eight heads of school, 40 teachers and 60 students. Structured questionnaires and an interview guide were used as research instruments. Data were analysed through descriptive statistics and thematic analysis. The findings revealed that classrooms in Ilemela municipality are overcrowded—exceeding the recommended limit of 45 students per class; students exceeded 90 within a single stream. On the basis of the findings, it was concluded that overcrowded classrooms had an effect on the teaching and learning process, since they limited the application and implementation of the competence-based curriculum and supportive classroom management practices which aided the effectiveness of the teaching and learning processes.

The study by West and Meier (2020) identified overcrowding in classrooms as a factor associated with poor academic achievement. The study's sample comprised 10 purposefully chosen participants who were knowledgeable and experienced in the field of teaching in overcrowded classrooms in the Foundation Phase in Tshwane West District of Gauteng Province, South Africa. The participants included heads of departments, primary school principals, higher education lecturers and a DBE official. In-depth, semi-structured interviews were conducted with each of the participants. The study found that the impact and challenges (such as didactical neglect, discipline

issues and negative teacher attitudes) related to overcrowded classrooms were associated with poor academic achievement.

Marais (2016) explored student teachers' challenges when teaching in overcrowded classrooms in South Africa. In this study, an exploratory research design combined with a qualitative approach was used, as it suited the purpose of the investigation. Purposive sampling was used to select 112 information-rich assignments received from final year (i.e. fourth year) students registered for a Bachelor of Education (BEd) degree (with specialisation in the Foundation Phase). Data were collected by means of a non-compulsory written assignment set out in student teachers' teaching practice workbooks. The findings revealed that numerous problems were experienced by student teachers, who were teaching in the overcrowded classrooms. Learners who struggled, fell behind and there was a lack of resources due to the overcrowded classroom. This means that an overcrowded trigonometry classroom is likely to have learners who underperform and are not supported or given the requisite attention and assistance. Also, it means that the limited resources (such as trigonometry square activities, activity sheets, calculators and transparencies) necessary for trigonometry are seldom used by all learners in a grade. Without a doubt, performance is increased in classes with fewer learners, partly because they receive more individual support from the teachers.

Imtiaz (2014) investigated and analysed the problems of teaching English to large classes in the public sector colleges of Lahore in Pakistan. The 12 public sector colleges in Lahore city comprised the whole population of the study. Three major colleges were chosen as the sample through random sampling. A survey research design was used and structured interviews were conducted with six English teachers from the three public sector colleges in Lahore, and a close-ended questionnaire was administered to 60 students from the same colleges. Twenty students from each college filled in the questionnaire as part of the survey to collect data to carry out this research. The results of the study confirmed that large classes—comprising more than 50 students in public sector colleges in Lahore—posed many problems for teachers and students in the teaching and learning process, respectively.

The study by Amer and Amalia (2021) explored the causes of overcrowding in primary schools in the north of Yemen, from the viewpoint of Yemeni teachers. Using

a qualitative approach, the study purposively selected four Yemeni primary school teachers from various regions. Data were collected through online semi-structured interviews. Teachers were questioned about overcrowding in classrooms and the contributing factors. Findings revealed that a lack of infrastructure, such as a shortage of classrooms, was one of the causes of such overcrowding. Other causes were having only one school in some areas and not having enough teaching staff.

The impact of overcrowded classrooms on the teaching-learning process at the elementary level in public sector schools in Quetta city was investigated by Ayub and Akhtar (2018). The participants were 260 male and female teachers as well as students, all drawn from 20 selected elementary level schools in Quetta city, Pakistan. The mixed method approach was used. Quantitative data were collected through structured questionnaires and qualitative data were collected through focused group discussions. The major findings of the study were that, at the elementary level, the majority of the classes were overcrowded and that decreased the possibility of an effective teaching and learning process.

Kagenyi's (2016) study as previously discussed also revealed that most of the schools were faced with the challenge of overcrowded classes which made it difficult for the teachers to have one-on-one interactions with the learners. These significantly contributed to the low performance of learners in trigonometry, which relies on learners' understanding the concept instead of memorisation.

2.2.2.10 Mathematics Anxiety and the Language Used in the Teaching and Learning of Trigonometry

The findings of the study by Makofane and Maile (2019) as previously discussed also revealed that learners experienced English as a language barrier which impacted negatively on their understanding of concepts which require interpretation. As a result, poor language proficiency impacted negatively on learner achievement, causing panic and anxiety. The study by Siyang (2018) examined the effectiveness of mother tongue-based instruction in teaching Mathematics. The study involved 60 Grade 9 students of Bagong Barrio National High School in the Philippines. The research employed the experimental method which involved two groups, the experimental group and the control group, which were both given a pretest and a posttest. The instrument used was a written 30-item test that explored the students'

participation by considering the students' results in the pretest and posttest. It was found that the use of mother tongue as a medium of instruction was more effective than the English language. Moreover, students who were taught using their native language showed a higher learning gain compared to those who were taught using English. Similarly, Karikari et al. (2022) examined the impact of mother tongue as the language of instruction and pupils' achievement in mathematics in rural upper primary classes in the Sefwi Akontombra District of Ghana. The participants of the study were 38 upper primary class teachers. The correlational study conducted indicated that there was a positive relationship between mother tongue usage as a medium of instruction and mathematics achievement. Furthermore, mother tongue utilisation impacted positively on effective communication.

Similarly, Chirimbana et al. (2022) study as previously discussed revealed that many learners struggled with English proficiency and reading comprehension. These language difficulties hindered learners' ability to correctly interpret and solve mathematical problems. The study further highlighted that deficiencies in reading skills contributed significantly to poor mathematical problem-solving performance.

Chikiwa and Schäfer (2018) explored how teacher questioning was used to foster critical thinking in selected Grade 11 multilingual mathematics classes in the Eastern Cape Province. A mixed-method design was used to collect and analyse both qualitative and quantitative data through classroom observations and interviews with three purposively selected Grade 11 mathematics teachers during their teaching of trigonometry and analytical geometry. The study found that teachers in these multilingual classes used lower-order levels of questioning during teaching. Higher-order questions, which research has shown have the potential to promote critical thinking, were infrequently used during teaching. Chikiwa's (2015) study aimed at identifying prevalent teacher code-switching strategies, ascertaining where and how teachers draw their mathematical vocabulary during teaching, and understanding how precise and consistent teacher code-switching is with regard to the established mathematics register. Data were obtained through document collection, as well as observing and interviewing three Grade 11 Mathematics teachers purposively selected from three secondary schools in the Eastern Cape Province. Results showed that the borrowing code-switching strategy was done consistently across the participating teachers. Very little transparent code switching was observed, and no

Grade 11 trigonometry terms in indigenous language were transparently and consistently code switched.

Webb and Webb (2013) used both quantitative methods (differences between pre- and posttests) and qualitative methods (classroom observation) in their study. The participants of the study were three Grade 7 mathematics teachers and Grade 7 mathematics learners. The study found that in language-diverse mathematics classes in South Africa, teaching was predominantly conducted in English only, and learners were often coerced to answer in English. Sociocultural influences have an impact on mathematical understanding and learning; thus, classroom dialogue, and the type of talk in which learners engage, can play an important role in enhancing mathematical reasoning.

2.2.3 Behavioural Factors

Interacting with personal and environmental factors is the behavioural component of the triad.

2.2.3.1 Mathematics Anxiety and Career Choices

Espino et al. (2017) evaluated mathematics anxiety and its impact on the career choices of Grade 11 learners in Philippines. The participants of the study were 40 Grade 11 students. Data were collected through structured questionnaire. The results showed that there is a significant relationship between mathematics anxiety, course and career choice of Grade 11 learners. On the other hand, Eidlin-Levy et al. (2023) investigated the relationship between mathematics anxiety and the choice of a mathematics-intensive career, examining how this relationship might change over developmental stages and differ by gender. A total of 427 Israeli students participated in the study. Of those, 294 were divided into one of the three research groups based on age: 87 primary school, 107 high school, and 100 university students. An additional 133 participants were part of the post-experimental group. In their study, learners completed a maths anxiety questionnaire and reported their desired career choice. The findings suggested that mathematics anxiety directly predicted the intensity of mathematics in career choices for high school and university students, but not for primary school students. Gender had a direct effect on younger students, as female students attending primary and high school preferred careers with a lower

maths intensity. The effect of gender on career choice mathematics intensity for university students was not direct but mediated by mathematics anxiety.

A study by Achuodho et al. (2020) investigated the relationship between anxiety and the choice of mathematics-related courses among female students in technical training institutes in the Western Region of Kenya. The study employed a concurrent triangulation research design within the mixed method research approach using a target population of 1,440 female students and 15 deans from 15 technical training institutes. The sample size comprised 302 female students, four female student representatives taking mathematics-related courses (purposive sampling), four female student representatives not taking mathematics-related courses (purposive sampling) and four deans of students. Questionnaires and interview schedules were the main data collection instruments used in the study. The study found a statistically significant strong negative relationship between anxiety among female students and choice of mathematics-related courses. This implies that, statistically, the more mathematics-anxious the female students are, the less likely they are to choose mathematics-related courses. In addition, Luu-Thi et al. (2021) investigated the relationship between mathematics anxiety and gender, grade, career choices, and academic achievement in Grades 10, 11, and 12 students in Vietnam. Their study used the Revised Version of the Mathematics Anxiety Rating Scale (RMARS) to survey 1,548 high school students from high schools in Vietnam. Findings revealed that academic coping strategies, gender, grade, and career choices were significant predictors of mathematics anxiety. Notably, grade 12 learners reported higher levels of mathematics anxiety than others. Furthermore, learners choosing finance and economics or industrial engineering to pursue into higher education also experienced higher levels of mathematics anxiety than others.

It becomes apparent from a synthesis of these findings that students' mathematics anxiety has a significant impact on their career choices, particularly in fields requiring strong mathematical competence. Additionally, gender, grade level, and academic performance influence the extent to which students experience mathematics anxiety in different contexts.

2.2.3.2 Mathematics Anxiety and Learner's Self-Regulation

Balali et al. (2023) investigated the mediating role of self-regulation in the relationship between mathematical educational beliefs and learners' mathematics anxiety. In their study, a correlational descriptive method was adopted by using structural equation modelling. The sample of the study was selected from 2,710 male students in the ninth grade of a senior public high school in the 4th district of Tehran. In this study, 300 students were chosen by a two-step cluster sampling method. Data were collected through Mathematics Anxiety Questionnaire, Mathematics Academic Beliefs Questionnaire and Self-Regulation Questionnaire. The findings showed that both mathematics educational beliefs and self-regulation had a direct effect on learners' mathematics anxiety, and mathematical educational beliefs had an indirect effect on mathematics anxiety through the mediating role of self-regulation. In contrast, Kahreh et al. (2018) examined whether teaching self-regulated learning strategies could reduce mathematics anxiety among learners with a dependent cognitive style. Their study followed a quasi-experimental design that included a pretest, post-test and a control group. The population included all first-grade high school female students in Holilan of Ilam, Nepal and a random sample of 136 participants. The data collection instruments were Witkin's Group Embedded Figures Test, and 18 geometric shapes, each of which consisted of several irregular geometric shapes. According to their findings, training in self-regulated learning strategies reduced mathematics anxiety among learners with a dependent cognitive style. Isleyen (2015) conducted a study in Erzurum Turkey to determine whether or not there is a relationship between elementary school learners' (5th, 6th, 7th, and 8th grades) mathematics self-regulation abilities and their mathematics anxiety. Both the Mathematics Anxiety Scale and the Self-Regulation Skill Scale for elementary school learners were used as data collection tools of the study in which a casual research design was used. It was observed that the secondary school learners, who had high levels of mathematics anxiety, had low levels of self-regulation skills.

In summary, these studies highlight how self-regulation plays a crucial role in mitigating mathematics anxiety, suggesting that it can serve as a target for intervention strategies to alleviate anxiety among learners.

2.2.3.3 Mathematics Anxiety and Learners' Engagement

Dodongan (2022) investigated if there was a link among anxiety towards mathematics, learning engagement, and students' perceptions of technology's usefulness in mathematics. The study population consisted of second-year college education students from multiple campuses of selected teacher education institutions in various municipalities of Davao de Oro, Philippines, all of whom had completed the GED 3 (Mathematics in the Modern World) course. A total of 264 respondents were randomly selected and proportionally distributed across the participating campuses. A causal-comparative research design was employed. Data were collected through three test questionnaires: the Mathematics Self-Efficacy and Anxiety (MSEA) Questionnaire, Classroom Engagement Inventory Questionnaire and Questionnaire on Students' Attitude towards E-learning environment. The findings indicated that both mathematics anxiety and perceived usefulness of technology in learning were significantly related to students' mathematics performance and served as predictors of their academic results in the subject.

Çağırğan and Soytürk (2021) investigated whether mathematics anxiety and learners' engagement in mathematics predict students' responsibilities toward learning, above and beyond what is accounted for by gender, grade level, enjoyment of mathematics, affection for the mathematics teacher, having their own room, and parents' involvement in their studies. The participants were 568 middle school students in Istanbul, Turkey. Data were collected through Student Engagement in Mathematics Scale and Mathematics Anxiety Scale. The results showed that learners' social, emotional, and cognitive engagement in mathematics were positively associated with their responsibility towards learning, whereas mathematics anxiety was a significant negative predictor of the learners' responsibility towards learning. Similarly, Quintero et al. (2021) investigated whether and how classroom engagement behaviours mediate the negative association between mathematics anxiety and mathematics achievement. The participants of the study were 207 students from 4th through 6th grades (50% female) in the United States. Mathematics anxiety was measured through self-report using the Mathematics Anxiety Scale for children. It was found that learners with higher mathematics anxiety demonstrated less cognitive-behavioural and emotional engagement compared to learners with lower mathematics anxiety levels. Achievement differences among learners with

various levels of mathematics anxiety were partly accounted for by their cognitive-behavioural engagement in the mathematics classroom.

In summary, these studies indicate that mathematics anxiety, learner engagement, and academic performance have a complex relationship in mathematics education. To foster a supportive learning environment and increase students' mathematical achievement and responsibility, it is essential to understand and address these factors.

2.2.3.4 Mathematics Anxiety and Learners' Performance

Essuman et al. (2021) explored the impact of mathematics anxiety on the academic performance of junior high school pupils in the Bongo district of Ghana. The population comprised all junior high school pupils in basic schools in the Bongo district, totalling 7,176, and was made up of 3,847 females and 3,329 males. Simple random sampling was employed to select a sample of 492 participants. Data were collected through the questionnaire. Findings from their study showed that mathematics anxiety negatively affected the mathematics performance of pupils and the study also revealed that, gender played a significant role in influencing the mathematics anxiety of pupils. In addition, Bornaa et al. (2023) examined the relationship between mathematics anxiety and learners' academic performance in advanced nations. The study used a quantitative approach and an analytical cross-sectional design to select 385 students at random from two senior high schools in Sagnarigu Municipality, Ghana. While student academic reports served as secondary data to gauge learners' success in mathematics, a 20-item mathematics anxiety questionnaire was the primary tool utilised to gauge students' level of arithmetic fear. The results of the study indicated that the secondary school learners' performance in mathematics was low, whereas their mathematics anxiety was high.

Samante and Alave's (2021) study (already cited in Section 2.2.1.6) revealed that the level of anxiety in Grade 4 pupils was moderate and their level of performance in mathematics as a whole was satisfactory. On the other hand, Zhang et al. (2019) conducted a meta-analysis of 84 samples from previous research examining the relationship between mathematics anxiety and mathematics performance. The analysis revealed a significant, moderate, and negative association between mathematics ability and mathematics anxiety.

Overall, these studies demonstrate that mathematics anxiety negatively impacts academic performance across a variety of educational settings and demographics.

2.3 Strategies to Reduce Mathematics Anxiety when Learning Trigonometry

According to Yadav and Singh (2018), to reduce mathematics anxiety among secondary school learners requires structured support in mathematics learning and problem-solving. They highlighted the roles of parents, teachers, and educationists in motivating students to approach mathematical challenges with confidence. The Instruction should begin with simple, accessible examples related to key concepts, progressively advancing to more complex problems to build learners' competence and reduce anxiety.

Supekar et al. (2015) demonstrated that sustained exposure to mathematical stimuli can reduce mathematics anxiety. Their study involved third grade learners (aged 8-9 years; with low & high mathematics anxiety) from multiple school districts in the San Francisco Bay area. The Scale for Early Mathematics Anxiety (SEMA) was used as a data collection instrument. The study found that repeated engagement with mathematical tasks helped reduce anxiety over time. Segumpan and Tan (2018) determined the effectiveness of the flipped classroom approach on the mathematics performance and anxiety of the Grade 7 students at the Central Mindanao University Laboratory High School in the Philippines. The participants were secondary school students (aged 12-13 years). The data were collected through MSEAQ. The results revealed that mathematics anxiety was lower and there was greater mathematics performance in the flipped classroom condition.

Jamieson et al. (2016) tested the efficacy of a psychological situational intervention targeting cognitive appraisals of stress to improve classroom exam performance. The participants were 93 developmental mathematics students (64 females, and 29 males) from an urban Midwestern community college. Data were collected through Abbreviated Math Anxiety Scale. The results demonstrated that instructions delineating the adaptive benefits of stress reduced mathematics anxiety and improved classroom performance. An experimental study by Lavasani and Khandan (2011) examined the effectiveness of cooperative learning in reducing mathematics anxiety and help-seeking behaviour of first grade of high school female students. The population was secondary school students (aged 13-14 years) in Iran. The participants were randomly selected from two schools. Data were collected through

18-item MAS. The results revealed that co-operative learning significantly reduced mathematics anxiety, decreased help-avoidance behaviour and increased help-seeking behaviour.

Chirimbana et al.'s (2023) quantitative study explored the effects of tailored instruction on mathematics anxiety among Grade 11 learners in the Ompundja Circuit, Oshana Region. Ninety-five teachers from 20 schools completed structured questionnaires to provide insights into the intervention. Findings indicated that differentiated instruction strategies were highly effective in reducing mathematics anxiety.

The need for educational stakeholders and curriculum planners to design programmes that enhance mathematics self-efficacy of the learners is evident. It benefits learners in doing mathematics and in pursuing science and engineering careers. The main purpose of the study by Olango (2016) was to determine the direct and indirect effects of mathematics anxiety on achievement in mathematics of first-year science and engineering students. Data were obtained from a descriptive survey from 245 students (201 males, and 44 females) from five departments of two faculties of Hawassa University, Ethiopia. Instruments used for data collection were standard scales of mathematics self-efficacy and mathematics anxiety adopted from the Mindfulness-Based Self Efficacy Scale - Revised (MSES-R) and RMARS for self-efficacy and anxiety, respectively. The study found that one of the major strategies that enhanced mathematics self-efficacy achievement was by reducing the anxiety-creating classroom climate, which was the teachers' responsibility.

The mixed sequential explanatory study of Ismail et al. (2022) explored students' level of mathematics anxiety, as well as teacher behaviour and speech which either intensifies or minimises mathematics anxiety among secondary school students. The questionnaire was distributed to 109 secondary school students in a school in Sokoto State, Nigeria. The results of the study disclosed that teachers' behaviour and speech, such as being too quick in mathematics classroom lessons, giving too many notes, exercises, punishments and embarrassing and alarming statements, had a significant effect in intensifying mathematics anxiety. The results also revealed that quizzes and competitions, a good learning environment, as well as intrinsic and extrinsic motivational statements helped in minimising mathematics anxiety.

Additionally, Xin and Guo (2022) analysed teachers' behaviour with regard to mathematics anxiety, as well as the role of intervention programmes. Their study employed a survey administered to 50 purposively selected students from various schools in the United States. The findings indicated that teachers' behaviours had a significant role in alleviating or reducing mathematics anxiety among the students.

In summary, to reduce mathematics anxiety and foster a positive learning experience for students, a multidimensional approach involving supportive teaching practices, collaborative learning environments, and targeted interventions is essential.

2.3.1 Inquiry and Problem-Solving Strategies

The study by Tertsea (2020) investigated the effect of inquiry and problem-solving methods on students' attitudes and performance in trigonometry in a junior secondary school in Benue State in Nigeria. The study used a quasi-experimental design. The population of the study consisted of 6,230 junior secondary school two (JSSII) students, with a sample of 211 students drawn using a purposive sampling technique. The students' attitude and performance in trigonometry were measured by Students' Trigonometry Attitude Questionnaire (STAQ) and Trigonometry Performance Test (TPT). The results indicated that students taught using inquiry-based and Polya's problem-solving methods behaved better and had a higher performance than those taught using the lecture method.

In addition, the study by Ganiyatu et al. (2022) investigated the impact of inquiry and problem-solving strategies on attitude, retention and performance in trigonometry among senior secondary school students in Zamfara State, Nigeria. A quasi-experimental research design with pretest-posttest control group design was adopted. The study used senior secondary school two (SSII) students with a population of 23,910. A multi-stage sampling procedure was used for the study. A simple random technique was used to select the classes that participated in the study. A total of 381 students in the six randomly selected intact classes were used as sample size. Three research instruments were developed and used. The Trigonometry Attitude Scale Questionnaire (TASQ) targeted the change in attitude, the TPT was used to measure the academic performance of the students, and the Trigonometry Retention Test (TRT) was used to measure the retention ability of the

students. The findings showed that there was no difference in the performance of male and female students in the trigonometric concepts taught using inquiry and problem-solving strategies. However, the male students retained better than their female counterparts in the trigonometric concepts taught using inquiry-based and problem-solving strategies.

In summary, these studies demonstrate the effectiveness of inquiry-based and problem-solving strategies in improving students' attitudes, retention, and performance in trigonometry, particularly in secondary schools.

2.3.2 The Use of Manipulatives

Teaching and learning mathematics for conceptual understanding is a complex process. The effective use of manipulatives as teaching tools has the potential to enhance learners' mathematical learning (Baruiz & Dioso, 2023). Again, it is hoped that manipulatives will be an important part of mathematics instruction in helping learners to build conceptual understanding of an abstract topic (Rosli et al. 2015). Brijlall and Niranjana (2015) designed a practical model representing an aeroplane and its runway to help learners make sense of trigonometric ratios in real-life situations. Their study examined how such a manipulative could support Grade 10 learners in understanding these ratios. Using an interpretive case study approach, they worked with five Grade 10 mathematics learners from a South African public high school. Data were gathered from learners' written responses, observations during lessons, and semi-structured interviews. The results showed that using manipulatives helped learners improve their understanding of trigonometric ratios. The researchers concluded that these tools serve as valuable supports for developing conceptual and procedural understanding in mathematics.

Kamina and Iyer (2009) pointed out that incorporating hands-on teaching tools in mathematics lessons helps learners move from concrete ideas to more abstract concepts, which improves their understanding of challenging topics. For example, Witzel (2005) further emphasized that manipulatives allow learners to progress from concrete experiences to abstract reasoning, connecting prior knowledge to new mathematical concepts.

Niranjan (2013) explored the use of artefacts (manipulatives) in teaching and learning trigonometric ratios to Grade 10 learners in a South African secondary school. The study, situated within the interpretative paradigm and employing a case study design, involved five Grade 10 learners. Data were collected through activity sheets, semi-structured interviews, and classroom observations. Analysis revealed that manipulatives positively influenced learners' understanding of trigonometric ratios, serving as effective mediating tools in developing both conceptual and procedural knowledge. A study by Larbi and Mavis (2016) was designed to investigate the efficacy of using algebra tile manipulatives in junior high school students' performance. The study sample comprised 56 students from two schools, purposely selected from two towns within the Komenda Edina Eguafo Abirem municipality in Ghana. Data were collected through mathematics achievement pretest and posttest. The results indicated that those students who were taught through extensive use of algebra tiles performed significantly better.

In summary, these studies demonstrate the importance of manipulatives to foster mathematical understanding by connecting abstract concepts to concrete experiences, and enriching the learning journey.

2.3.3 Peers' Roles and Learners' Motivation

Teachers can also minimise mathematics anxiety by encouraging peer support through simple classroom activities, such as directing peers to clap when a learner gives the correct answer or peers sending short motivational notes to each other to encourage learning mathematics. Garba et al. (2020) explored how daily interaction with peers can contribute directly to intensify mathematics anxiety and can also play a role in minimising mathematics anxiety among secondary school students of Sokoto State, Nigeria. A total of 20 students with high mathematics anxiety were identified to be participants of the study. The data were gathered from the interviews and photos. The findings revealed that peers' behaviour—such as weak students causing trouble and intelligent students dominating the lesson—and speech—such as using frightening and discouraging statements in the mathematics classroom—had a direct effect on intensifying mathematics anxiety. However, the findings also showed that peers' achievement, peer group discussions, and motivational and supportive statements had a great impact in minimising the level of mathematics anxiety.

Roberts and Spangenberg (2020) as previously discussed showed that peer tutors understood their role to motivate Grade 8 and Grade 9 learners to learn mathematics. Pastera et al.'s (2018) study aimed to generate a model of the students' academic performance in mathematics using their intrinsic and extrinsic motivation. The study used a correlational research design, which consisted of 140 responses from selected college students of Agusan del Sur State College of Agriculture and Technology in the Philippines. To determine the intrinsic and extrinsic motivation in learning mathematics, participants were evaluated based on a modified checklist from the Academic Motivation Scale. The results of the study revealed that intrinsic and extrinsic motivation had a significant impact on the students' academic performance in mathematics.

Collectively, these studies demonstrate the pivotal role that peers and motivation play in shaping students' experiences and outcomes in mathematics. Students' mathematics anxiety can be reduced by fostering positive peer interactions, both intrinsic and extrinsic motivation in learning environment.

2.3.4 Parents' Roles and Responsibilities

According to Aunola and Nurmi (2005), parents—particularly mothers, play an important role in children's development—need to be shown and encouraged to incorporate mathematics applications into everyday activities in the home environment. This will help children to see how mathematics is applied in daily life, while also modelling positive risk-taking in problem-solving. Bartley and Ingram (2017) explored the relationship between parents' mathematics self-efficacy and emotional arousal towards mathematics and that of their 12- and 13-year-old children. Eighty-four parent-child pairs from seven schools in New Zealand were examined using an embedded design methodology. Although no significant correlation was found between parents' mathematics self-efficacy and children's mathematics results, parents' emotional arousal towards mathematics influenced their willingness to assist with homework.

Mutodi and Ngirande (2014) as previously discussed also revealed that parental involvement including supporting homework, providing conducive study environments, motivating children, and setting realistic expectations was positively associated with learners' academic performance. Therefore, performance and

dimensions of parental involvement are positively related. These findings highlighted that parents' active participation can enhance children's mathematics achievement.

In summary, these studies indicate that parents play a significant role in the development of children's mathematical skills. By actively incorporating mathematical concepts into everyday activities, maintaining a positive attitude, and demonstrating supportive behaviour, parents can significantly enhance their children's mathematical ability and academic achievement. Further, it emphasises the importance of collaboration between parents and teachers in order to achieve optimal educational outcomes for students, emphasising the need to approach mathematics education holistically, encompassing both home and school environments.

2.3.5 The Use of Information and Communications Technology (ICT)

The study by Chinweoke (2016) investigated the effect of ICT on secondary school students' mathematics performance using a quasi-experimental, non-randomised pretest–posttest, non-equivalent control group design. Stratified random sampling was used to select four out of thirteen coeducational public secondary schools in the Ihiala Local Government Area, Anambra State, Nigeria. The study sample consisted of 398 SS2 students (180 males and 210 females), with the schools divided into experimental and control groups. The experimental group received ICT-based instruction, while the control group was taught using conventional lecture methods. Data were collected using the Mathematics Achievement Test (MAT). Findings revealed that students taught using ICT performed significantly better than those taught through traditional methods. Moreover, the study indicated that ICT use was gender-inclusive, benefiting both male and female learners equally in the learning of trigonometry.

Rahman and Puteh (2016) measured underachievers' motivation level towards teaching and learning Trigonometry II topic using the GeoGebra Learning Module (GLM). Using an explanatory mixed-methods approach combining surveys and interviews, the study involved 21 pupils in Muar, Johor, who engaged with the GLM over a two-week period. Motivation levels were assessed using a questionnaire adapted from the Instructional Material Motivation Scale (IMMS). Learners were found to have positive motivation towards the use of the GLM in the teaching and

learning of trigonometry, thus, demonstrating the potential use of the GLM among low achieving learners. With the high failure rate in high school mathematics, the integration of ICT tools and mathematics software is becoming increasingly valued as an intervention tool in upgrading performances in mathematics. Mathematics is misinterpreted as being abstract and boring to most learners. Therefore, with the advent of Geogebra, a solution to the problem has been found; but it must be remembered that teachers are central to the success or the failure of the integration of ICT tools, including Geogebra (Mokotjo & Mokhele, 2021).

Naidoo and Govender (2014) conducted a case study investigating the use of dynamic online software in teaching Grade 10 trigonometric graphs. The study involved 25 Grade 10 mathematics learners from a school in southern Durban, KwaZulu-Natal, South Africa. Data were collected through two trigonometry worksheets, semi-structured interviews with selected learners, and classroom observations. The findings indicated that the dynamic online environment enhanced learners' conceptual understanding of trigonometric graphs. By allowing each graph to be visualised dynamically, the software reduced the need for complex calculations, enabling learners to focus on critical mathematical ideas and develop a more robust understanding of the concepts.

Similarly, Picaza (2023) explored the use of GeoGebra representations to improve students' achievement in trigonometry through an experimental design. The participants were college students from Davao De Oro State College in the Philippines. The results revealed a significant difference in posttest and gain scores between the experimental group, taught using GeoGebra, and the control group, taught through traditional methods. This demonstrates that dynamic visualization tools like GeoGebra can effectively enhance learning outcomes in trigonometry.

Additionally, Maulyda et al. (2019) conducted a descriptive qualitative study to examine how college students represent their understanding of changes in trigonometric function coefficients and their corresponding graphs through GeoGebra. A class of 30 college students completed worksheets, and the findings indicated that students expressed their understanding through three forms: verbal representation, mathematical expressions, and visual representations.

Bedada and Machaba (2022) investigated the effectiveness of GeoGebra in helping Grade 12 students make connections between different representations of trigonometric functions and graph interpretation. Using a non-equivalent control-group pretest–posttest quasi-experimental design, the study involved 73 Grade 12 STEM students from schools in Ethiopia’s Hadiya Zone. The results highlighted that technology-oriented classrooms serve as powerful and accommodating tools that facilitate conceptual understanding and support students in visualizing complex mathematical ideas. Specifically, GeoGebra-assisted instruction was more effective than the traditional chalk-and-talk method of teaching in improving students’ ability to make connections between representations of trigonometric functions and their interpretation of trigonometric function graphs.

Mosese and Ogbonnaya (2021) investigated the effectiveness of GeoGebra in enhancing Grade 12 students’ ability to make connections between different representations of trigonometric functions and their interpretation of graphs. Using a non-equivalent control-group pretest-posttest quasi-experimental design, the study involved 61 students from two schools. The findings indicated a statistically significant difference in mean achievement between the experimental and control groups, with students in the GeoGebra-assisted instruction group performing better in connecting representations of trigonometric functions and interpreting their graphs. This study corroborates previous research demonstrating that dynamic mathematics software, particularly GeoGebra, significantly improves students’ conceptual understanding and graphical interpretation skills in trigonometry.

In summary, these studies demonstrate the potential of ICT tools, especially GeoGebra, in transforming the teaching and learning of trigonometry, which could be beneficial to educators seeking to improve students’ ability to comprehend complex mathematics.

2.3.6 The Use of the Activity-Based Approach

Oribhabor (2020) evaluated the effect of the activity-based teaching method on students’ achievement in secondary school mathematics. The study employed a quasi-experimental pretest-posttest design using intact classes. A sample of 96 students from two senior secondary schools in Calabar Metropolis, Cross River State, Nigeria, participated in the study. Data were collected using a 20-item Essay Mathematics Test (MT) developed by the researcher to assess students’

achievement in mathematics. Oribhabor (2020) evaluated the effect of the activity-based teaching method on students' achievement in secondary school mathematics. The study employed a quasi-experimental pretest-posttest design using intact classes, involving 96 students from two senior secondary schools in Calabar Metropolis, Cross River State, Nigeria. Data were collected using a 20-item Essay Mathematics Test developed by the researcher. Findings indicated that the activity-based method significantly improved students' mathematics performance, highlighting the effectiveness of hands-on, participatory learning in enhancing conceptual understanding.

The study concluded that learners would benefit greatly from teaching outcomes in schools if the activity method were used as a pedagogical approach in mathematics instructional delivery. Moreover, the failure rate in mathematics would decline significantly if an activity-based teaching method were adopted by mathematics teachers.

In another study, Nwoke (2021) investigated how the activity-based learning approach could enhance the creative skills of primary school pupils. The study used a sample of 185 pupils from six purposively selected government-owned primary schools in Owerri West Local Government Area of Imo State, Nigeria, employing a quasi-experimental design and a Mathematics Creativity Test (MAT) as the data collection instrument. Results revealed that the activity-based approach improved pupils' creative mathematical abilities, irrespective of gender and ability levels, emphasizing the approach's capacity to foster both cognitive and creative skills in pupils.

Similarly, Çelik's (2018) conducted an experimental study to examine the effects of activity-based learning on sixth-grade students' mathematics achievement and attitudes towards mathematics activities. The study involved 78 students (44 females, 34 males) from two classes in Siirt, Turkey, during the 2016–2017 academic year. Data were collected through Mathematics Success Test (MST) and Mathematics Activities Attitude Scale (MAAS). Findings demonstrated that activity-based learning significantly enhanced students' academic achievement and positively influenced

their attitudes toward mathematics activities, supporting the motivational and performance benefits of engaging instructional strategies.

Maphutha et al. (2022) explored the effect of the activity-based approach on Grade 11 learners' performance in solving two-dimensional trigonometric problems in selected secondary schools in Limpopo Province, South Africa. A sequential explanatory design was employed, combining quantitative and qualitative methods. The experimental group was taught using the activity-based approach, while the control group received traditional instruction. Learners' performance was measured through a 2D trigonometry test administered as pre- and posttests, and focus group interviews captured learners' experiences. Results revealed that learners exposed to the activity-based approach achieved higher scores than those in the control group, demonstrating the effectiveness of hands-on, interactive teaching strategies in improving understanding of trigonometric problem-solving.

In a related study, Ayara et al. (2024) investigated the effect of the activity-based method on students' academic achievement and retention in solving graphical problems in mathematics in Onna Educational Area, Nigeria. Using a quasi-experimental design, the study involved a population of 1,174 SS2 students across nine public secondary schools, with data collected through the Students' Mathematics Achievement Test (SMAT). Results showed that students taught using the activity-based method performed significantly better than those taught using traditional lecture methods.

In summary, both studies demonstrated that the activity-based approach has a significant positive impact on students' mathematics performance. Teachers can create a more conducive and effective learning environment for students by recognising and implementing this approach in mathematics education.

2.3.7 The Effective Use of Language in the Teaching and Learning of Trigonometry

Various strategies can be implemented in mathematics classes, and a community of practice can be developed which can lead to effective mathematical learning. Teachers play a significant role in scaffolding learners' understanding by employing strategies such as open-ended questioning, Socratic questioning, and prompting learners to reason and verbalize their thought processes. In language-diverse

mathematics classrooms, it is crucial that transitions between languages are learner-centred rather than enforced, allowing students to express their mathematical thinking in the language in which they are most comfortable.

Webb and Webb (2013) as previously discussed also revealed that in language-diverse mathematics classes in South Africa, teaching is predominantly delivered in English only and learners are often coerced to answer in English. The study found that sociocultural influences had an impact on mathematical understanding and learning; thus, dialogue, and the type of talk in which learners engage, can enhance mathematical reasoning. The classroom climate can enhance dialogue if it is non-threatening and the learners feel comfortable in voicing opinions without fear of retribution or ridicule. Therefore, in this environment, the teacher can cater for both the mathematical and the language needs of the learners.

Chikiwa and Schäfer (2018) as previously discussed also revealed that teachers in the multilingual classes used lower-order levels of questioning during teaching. Higher-order questions, which research has shown to have the potential to promote critical thinking, were infrequently used during teaching. Teachers also used everyday vocabulary to promote visualisation of mathematical concepts in the learners' first language to stimulate visual thinking, for conceptual understanding of trigonometric concepts. Learners' first language was used as a way of building on prior knowledge; it was used to make connections within mathematics and with the real world. Teachers also used terms that promoted multiple representations of mathematical concepts. It was found that while teachers did not make extensive use of the learners' first language to help promote visualisations, they used everyday words which were familiar to their learners, thereby building on their prior knowledge (Chikiwa & Schäfer, 2019).

In summary, these studies emphasise the necessity of integrating language and mathematics, particularly in multilingual contexts. Teachers can create inclusive learning environments where all students can thrive if they create a supportive classroom climate, use diverse questioning techniques, and capitalise on learners' first languages.

2.3.8 The Use of Problem-Based Learning (PBL) in Teaching and Learning Trigonometry

Zakariya et al. (2016) conducted a quasi-experimental study involving 149 junior secondary school students in Nigeria to examine the impact of PBL on mathematics performance and retention. The experimental group consisted of 81 students (53 males and 28 females), while the control group had 68 students (39 males and 29 females). Data were collected through Mathematics Performance Tests 1 and 2 (MPT 1 & 2). The study revealed that learners taught through PBL significantly outperformed their peers taught using traditional methods. Additionally, students exposed to PBL were able to retain the learned content for at least two weeks, demonstrating both immediate and short-term retention benefits.

Similarly, Gerhana et al. (2017) investigated the effectiveness of PBL combined with a scientific approach, considering students' interpersonal intelligence, among Grade 10 students in Indonesia. Using a quasi-experimental design, two classes were randomly selected: an experimental class of 32 students and a control class of 31 students. Data collection involved tests and observation sheets. The study found that PBL was more effective than traditional scientific approaches in enhancing students' mathematics learning achievement.

Amedume et al. (2022) as previously discussed also revealed that the PBL approach was very effective in the teaching and learning of trigonometry, promoting students' active participation in the instructional process, content mastery, and improving their creative thinking and independent problem-solving skills.

Similarly, Padmavathy and Mareesh (2013) tested the PBL approach in middle schools in India using a randomized control group pretest–posttest design with 30 students in each group. Their findings indicated that PBL positively influenced students' understanding of mathematical concepts and improved their ability to apply these concepts in real-life contexts.

In summary, these studies demonstrate that PBL enhances mathematical education across a variety of educational settings.

2.3.9 The Use of the 5E (Engage, Explore, Explain, Elaborate and Evaluate) Instructional Model in Teaching and Learning Trigonometry

Boakye and Nabie (2022) examined the effect of the 5E instructional model on senior high school students' mathematical achievement in the application of the sine rule in Bekwai Municipality, Ashanti Region, Ghana. Using a quasi-experimental, non-equivalent control group pretest–posttest design, two intact classes were selected via convenience sampling to serve as experimental and control groups. Data were collected through pretests and posttests in trigonometry and questionnaires to gather both quantitative and qualitative insights. The analysis showed that learners taught through the 5E model performed noticeably better than those in the control group, indicating that the approach had a positive effect on their trigonometry achievement.

In a related study, Tuna and Kacar (2013) examined how the 5E learning cycle, grounded in constructivist principles, influenced Grade 10 learners' achievement and retention in trigonometry in Kastamonu, Turkey. The researchers compared two classes: one taught through the 5E model and another using the traditional curriculum. Their results showed that students who were instructed with the 5E approach achieved higher scores and retained trigonometric concepts better than those in the control group.

Omotayo and Adeleke (2017) further explored the effectiveness of the 5E instructional model for enhancing mathematics learning outcomes. A pretest–posttest quasi-experimental design was employed, involving 172 students (96 males, 76 females, mean age 15) in Ibadan Metropolis, Oyo State, Nigeria. Findings demonstrated that the 5E instructional approach significantly improved learners' performance in mathematics compared to their peers taught via traditional methods.

In addition, Alshehri (2016) further investigated the impact of the 5E Instructional Model on mathematics achievement and retention among fifth-grade students in Khamiss Mushayt Province, Saudi Arabia. Using a quasi-experimental design, the study involved 30 students in the experimental group and 29 in the control group. Pre- and posttests were administered to measure learning outcomes. In the experimental class, learners received instruction through the 5E instructional model, which was implemented within a constructivist teaching approach. Findings indicated

that the 5E model was more effective than traditional teaching methods, enhancing both achievement and retention.

In summary, these studies indicate that the 5E Instructional Model is effective in enhancing learning outcomes in mathematics, particularly trigonometry, emphasising its superiority to traditional instruction.

2.4 Theoretical Framework

This study aimed to explore mathematics anxiety among Grade 11 learners specifically within the context of trigonometry. To establish a theoretical framework for this investigation, Bandura's social cognitive theory was referenced. Bandura (1986) proposed that learning is shaped by multiple interacting determinants. According to Bandura's social cognitive theory, human functioning can be understood through the model of triadic reciprocity, in which behaviour, personal factors, and environmental conditions all operate as interacting determinants of one another.

The interaction between personal characteristics and learning behaviour, referred to as personal-behaviour interaction, is an important aspect of Bandura's social cognitive theory. It recognises that a person's thoughts, emotions and biological properties can influence their actions (or behaviour) and vice versa (Bandura, 1977, 1986). For instance, an individual's expectations, beliefs, self-perceptions, goals, and intentions can guide, shape, or modify behaviour. Simultaneously, the behaviour they exhibit can affect their thoughts and emotions. In essence, what a person thinks, feels and believes impacts how they behave (Bandura, 1986).

Another significant interaction within Bandura's theory is the personal-environmental interaction. This interaction highlights the influence of personal learning characteristics and environmental factors. Human beliefs, expectations, and cognitive competencies are developed and altered through social influences and existing structures within the individual's environment. Social influences can convey information and shape personal thoughts and emotions through processes such as modelling, instruction and social persuasion (Bandura, 1986). Essentially, personal characteristics, including cognitive competencies, emotional skills, beliefs, and expectations, can be modified by environmental influences (Bandura, 1986).

The behaviour-environmental interaction represents the interplay between environmental factors and learning behaviour. It emphasises how behaviour

contributes to determining aspects of an individual's environment and, in turn, how the environment can shape behaviour (Bandura, 1969, 1977, 1986). An example of the behaviour-environment link is demonstrated through an instructional sequence, where a teacher presents information and directs learners' attention to instructional aids.

In the context of Grade 11 mathematics learners studying trigonometry, these three factors interact. As a teacher presents a lesson on trigonometry, learners reflect on the content taught (environment influencing cognition, a personal factor). If learners encounter difficulties, they may ask questions (cognition influencing behaviour). The teacher then addresses their concerns (behaviour influencing environment). Subsequently, the teacher assigns tasks related to trigonometric functions for the learners to complete (environment influencing cognition, which, in turn, influences behaviour). As learners work on the task, their perception of their performance affects their behaviour (behaviour influencing cognition), leading them to seek permission from the teacher to continue working (cognition influencing behaviour).

The interaction between person, environment, and behaviour in learning settings is further supported by Schunk et al. (2008). These authors illustrate how external influences such as modelling, instructional strategies, and teacher feedback can shape learners' internal processes, including goal setting, task-specific self-efficacy, casual attributions for success or failure, and self-regulatory behaviours like planning, monitoring progress, and managing distractions. For example, teacher feedback on trigonometry tasks may enhance a learner's confidence and motivation, thereby influencing their goals. Both environmental and personal factors can promote behaviours such as sustained effort and persistence which are essential for academic development. However, these behaviours also reciprocally influence personal factors as well. Increased effort (behaviour) can lead to heightened confidence and interest in learning trigonometry. Additionally, behaviours can also affect the broader learning environment. When learners display a lack of persistence or misunderstanding, teachers may adapt instructional strategies (from traditional to learner-centred approaches) or group assignments, thereby altering the learning environment for the learners.

Bandura's social cognitive theory is based on the triadic reciprocity model in which personal traits, environment and behaviour interact. Therefore, the next section is a summary of mathematics anxiety in learners when learning trigonometry as viewed through learners' experiences towards mathematics in the form of personal, environment and behaviour.

2.5 Summary

This literature review focused on studies about mathematics anxiety. Through this review, crucial points regarding mathematics anxiety were identified for future research. It provided a descriptive picture of mathematics anxiety in educational settings and its relationship with various influencing factors.

Personal factors: Motivation and mathematics anxiety play a complex and multifaceted role in academic performance. Although some studies found a moderate correlation between motivation and mathematics anxiety, most reported a negative relationship (Adao et al. 2015; Akbar, 2015; Suren & Kandemir, 2020). External support, societal influences, and gender dynamics also shape this relationship, ultimately influencing learners' experiences and outcomes in mathematics. Researchers have also emphasised the connection between learners' attitudes and mathematics performance (Dowker & Sheridan, 2022; Mutengi et al. 2021), highlighting the need to address negative attitudes to improve performance.

Environmental factors: Research indicates a correlation between mathematics anxiety and peer influence. Negative peer behaviour and speech can worsen mathematics anxiety, while positive peer interactions, group discussions, and encouragement can reduce it (Bakar et al. 2021). Studies also highlight the role of parents in learners' mathematical achievement (Deringöl, 2022; Mutodi & Ngirande, 2014), stressing the value of parental involvement. A consistent association has been found between lower socio-economic status and higher mathematics anxiety, showing the importance of addressing educational inequalities (Adimora et al., 2015; Gegbe et al., 2015). Teachers' attitudes, beliefs, and levels of anxiety also significantly influence learners' performance (Atnafu, 2014).

Behavioural factors: Findings show that mathematics anxiety affects learners' career choices, particularly in fields requiring strong mathematical competence (Achuodho et al., 2020). Gender, grade level, and academic performance also

influence the degree of mathematics anxiety (Eidlin-Levy et al., 2023). Studies further reveal that self-regulation plays a crucial role in mitigating mathematics anxiety and can serve as a target for interventions (Kahreh et al., 2018). Mathematics anxiety, learner engagement, and academic performance are interrelated; understanding these factors is essential for creating supportive learning environments and improving responsibility and achievement (Dodongan, 2022). Overall, research consistently shows that mathematics anxiety negatively affects academic performance across various educational contexts.

The reviewed literature and the discussions of personal, environmental, and behavioural factors were structured within the framework of Bandura's Social Cognitive Theory (1986). This theory emphasises the reciprocal interaction among personal, behavioural, and environmental determinants that shape learning behaviour. It therefore provides a useful lens for understanding how mathematics anxiety develops and operates in classroom contexts. Guided by this framework, the current study investigated how these factors interact in Grade 11 trigonometry to influence learners' engagement, coping behaviours, and performance patterns.

Chapter 3

Research Design and Methodology

This chapter outlines the research paradigm, research design and approach chosen for this study, as well as sampling, data collection instruments and development of the instruments, data analysis and ethical considerations. Research methodology refers to the different techniques, methods and procedures that were used in the research design or research method implementation process (Creswell, 2009).

3.1 Research Paradigm

It can be said that a functional description of a research paradigm is a framework through which an inquiry ought to be conducted (Kivunja & Kuyini, 2017). Scientific literature based on educational studies defines a research paradigm as the overall theoretical research orientation of a researcher (Mack, 2010). The orientation is expressed through the researcher's assumptions, principles or philosophical orientations. For this study, I selected the pragmatic paradigm. Pragmatism is pluralistic and emphasizes practical solutions that effectively address research problems (Creswell & Plano Clark, 2011). This paradigm allows for the use of multiple methods, balancing both objective and subjective knowledge to address research objectives. It provides researchers the flexibility to select methods or strategies that best respond to the research questions (Creswell, 2007). This type of paradigm was chosen because I wanted to incorporate both qualitative and quantitative aspects.

3.2 Research Method

This study employed a mixed-methods approach, combining quantitative and qualitative research methods (Poth & Munce, 2020). The rationale for this approach was grounded in the nature of the research questions, which required both numerical measurement and in-depth exploration of participants' experiences.

Mixed-methods research approaches offer unique opportunities to delve into contextual factors, such as self-efficacy and parental influence, qualitatively, while also developing quantitative measures. Certain factors, like inner emotions, confidence, social norms, and psychological drivers may not be readily observable and therefore require quantitative methods for analysis.

Qualitative research is used to investigate and understand how people interpret and make sense of issues that affect them within social or human contexts (Creswell,

2007). This approach typically involves developing research questions and procedures as the study progresses, collecting data in participants' natural settings, and analysing data inductively to identify patterns or themes, with the researcher interpreting the significance of the findings (Creswell, 2007). In this study, qualitative data were obtained through questionnaires administered to both teachers and learners, semi-structured interviews with these participants, and classroom observations. The aim of this approach was to capture rich, contextualized information within real-world settings to gain a comprehensive understanding of participants' experiences and perspectives (Creswell, 2009).

Quantitative research, on the other hand, is concerned with testing objective theories by examining relationships among measurable variables. These variables are typically assessed using structured instruments, generating numerical data that can be statistically analysed (Creswell, 2007). In this study, quantitative data were collected through questionnaires completed by teachers and learners, as well as through tests designed to assess learners' performance and perceptions in trigonometry.

3.3 Research Design

This study adopted an exploratory sequential mixed-methods design, which begins with the collection and analysis of qualitative data, followed by quantitative data collection and analysis, culminating in the integration of results (Creswell, 2018). In this design, qualitative data were prioritized initially to explore learners' experiences and perceptions. The insights gained from the qualitative phase then informed the quantitative phase, allowing for the testing or generalization of qualitative findings (Creswell & Plano Clark, 2015). Specifically, qualitative methods, including interviews and classroom observations, were used first to investigate mathematics anxiety among Grade 11 learners studying trigonometry. Subsequently, quantitative methods, including questionnaires and administered tests, were employed to further examine and substantiate the patterns identified in the qualitative data. This sequential approach enabled a comprehensive understanding of mathematics anxiety in the target population.

3.4 Population and Sampling

The population for this study comprised all Grade 11 mathematics learners and their respective mathematics teachers from two selected secondary schools in the Vhembe West District of Limpopo Province, South Africa. Purposive sampling was employed to select participants from one classroom per school, with each classroom consisting of 20 learners and their mathematics teacher. The two schools were located approximately two kilometres apart. Grade 11 teachers were included because they teach mathematics, including trigonometry, and had at least five years of experience teaching and observing the learners.

Selected participants engaged in lesson observations, with four lessons observed per school, and completed both open- and closed-ended questionnaires. For the semi-structured interviews, learners were purposively selected based on their performance in a written test. Specifically, six learners (three from each school) and one teacher from each school participated in the interviews.

3.5 Data Collection Instruments

This study employed multiple data collection instruments, including questionnaires, semi-structured interviews, and lesson observation schedules. Data collection followed a sequential mixed-methods approach. Initially, qualitative data were collected through open-ended questionnaires, lesson observations, and semi-structured interviews. Subsequently, quantitative data were gathered using closed-ended questionnaires and administered tests. All data collection activities were conducted at the respective schools, with field notes recorded during each session.

3.5.1 Questionnaires (Learners and Educators)

To make things simple, a questionnaire was used to gather data from educators and learners. I used an educators' questionnaire because I wanted to know about the suggested strategies that teachers who teach trigonometry can adopt to relieve or address learners' mathematics anxiety for higher achievement in trigonometry. I also used a learner questionnaire because I wanted to know the causes and effects of mathematics anxiety on learners, as expressed personally. I visited the educators and learners at their schools, and their educators administered the questionnaires after school so that there were no interruptions of teaching and learning during school periods. In all the selected schools, I approached the principal where the questionnaires were left for forwarding to teachers and learners. Only those learners

who were willing to take part in this research by signing consent forms completed the questionnaire. The completed questionnaires for both teachers and learners were handed to the principal and were collected by me.

3.5.2 Semi-Structured Interviews (for Learners and Teachers)

This posttest semi-structured interviews provided an opportunity to explore the reasons for the mathematics anxiety learners experienced. The selected interview scripts were drawn from learners who achieved the highest, average and lowest marks. The interview questions asked learners about the reasons for their anxiety and academic performance, while the focus for teachers was on whether and how their instructional practices contributed to mathematics anxiety in learning trigonometry. The semi-structured interview questions were carried out after every lesson observation in this study. Three learners (one who passed with a score of 80-100%, one who passed with a score of 50-79%, and one who scored 0-49%) were chosen from a group of 20 learners in each of the two selected schools. Additionally, one educator from each selected school was interviewed. Thus, a total of six learners and two teachers participated in the semi-structured interviews.

3.5.3 Observations of Participants in a Classroom

I observed four mathematics lessons per Grade 11 teacher at each selected school. During these lessons, I evaluated signs and symptoms of mathematics anxiety among learners while they were learning trigonometry. This was done through careful observation of various classroom interactions. I observed how learners participated in class discussions, asked questions, took notes, and completed assignments. Attention was given to their punctuality, ability to stay focused during lessons, and efforts to avoid distractions. The willingness of learners to attempt questions, even when unsure of the answers, was observed, as well as their tendency to avoid difficult tasks altogether. I also observed learners' perseverance through challenges, noting whether they became visibly frustrated or avoidant. Additionally, the interactions among learners were scrutinised to see if they supported each other's learning or exhibited competitive or dismissive behaviours. Observations included whether learners felt comfortable seeking help from peers or the teacher when they encountered difficulties and whether they showed signs of anxiety such as fidgeting, avoiding eye contact, or appearing tense. The confidence or hesitation of learners when asked to share their work or explain their thought process was also observed.

In addition, I observed the teaching strategies employed during these lessons. This included the use of positive and encouraging non-verbal cues by the teachers to help reduce anxiety, and whether instructions were paced in a way that allowed learners enough time to process information, avoiding a rushed lesson that could increase anxiety. I noted the use of positive reinforcement, such as praise or encouragement, to create a supportive learning environment. I also observed whether a variety of teaching methods were used to accommodate different learning styles and inclusivity, aiming to reduce anxiety for learners who struggled with traditional approaches. Teachers' awareness of individual learners' strengths, weaknesses, and learning preferences was evaluated to see how they tailored their instruction and support to reduce anxiety. I also assessed the approachability and availability of teachers for extra help to support learners and reduce anxiety about understanding the material. Furthermore, the classroom environment was observed to determine if making mistakes was seen as a natural part of learning and an opportunity for growth, which could help reduce anxiety related to the fear of failure. The incorporation of real-world examples and applications of trigonometry concepts was noted to see if it made the subject more relevant and less abstract, potentially reducing anxiety for some learners. Finally, the effective use of technology and visual aids to enhance understanding and engagement was observed, as this could support diverse learning styles and reduce anxiety.

3.5.4 Test (document analysis)

The test included questions on numerical reductions with special angles; trigonometric equations and the proving of identities. These concepts of trigonometry were chosen because they require learners to have a basic understanding of relevant and related aspects of algebra and trigonometry. All the learners in the purposive sample wrote a test; however, a total of six learners' scripts (three per school using seven levels to categorise them) were purposefully selected for analysis of performance, to identify errors, and for interviewing learners about how they felt when they were writing the test. I had observed many times when learners were writing an invigilated test/tasks/examination, that they would show signs of anxiety and I would not know the reasons for this.

3.6 Data Analysis and Interpretation

This study involved the collection and analysis of both qualitative and quantitative data. Qualitative data—including open-ended questionnaires, semi-structured interviews, and classroom observations—were analysed using thematic analysis. This involved coding the data, identifying patterns, grouping related codes into categories, and deriving overarching themes that addressed the research questions (Nowell et al., 2017). Again, error analysis was conducted so that I could understand learners' challenges when answering questions in the diagnostic trigonometric test.

Quantitative data, though limited in scale, were drawn from a diagnostic mathematics test and closed-ended learner questionnaires. While the small sample size (N = 40 learners and two teachers across two schools), do not necessarily preclude inferential statistical analysis, this study focused on descriptive statistics, specifically frequencies and percentages, to address the research objectives. These descriptive results served to triangulate and support the qualitative findings by highlighting general trends in learners' performance and self-reported levels of anxiety.

The diagnostic test results were qualitatively interpreted by examining common error patterns and learner responses, which were then aligned with emerging themes such as cognitive overload, test anxiety, and performance-related stress. This integration of qualitative and descriptive quantitative data offered deeper insight into how instructional practices, learner attitudes, and test-related pressures interact to influence mathematics anxiety.

3.7 Methodological Norms

3.7.1 Trustworthiness/Validity of the Instruments

Trustworthiness, also known as validity, refers to the extent to which a researcher can be confident in the accuracy and authenticity of the study findings, including the interpretation of the data and the methods of analysis (Polit & Beck, 2014). In essence, it is a measure that is used to assess the authenticity and accuracy of results (Lincoln et al., 2011). Apart from determining the truthfulness of data, trustworthiness refers to the extent to which data generated from a study is plausible and credible (McMillan & Schumacher, 2010). In this study, validity was ensured by having the contents of the questionnaires and interviews reviewed by an expert knowledgeable in the mathematical branch of trigonometry.

3.7.2 Credibility/Reliability of the Instruments

Reliability refers to the consistency of an instrument in producing the same results when administered under similar conditions over time (Creswell, 2010). In this study, the reliability of the closed-ended questionnaires was ensured through pre-testing and refinement prior to formal data collection. A pilot test was conducted with a small sample of the target population to assess comprehension and the accuracy of responses. The pilot data were subsequently analysed using Cronbach's alpha in SPSS to determine internal consistency.

Credibility relates to the truthfulness and accuracy of participants' responses and the extent to which the researcher's interpretation of the data reflects these responses (Polit & Beck, 2012). To establish credibility for the qualitative instruments, the interview schedules were piloted, and participants' responses were continuously cross-checked against the research questions and objectives to ensure alignment. Furthermore, content validity was confirmed by ensuring that the test items adequately covered the Grade 11 trigonometry curriculum, reflecting the intended depth and scope of the subject matter (Creswell, 2008).

3.8 Ethical Considerations

Ethical conduct in research involves the relationship between the researcher and participants and is guided by principles such as informed consent, anonymity, and confidentiality (Kitto & Knitt, 2019). Adherence to research ethics is essential to protect participants' dignity, privacy, and rights. For this study, ethical clearance was obtained from the UNISA College of Education (CEDU) Ethics Review Committee

(Ref: 2024/05/08/61956643/22/AM) as well as the Limpopo Provincial Research Ethics Committee. In addition, approval to carry out the study was requested from the Vhembe West District office and from the principals of the participating schools.

3.8.1 Informed Consent

To ensure ethical compliance, the identities of participating schools, teachers, and learners were kept confidential. Participant information sheets and informed consent forms were prepared and distributed prior to the commencement of data collection. I informed the participants of the purpose of the research, and that participation was voluntary. For learners under 18 years of age, I sent informed consent letters to both parents and learners, which had to be completed first before learners were handed questionnaires to complete.

3.8.2 Anonymity and Confidentiality

Confidentiality of participants was maintained through the use of consent documents and pseudonyms to protect their identities. Learners were informed of their right to withdraw from the study at any time or to refrain from answering any question without penalty. Furthermore, participants were assured that the information they provided would remain confidential and anonymous, and that no responses would be disclosed to their schools or teachers.

3.9 Autonomy

In essence, autonomy in a research study involves allowing participants to feel empowered to make decisions, that is, ensuring that they are fully aware of their right or the choice to withdraw from participating in an on-going research study (O'Donoghue, 2018). For this study, I ensured autonomy by informing all the selected participants of their right not to participate and that no penalty would be imposed should they withdraw.

3.9.1 Non-Maleficence or Protection from Harm

While conducting educational research, the lead researcher has a responsibility to ensure that they minimise chances of participants being exposed to harm (O'Donoghue, 2018). Throughout the study, I made every effort to treat all participants with honesty, respect, and consideration.

3.10 Conclusion

This chapter has outlined the research design and methodology employed in the study. It provided a detailed description of the population and sampling techniques used, as well as the instruments utilized for data collection. Additionally, the procedures for data analysis and interpretation were discussed, highlighting how both qualitative and quantitative methods were integrated to address the research questions effectively.

Chapter 4

Presentation and Analysis of Findings

4.1 Introduction

This chapter presents and analyses the data collected from classroom lesson observations, diagnostic test responses, interviews with teachers and learners, and both open- and closed-ended questionnaires. These tools were used to explore and explain the sources of anxiety that learners experience when learning trigonometry in Grade 11 mathematics.

The study followed an exploratory sequential mixed-methods design. Qualitative data were prioritised, analysed thematically, and supported by quantitative data from closed questionnaires and test scores. The diagnostic test, although quantitative in format, was interpreted qualitatively to explore performance-related anxiety and cognitive patterns. Statistical data were analysed using Microsoft Excel, primarily to provide descriptive insights into learner anxiety.

The research was guided by the following questions:

- What are the signs of mathematics anxiety among selected Grade 11 learners when learning trigonometry?
- What factors contribute to mathematics anxiety when learning trigonometry?
- What measures can help address or reduce mathematics anxiety to promote higher achievement?

The chapter is organised around key themes developed from coded data. Each theme is supported by quotations and examples from lesson observations, interviews, open-ended questionnaires, and test responses. Where applicable, findings from the diagnostic test are incorporated under relevant themes to triangulate learners' experiences and observed behaviours.

The following sections present the thematic structure used in the analysis, followed by a detailed discussion of each theme supported by evidence from the data.

4.2 Qualitative Results

This section presents findings from the qualitative data sources: classroom lesson observations, open-ended questionnaires, and semi-structured interviews with teachers and learners. The data were analysed thematically, and themes were developed based on recurring patterns across different data sources.

4.2.1 Coding and Labelling of Participants

Participants were coded based on their schools: learners in School A were coded as LA 1 to LA 20, and those in School B as LB 1 to LB 20. Teachers were coded as TA (School A) and TB (School B). Table 1 below provides an overview of how participants were coded:

Table 1: Coding of Participants

Participant Type	School A	School B
Learners	LA 1 – LA 20	LB 1 – LB 20
Educators	TA	TB

To systematically analyse the qualitative data, responses were coded and categorised to identify recurring patterns and develop relevant themes that aligned with the research objectives.

4.2.2 Thematic Analysis Approach

An inductive thematic analysis was employed to explore learner experiences of mathematics anxiety in trigonometry. This means that codes, categories, and themes were derived directly from the raw data rather than being predetermined. The qualitative data included classroom observation notes, interview transcripts, open-ended questionnaire responses, and diagnostic test reflections.

I systematically reviewed these data sources to identify and label codes, which were then organised into broader categories and grouped into overarching themes. Emphasis was placed on identifying recurring patterns, similarities in learner responses, and consistent classroom behaviours that reflected signs of anxiety or coping strategies.

This approach ensured that the findings were grounded in participants lived experiences and allowed for a rich understanding of how mathematics anxiety manifests and might be addressed. Table 2 presents the full structure of codes, categories, and themes developed through this inductive process. Codes were grouped into categories and then into themes, based on recurring patterns and relevance to the research questions. The process emphasised identifying signs of anxiety, contributing factors, and strategies to mitigate anxiety.

4.2.3 Codes, Categories and Themes

Table 2 below presents a summary of the codes, categories, and themes that emerged from the qualitative data.

Table 2: Codes, Categories and Themes

Codes	Categories	Themes
- Lack of focus in the class, avoidant, avoiding eye contact	- Behavioural signs of anxiety	Observable signs of mathematics anxiety
- Hesitation to answer questions, fear of being mocked, lack of confidence	- Social distress signs	
- Lack of participation in class activities, frustration, giving up easily	- Emotional reactions and cognitive signs	
Taking mathematics tests, lack of parental support, peer judgement	- External factors	Socio-emotional and contextual factors contributing to anxiety
Fear of failure, bad past experiences, panic during testing	- Test-related anxiety and prior experiences	
- Difficulty in understanding trigonometric concepts, mix up between rules and formulas	- Cognitive overload	Performance-related factors contributing to anxiety

Codes	Categories	Themes
- Unsure how to apply formula even after instruction	- Conceptual uncertainty	
- Nervousness during tests, fear of failure	- Test pressure	
- Traditional, teacher-centred instruction, lack of engagement	- Inappropriate teaching strategies	The use of ineffective teaching strategies exacerbates anxiety
- Lack of teaching and learning visual aids, failure to accommodate diverse learning styles	- Instructional factors	
- Positive reinforcement in each lesson, praise, encouragement	- Supportive feedback strategies	Supportive teaching strategies and diverse instructional methods reduce anxiety
- Extra lessons, teacher availability for help	- Learner-teacher relationships and interactions	
- Use of visual aids, relating mathematics to daily life with examples, incorporating practical problems	- Engaging teaching techniques	
Making mistakes a natural part of learning	Creating a positive learning environment	

4.3 Presentation and Discussion of Themes

This section will present each theme identified from the thematic analysis in detail, structured according to the categories and codes outlined in Table 2.

4.3.1 Theme 1: Observable Signs of Mathematics Anxiety

This theme captures the behavioural, emotional, and social manifestations of anxiety observed in learners during trigonometry lessons. Data from classroom observations, open-ended questionnaires, and interviews revealed how anxiety was visibly expressed through avoidance behaviours, low confidence, and emotional withdrawal.

4.3.1.1 Behavioural Signs of Anxiety

Avoidant Behaviour

Learners displayed a range of avoidant and disengaged behaviours during trigonometry lessons. For example, 14 out of 20 learners in School A avoided making eye contact with the teacher during instruction and showed reluctance to participate in discussions or problem-solving tasks. These behaviours were particularly noticeable in lessons involving fundamental concepts such as solving right-angled triangles and applying Pythagoras' Theorem. In Lesson 1 of School A, the teacher introduced the topic by emphasising how to label each side of a triangle based on a given angle—defining the hypotenuse, opposite, and adjacent sides. However, the lesson was dominated by teacher talk, with minimal learner interaction. Most learners were only watching, not taking notes, and not attempting to solve any examples. The notes demonstrated by the teacher—such as the positioning of triangle sides and explanation of Pythagoras' Theorem—were not recorded by the learners, reflecting a missed opportunity for active engagement. Figure 1 illustrates the teacher's sample notes from this session.

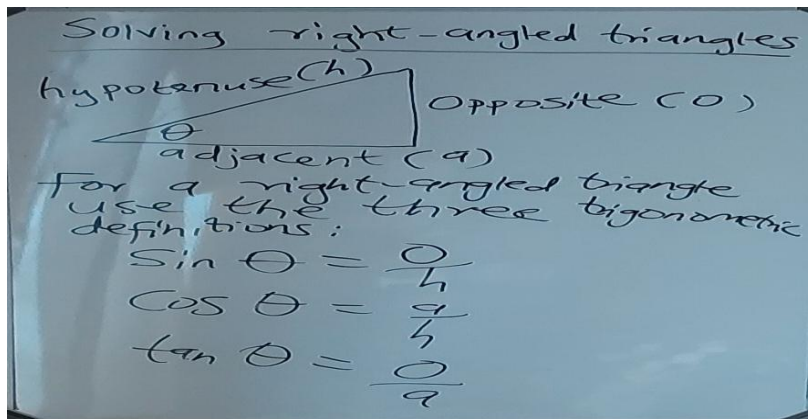


Figure 1: Teacher's Sample Class Notes on Solving Right-Angled Triangles

Avoiding Eye Contact

In addition to the 14 learners who avoided eye contact, 11 out of 20 learners in School A were specifically observed displaying avoidant behaviour during lesson interactions. This avoidant behaviour—refusing to engage when prompted or hesitating to attempt questions—was a clear indicator of rising frustration linked to their difficulty in understanding the content. In School A, for example, 14 out of 20 learners were noted as avoidant and disengaged during a lesson focused on right-angled triangles. These learners showed difficulty in applying the three trigonometric ratios—sine, cosine, and tangent—and struggled with algebraic manipulations needed for solving triangle problems.

During the diagnostic test in School A, six out of 20 learners exhibited avoidant behaviours such as neglecting the basics of Grade 10 trigonometry. These learners also showed difficulty in concentrating and focusing on test questions. These errors were predominantly conceptual in nature. Learners demonstrated misunderstandings in identifying and applying trigonometric principles from previous grades. The errors were rooted in a lack of understanding of Pythagoras' Theorem—a concept introduced in Grade 9—as well as difficulty in distinguishing the hypotenuse, opposite, and adjacent sides of a triangle. One learner LA 17 stated, "Trigonometry is difficult and it makes me scared," reflecting emotional distress tied to conceptual

confusion. This was supported by LA 11, who echoed, "Trigonometry is difficult and it makes me to be scared." Figure 2 illustrates LA 17's written response to Question 1.1, where the learner misidentified triangle components—a pattern also evident in Table 8, where six out of 20 (30%) learners in School A made conceptual errors. These results reinforce the challenges learners faced with foundational trigonometric knowledge.

$$1.1 \frac{\sin 25^\circ \times k}{1} = 24$$

$$k \times 1 = 24 \sin 25^\circ$$

$$k = 10$$

Figure 2: LA 17's Written Response to Question 1.1 from Diagnostic Test

Lack of Focus in the Class

Physical manifestations of anxiety were also noted. In School A, 14 out of 20 learners were observed fidgeting, tapping their pens, or showing signs of restlessness during lessons on right-angled triangles and trigonometric ratios. In one case, a learner was even observed sleeping during a lesson, indicating a complete disengagement from the learning process. These behaviours were attributed to the passive, teacher-centred instruction style, where learners were expected to absorb information without active engagement or scaffolding. In both schools, lessons were often delivered in a lecture-style format, limiting opportunities for learners to ask questions, engage with examples, or receive tailored feedback. This instructional approach likely exacerbated learners' anxiety and discouraged them from participating actively in trigonometry lessons.

Classroom observations further revealed that even when learners made mistakes, they were hesitant to seek clarification. For example, 13 out of 20 learners in School A refrained from asking questions during lessons, a pattern attributed to fear of being judged or mocked by their peers. For instance, in Lesson 1 of School A, despite

visible confusion, no learners raised questions or asked for help. This lack of interaction compounded their frustration and deepened their anxiety.

In School B, similar behavioural signs of anxiety were observed. In particular, 19 out of 20 learners displayed procedural errors when answering Question 1.1 in the diagnostic test. These errors often involved incorrect application of trigonometric rules, such as using Pythagoras' Theorem without considering quadrant-based sign conventions. For example, learner LB 20 attempted to apply Pythagoras' Theorem but failed to use the CAST diagram to determine the correct sign of the answer. While the response was mathematically structured, the learner concluded with an incorrect positive value instead of a negative one. This procedural misunderstanding is illustrated in Figure 3, which presents LB 20's response to Question 1.1. Learner LB 20 commented, "I practise a lot and I do not get marks I expect," highlighting frustration linked to unproductive effort and anxiety. This was supported by another learner, LB 4 who remarked, "I always focus but not understanding," pointing to anxiety linked to procedural confusion and lack of conceptual clarity. The learner remarked, "I practise a lot and I do not get marks I expect," which reflects the anxiety tied to performance pressure and procedural uncertainty.

11. $r^2 = x^2 + y^2$
 $(25)^2 = (k)^2 + (24)^2$
 $625 = k^2 + 576$
 $625 - 576 = k^2$
 $\sqrt{49} = \sqrt{k^2}$
 $7 = k$
 $\therefore k = 7$

①

Figure 3: LB 20's Written Response to Question 1.1 from Diagnostic Test

Further evidence of anxiety in School B included learners' hesitance to ask questions and visible signs of disengagement during lessons. In one observed lesson, 16 out of 20 learners avoided eye contact with the teacher. Additionally, 14 learners exhibited fidgeting or restlessness during instruction, consistent with physical signs of discomfort and passive engagement due to teacher-centred delivery. Learners avoided eye contact and refrained from participating in class discussions due to fear

of being judged or mocked. For example, in one lesson, 16 out of 20 learners avoided raising their hands or responding to questions even when they appeared confused.

Responses from the learner questionnaires further illustrated how these behavioural signs were linked to internal feelings of fear, tension, and low self-belief. For instance, learners reported being "scared," "stressed," or "uncomfortable" when faced with trigonometric content. Notable examples include:

LA 3: "Trigonometry is difficult and it makes me to be scared."

LA 9: "Sometimes I am tensed when doing reduction of general solution."

LA 10: "I am stressed due to lack of knowledge and understanding."

LA 12: "I feel uncomfortable because I am not good at mathematics."

LA 20: "I feel bad because when the teacher teaches trigonometry, I don't hear anything."

LB 1: "I am stressed when I face a difficult aspect in trigonometry."

LB 5: "I am worried that I cannot pass trigonometry, but I have encouraged myself that I can do it even if it is hard."

LB 8: "I feel nervous because I don't fully understand."

These responses reinforce the observed behavioural signs of disengagement, avoidance, and cognitive shutdown, revealing how emotional states directly impact learner participation and performance in mathematics.

These behavioural patterns were documented across four separate lesson observations conducted in both School A and School B. For example, in Lesson 1 of School A, which focused on solving right-angled triangles, many learners struggled to apply foundational concepts such as Pythagoras' Theorem and trigonometric ratios. In Lesson 2, involving the application of sine, cosine, and area rules, learners continued to exhibit avoidant behaviours when encountering multi-step problems. Similar anxiety-related behaviours persisted in Lessons 3 and 4, especially during the use of abstract concepts or geometry-based applications. These consistent patterns suggest that anxiety was not situational but rather sustained across instructional contexts.

In summary, behavioural signs of mathematics anxiety were evident across both schools in learners' avoidant behaviours, physical restlessness, and lack of engagement. These signs reflect a deeper discomfort and fear related to the learning of trigonometry, largely exacerbated by inadequate instructional approaches and lack of learner support.

In lesson 1 of School A (solving right-angled triangles), 14 out of 20 learners showed the behavioural signs of anxiety. They were avoiding the teacher as if they knew the basics of trigonometry, but they struggled. It made them frustrated. The anxiety was observed in a specific group of learners who had a prior knowledge gap in right-angled triangles. They were learning how to solve right-angled triangles with an emphasis on finding the sizes and angles. It was difficult for the learners to use three trigonometric definitions for a right-angled triangle, and they found it difficult to apply relevant algebraic manipulations when working with the solving of right-angled triangles. Learners were taught how to solve right-angled triangles and also how to use the theorem of Pythagoras. The teacher emphasised that when solving a right-angled triangle, each side is labelled based on a given angle. The hypotenuse is the longest side of the triangle, which is always opposite to the right angle, the opposite side is the side opposite to the given angle.

During Lesson 1 at School A, one of the learners was sleeping in the classroom. This was probably due to the teacher's use of teacher-centred methods in which learners were only listening and watching, becoming passive participants. The lesson was more abstract; the teacher did not relate the lesson to learners' daily encounters. Again, learners were afraid to answer questions because of the fear of being judged and mocked by their peers. This triggers mathematics anxiety in learners. Learners were not given time for questions and discussions. Furthermore, learners' different learning styles were not considered as the teaching approach did not accommodate every learner. During the lesson, 16 out of 20 learners avoided eye contact with the teacher. They were afraid to be judged and labelled for not participating in the teaching and learning of trigonometry. Again, learners did not ask any questions for clarification because they were afraid to be judged by their peers for giving wrong answers. Additionally, 14 out of 20 learners exhibited fidgeting behaviour, starting to make small movements with their hands. They did not pay attention while the teacher

was teaching. They showed signs of discomfort and restlessness. The learners were not patient enough to listen, and they ended up tapping their pens.

Extracts from some of the responses from the questionnaires illustrate these findings, thus:

LA 4: "Because other learners laugh at you."

LA 15: "Sometimes learners laugh at you when you are asking questions."

LA 12: "I feel uncomfortable because I am not good at mathematics."

LA 14: "I feel nervous."

LB 3: "Ashamed and sad."

LB 6: "I do but I am shy and learn slowly."

LB 17: "I feel bad and worried."

LB 19: "I don't feel good."

On the other hand, in Lesson 2 at School B (application of the sine, cosine and area rules) 14 out of 20 learners had difficulty in applying sine, cosine and area rules. They mixed them up by using the sine rule where they were supposed to use the cosine rule. That is, they used the sine rule when they were given three sides and they were supposed to calculate an angle. This happened again when two sides were given and they were supposed to calculate the third side. On the other hand, they used the cosine rule when two sides and an angle were given instead of using the sine rule. They also lacked prior knowledge of algebra and geometry, that was needed to calculate the missing angles and sides.

There were times when learners did not actively participate or engage in the lesson. That happened when they came across challenging and difficult aspects in the lesson that made them feel tense. They just watched while the teacher continued teaching. When the time came to write classwork, they did not write, as they had not participated in the lesson or even copied notes during the lesson. The teacher did not relate the lesson to learners' daily encounters when he taught them. The trigonometric concept was more abstract and less relevant to real life. Additionally, the anxiety was influenced by the teaching methods used, as they were more

teacher-related and learners were not given enough time to contribute to their learning or to be active participants. Again, peers contributed to mathematics anxiety because some learners were afraid to ask or answer questions due to the fear of being judged, mocked or laughed at.

Extracts from some of the responses from the questionnaires and interview illustrate these findings:

LA 3: "Trigonometry is difficult and it makes me to be scared."

LA 9: "Sometimes I am tensed when doing reduction of general solution."

LA 10: "I am stressed due to lack of knowledge and understanding."

LA 12: "I feel uncomfortable because I am not good at mathematics."

LA 20: "I feel bad because when the teacher teaches trigonometry, I don't hear anything."

LB 1: "I am stressed when I face a difficult aspect in trigonometry."

LB 5: "I am worried that I cannot pass trigonometry, but I have encouraged myself that I can do it even if it is hard."

LB 8: "I feel nervous because I don't fully understand."

4.3.1.2 Social Distress Signs

Social distress refers to the anxiety learners experience in response to peer judgement, classroom dynamics, and social interactions within the learning environment. This theme captures how fear of ridicule or embarrassment influenced learners' willingness to participate, particularly during lessons involving complex trigonometric concepts. Such fear led many to withdraw from discussions, avoid answering questions, or stay silent even when confused.

Hesitation to Answer Questions

Classroom observations revealed that learners in both schools were hesitant to engage publicly. In Lesson 2 of School A, 13 out of 20 learners refrained from raising their hands, despite being visibly unsure about how to solve non-right-angled triangle

problems. Similarly, in School B, nine out of 20 learners were observed avoiding participation for fear of being judged. During lesson interactions, some learners who attempted to answer questions and got them wrong were laughed at by their peers, which discouraged further participation.

This was echoed in questionnaire responses:

LA 4: "Because other learners laugh at you."

LA 15: "Sometimes learners laugh at you when you are asking questions."

LB 6: "I do but I am shy and learn slowly."

LB 3: "Ashamed and sad."

LB 17: "I feel bad and worried."

LB 19: "I don't feel good."

Such responses highlight how peer interactions shaped learner self-perception and participation.

Lack of Confidence

Lesson 2 at School A, which focused on solving non-right-angled triangles using sine and cosine rules, serves as a clear example of learners' lack of confidence. Thirteen out of 20 learners appeared visibly unsure and reluctant to participate. Many confused sine and cosine rules, defaulting to strategies used for right-angled triangles. Their lack of prior knowledge contributed to their social withdrawal, as they were afraid to raise their hands or share ideas. In Lesson 3, which built on the same concepts, 12 out of 20 learners showed low confidence, with several avoiding eye contact, looking down, or doubting their abilities. These observations suggest that content unfamiliarity reinforced feelings of shame and peer anxiety. The emotional weight of social judgement was particularly strong among learners who lacked confidence in their understanding of trigonometry. This lack of confidence created a cycle in which fear of embarrassment led to non-participation, which in turn reinforced feelings of inadequacy.

In both schools, it was observed that, even when teachers encouraged participation, the classroom environment did not always feel psychologically safe for all learners.

In some cases, learners were willing to engage only in one-on-one discussions with the teacher or preferred to seek help privately.

Fear of Being Mocked

Questionnaire data further confirmed these patterns, with nine out of 20 learners in School A and seven out of 20 in School B expressing discomfort or low confidence in social learning situations. While some learners demonstrated a growth mindset and were willing to make mistakes as part of the learning process, others withdrew entirely, fearing judgement from peers. Teachers responded by using subtle forms of encouragement—such as thumbs up, smiling, or saying “good work”—to reinforce participation and reduce anxiety. This helped create a more supportive classroom climate, though not all learners responded equally. Learners with persistent low confidence reported feeling unmotivated, reluctant to attend class, or hesitant to engage. These findings suggest that social distress not only disrupts learning in the moment but can also have lasting effects on self-esteem, academic risk-taking, and emotional well-being.

Extracts from some of the responses from the questionnaires illustrate these findings as follows:

LA 2: “Tired and anxious.”

LA 12: “I feel uncomfortable because I am not good in mathematics.”

LA 14: “I feel nervous.”

LA 15: “Sometimes learners laugh at you when you are asking questions.”

LB 2: “Learning trigonometry to me is very hard.”

LB 13: “My confidence is very poor.”

LB 15: “Our peers laugh at others when they ask.”

LB 19: “I have low confidence.”

LB 20: “My confidence is not well.”

Such responses highlight how social interactions shaped learner confidence.

4.3.1.3 *Emotional Reactions and Cognitive Signs*

Lack of Participation in Class Activities

This category refers to the emotional expressions and cognitive disengagement learners displayed in response to trigonometric content. Emotional signs such as sadness, hopelessness, fear, guilt, and stress were frequently observed and self-reported. These symptoms emerged when learners felt overwhelmed by complex content, struggled to understand instructions, or feared failure and ridicule. Cognitive signs included passive learning behaviours, lack of problem-solving attempts, poor memory recall during tests, and difficulty applying known rules and formulas.

Most of the learners did not participate fully in class discussions because the lesson was teacher-centred. The teacher dominated the lesson, so there was no time for active participation of learners. Thus, most learners were only watching while the teacher was teaching. Even though learners were supposed to take notes during Lesson 1 at School A (solving right-angled triangles), they did not take notes. In that lesson, learners were taught how to solve right-angled triangles and how to use Pythagoras' theorem.

In School A, for instance, during Lesson 1 on solving right-angled triangles, 12 out of 20 learners did not participate in classroom discussion, and 11 learners disengaged entirely. These learners did not take notes, refused to attempt classwork, and failed to ask for clarification even when confused. In the same lesson, 12 out of 20 learners did not participate in the classroom task, while only eight engaged. Additionally, 11 learners were fully disengaged, compared to nine who showed some level of interaction. Learners who did not participate often lacked the algebraic and calculation skills needed to manipulate equations or isolate variables. During this session, the teacher provided a worked example demonstrating how to solve a right-angled triangle problem using trigonometric principles, as shown in Figure 4. The example featured triangle EFD, where EF was the unknown side 'd', angle EFD was θ , side FD measured 58 cm, and side ED was 32 cm.

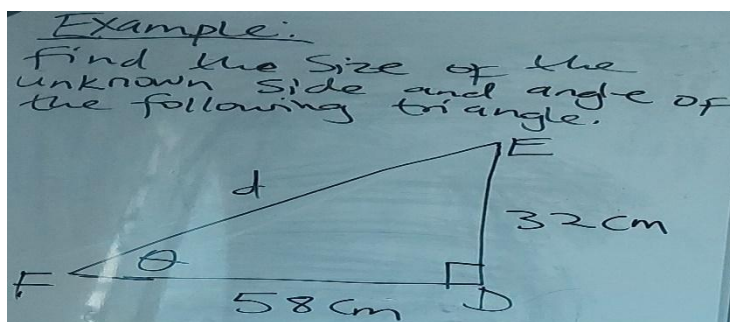


Figure 4: Sample Example of Solving the Right-Angled Triangle Problem

Learners were expected to calculate both the missing side and angle using either trigonometric ratios or Pythagoras' Theorem. This was followed by a class activity, which most learners did not attempt. Their lack of participation was attributed to both low confidence and poor conceptual understanding. Figure 5 presents the class activity task, which involved solving two right-angled triangle problems: the first required learners to calculate the missing side of triangle ABC given an angle of 69 degrees and side AB measuring 24 cm; the second involved a triangle with hypotenuse AC measuring 13 cm and opposite side AB at 12 cm.

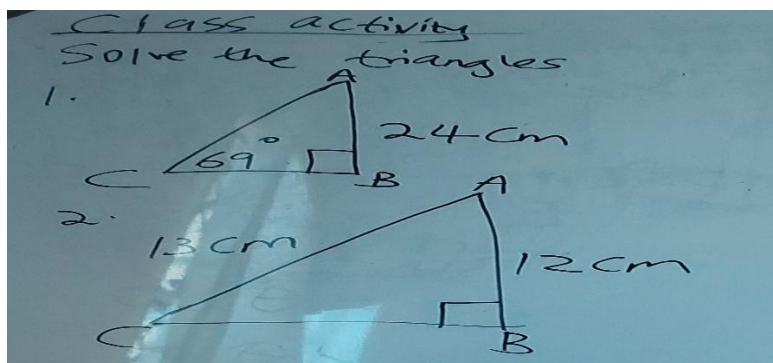


Figure 5: Learner's Sample Class Activity on Solving Right-Angled Triangle

Frustration

Despite the opportunity to apply the concept demonstrated, several learners did not engage. This was compounded by the teacher's continued reliance on teacher-centred methods, limited use of visual aids, and failure to accommodate diverse

learning styles. As a result, learners displayed signs of frustration, spoke negatively about their abilities, and eventually disengaged. Despite receiving support, most disengaged learners failed to follow or apply the steps independently, indicating both cognitive overload and emotional withdrawal. Many appeared emotionally withdrawn. One learner was observed sleeping in class, while others tapped pens or fidgeted—non-verbal indicators of frustration or mental fatigue. The learners also showed poor algebraic manipulation skills, which further diminished their motivation to engage. These signs were compounded in Lesson 4, where learners had to apply triangle rules to solve multi-step problems. Several learners gave up without trying or remained silent, afraid to make mistakes.

In School B, similar cognitive and emotional symptoms emerged. Learners were often overwhelmed by abstract or unfamiliar content. In one lesson on applying triangle rules in real-life contexts such as navigation, 16 out of 20 learners appeared mentally blocked and disengaged. They showed confusion in selecting appropriate rules and lacked confidence in their answers. This led to a visible shutdown in participation, with many not completing activities or asking for support. Some learners expressed feelings of helplessness in interviews, suggesting a deep internal struggle with mathematics.

The learner questionnaires support these findings:

LA 10: "I get stressed."

LA 14: "I am very sad."

LA 17: "I feel bad."

LB 3: "Bad, failure, because I don't understand that much about mathematics and I have tough time during maths periods."

LB 6: "I feel as if I cannot do it because I don't understand much about trigonometry."

LB 12: "I feel guilty because I don't understand trigonometry clearly."

LA 20: "I feel bad because when the teacher teaches trigonometry, I don't hear anything."

LB 13: "I don't feel good because it is one of the chapters that I really struggle with."

Learners Giving up Easily

Additionally, the emotional and cognitive distress was intensified by instructional methods. Lessons were frequently teacher-centred, lacking differentiation and support for diverse learning styles. No visual aids, manipulatives, or real-life contextualisation were used. This made trigonometry seem more abstract and disconnected, which in turn increased feelings of failure, isolation, and disengagement.

In many cases, learners were present in the classroom but mentally absent. Some merely copied down notes without processing the information, while others stared at their books or avoided eye contact altogether. These behaviours indicate a breakdown in both emotional resilience and cognitive functioning, consistent with the phenomenon of academic shutdown.

These emotional and cognitive signs highlight the depth of mathematics anxiety as experienced internally by the learners. Unlike social distress, which is driven by peer dynamics, emotional and cognitive anxiety is rooted in learners' internal struggles with content mastery, lack of conceptual understanding, and fear of failure. These findings indicate that mathematics anxiety manifests through emotional withdrawal, cognitive shutdown, and disengagement. This theme directly responds to Research Question 1 by illustrating how internalised stress and limited cognitive readiness hinder learners' ability to engage meaningfully with trigonometric content and classroom activities.

During Lesson 1 at School A, 12 out of 20 learners did not participate, whereas eight learners participated. Those who did not participate or engage had poor algebraic skills, particularly in making a variable the subject of a formula, as well as poor calculation skills. During the teaching and learning process, the teacher gave examples of questions concerning what he had taught about solving right-angled triangles.

Learners did not show any interest in learning trigonometry because their teacher did not accommodate their different learning styles. One of the learners was sleeping while the teacher was teaching, and the engagement of other learners was very limited during the lesson due to fear of being mocked and laughed at. They were only following the teacher's directions without making any contribution of their own.

Learners were frustrated and started to talk negatively about themselves. This resulted in them giving up easily and losing interest in learning trigonometry. This was also influenced by the teacher-centred approaches that were used by the teacher. Extracts from some of the questionnaire responses illustrate these findings:

LA 10: "I get stressed."

LA 14: "I am very sad."

LA 17: "I feel bad."

LB 3: "Bad, failure, because I don't understand that much about mathematics and I have tough time during maths periods."

LB 4: "I feel like I need to study harder because I know that if I study hard, I will perform well."

LB 6: "I feel as if I cannot do it because I don't understand much about trigonometry."

LB 12: "I feel guilty because I don't understand trigonometry clearly."

Such responses highlight how emotional reactions shaped learner engagement and participation.

4.3.2 Theme 2: Socio-Emotional and Contextual Factors Contributing to Anxiety

This theme focuses on influences beyond immediate classroom behaviour that shape how learners' approach and experience trigonometry. In the data, peer judgement, limited support at home, prior negative experiences with mathematics, and teaching practices were recurring issues. These factors often intersected and contributed to lower confidence and reduced participation.

4.3.2.1 External Factors

External factors refer to influences outside the lesson that affect learners' readiness to engage. In the data, three issues were evident: home/parental support, peer judgement beyond the lesson, and availability of resources.

Parental Support

Questionnaire responses showed mixed experiences. Some learners reported encouragement at home, for example:

LA 1: "They support me and tell me to be strong; they think mathematics is the best for me."

LA 2: "My parents support me, and they keep telling me to practise if I want to make it in life."

LA 6: "They support and encourage me to do well."

LB 5: "They advise and encourage me and say I must practise maths because it is the key to success."

LB 12: "They assist me every day to do well."

Others reported limited or negative support, for example:

LA 5: "I don't have someone who encourage me when I am studying."

LB 13: "My parents do not give me any support."

LB 16: "They don't show any support and favour."

LB 19: "My parents are not happy because they think I will not make it."

These differences in home conditions were linked to learners' confidence and preparedness for class activities.

Peer Judgement Beyond the Lesson

Learners compared themselves with others and worried about being judged before activities even started. In Lesson 2 at School B, 13 out of 20 learners were shy to share their work because they were afraid to be judged and laughed at by peers. In Lesson 2 of School A, 10 out of 20 learners showed similar hesitation. This pressure carried into lessons and discouraged participation.

Resource Constraints and Diagnostic Performance

In the diagnostic test (general solution), four out of 20 learners in School B started Question 2.3 well but displayed procedural errors. One learner (LB 4) applied algebra

using the additive inverse but struggled with factorisation (extracting the common factor $\cos x$) and did not justify their steps. The learner added, "Our school does not have teaching resources that are used in the class" (Figure 6).

2.3 $\sqrt{2} \sin x \cos x = \cos x$
 $\sqrt{2} \sin x \cos x - \cos x = 0$
 $\sqrt{2} \sin x 2 \cos x = 0$ X

Figure 6: Diagnostic Test Q2.3 (School B)—Learner LB 4

As evidenced by Figure 6, above, the learner used the additive inverse correctly. However, it was difficult for them to do the next step correctly, and the learner did not proceed correctly where factorisation was supposed to be applied. Therefore, the learner failed to arrive at the solution.

I asked a question: "What is your view on the use of teaching resources in learning trigonometry?" Another learner (LB 11) stated, "The use of teaching resources can make me to fail if I do not understand."

In School A, six out of 20 learners displayed procedural errors on Question 2.3; learners partially applied correct rules but did not follow all required procedures or justified their steps (Figure 7).

2.3 $\sqrt{2} \sin x \cos x = \cos x$
 $\sqrt{2} \sin x \cos x - \cos x = 0$
 $\cos x (\sqrt{2} \sin x - 1) = 0$
 $\cos x > 0$ or $\sqrt{2} \sin x - 1 = 0$
 $\sin x = \frac{1}{\sqrt{2}}$

Figure 7: Diagnostic Test Q2.3 (School A)—Learner LA 17 - Example of Procedural Error

From Figure 7, above, it can be seen that the learner displayed a procedural error when trying to determine the general solution of the trigonometrical equation. LA 17 partially applied the correct rule to a question, showing she possessed some knowledge required in the question. However, she failed to follow all the required procedures. She worked out the problem but only solved part of it correctly and she did not justify every step when solving the equation to enhance understanding.

I asked the question: “What is your view on the instructional practices used by a teacher in trigonometry teaching that can contribute to mathematics anxiety?” Learner LA 17 noted, “The instructional practices that are used by a teacher contribute to mathematics anxiety.” LA 11 added, “The instructional practices used by a teacher do not make me to enjoy trigonometry.”

Taken together, limited home support, fear of peer judgement, and resource constraints set the stage for anxiety that later appears as silence, hesitation, or withdrawal in class.

4.3.2.2 Test-Related Anxiety and Prior Experience

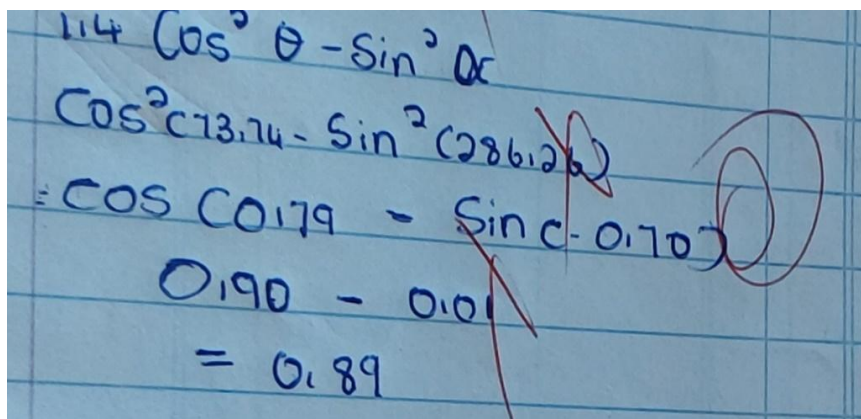
Learners with negative or uncertain experiences in mathematics reported feeling tense during assessments. This was visible in lessons and diagnostic tasks.

Lesson Observations

In Lesson 4 at School A (application of triangle rules using numerical values), 14 out of 20 learners had difficulty working with prior geometry basics and were afraid to be judged if they asked questions. In Lesson 1 at School B (solving triangles with no right angles), 16 out of 20 learners were not comfortable seeking help from peers or the teacher due to fear of judgement and gaps in prior knowledge about the sum of angles in a triangle.

Diagnostic Evidence

Beyond the patterns already noted for Question 1.1 (see Tables 3 and 4), further evidence appeared in Question 1.4. In School B, 15 out of 20 learners made conceptual errors on 1.4; learners lacked prior knowledge of operations with common fractions and relied on calculators, producing decimals where fraction work was required (Figure 8).



The image shows a student's handwritten work on a grid background. The work is as follows:

$$\begin{aligned} &1.4 \cos^2 \theta - \sin^2 \theta \\ &\cos^2(13.74) - \sin^2(286.26) \\ &= \cos(0.179) - \sin(-0.707) \\ &0.90 - 0.01 \\ &= 0.89 \end{aligned}$$

There are red markings on the work: a large red 'X' is drawn over the entire calculation, and a red circle is drawn around the final answer, 0.89.

Figure 8: Diagnostic Test Q1.4 (School B)—Learner LB 20

Figure 8, above, reveals that the learner displayed a conceptual error, indicating a lack of prior knowledge about the addition and subtraction of common fractions. This was evident in her use of decimal numbers. Additionally, she had difficulty in applying the basics of trigonometry. She got the answer by using a calculator, without showing conceptual understanding.

I asked a question: “Do you normally get anxious or worried when learning trigonometry? And if so, why?” LB 20 remarked, “I practise a lot and I do not get marks I expect because of worry and fear.” LB 4 added, “I cannot do trigonometry, and I am also scared because there are many diagrams.”

In School A, 10 out of 20 learners made conceptual errors on 1.4 and used calculators where they were not required. This resulted in decimal answer (Figure 9).

$$1.4. \cos^2 \theta - \sin^2 \theta = 1$$

$$\cos\left(\frac{-7}{24}\right)^2 - \sin(286,26) = 1$$

Figure 9: Diagnostic Test Q1.4 (School A)—Learner LA 11

From Figure 9 above, it can be seen that the learner displayed a conceptual error, indicating a lack of conceptual understanding of trigonometric ratios and common fractions. Additionally, he used a calculator when it was not supposed to be used, which resulted in decimal fractions.

I asked: “How do you view the study of trigonometry? When you think about a test that you failed, does that motivate you to do better, or does that make you scared of trigonometry?” LA 11 said, “Trigonometry is difficult and it makes me to be scared,” and LA 17 stated, “I am worried and afraid of trigonometry.”

These patterns indicate that prior difficulties and test settings increased anxiety during assessment, which slowed problem solving and led to avoidant behaviour.

4.3.2.3 Instructional Practices and Teaching Style

Across observations, lessons were teacher-centred with extended teacher talk and limited interaction. Visual supports and concrete examples were seldom used. These conditions matched patterns already described in Theme 1 and were associated with quiet classes, minimal note-taking, and limited voluntary participation.

Observation Detail

In Lesson 1 at School A (solving right-angled triangles and stating/using Pythagoras’ Theorem), learners mostly watched and became passive participants; one learner fell asleep. In Lesson 2 at School B (application of sine, cosine, and area rules), learners mixed rules (e.g., using the sine rule when three sides were given and an

angle was required, or using the cosine rule when two sides and an angle were given), and there was little interaction because of lecture delivery (Figures 10–12).

Using theorem of Pythagoras to solve right angled triangle
 Pythagoras' theorem states that, for a right-angled triangle,

$$c^2 = a^2 + b^2$$

 With this result it is very easy to calculate the length of the hypotenuse of a right-angled triangle

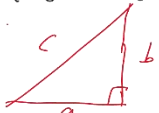


Figure 10: Lesson 1 School A

Solving triangles that are not right-angled
The Sine rule

$$\frac{a}{\sin A} = \frac{b}{\sin B} = \frac{c}{\sin C} \quad \text{or} \quad \frac{\sin A}{a} = \frac{\sin B}{b} = \frac{\sin C}{c}$$

 The Sine rule is used if two angles and a side or two sides and the non-included angles are given.

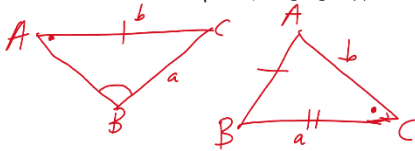
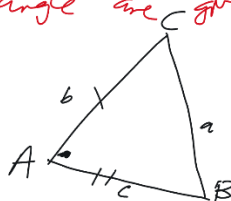


Figure 11: Lesson 2 School B

The Cosine rule
 When two sides and the included angle are given

$$\begin{aligned} a^2 &= b^2 + c^2 - 2bc \cos A \\ b^2 &= a^2 + c^2 - 2ac \cos B \\ c^2 &= a^2 + b^2 - 2ab \cos C \end{aligned}$$



The Cosine rule is used in this form to determine the third side of a triangle when two sides and the included angle are given

Figure 12: Lesson 2 School B

Teacher Perspectives

Teachers A and B, when asked whether instructional practices contribute to mathematics anxiety in learning trigonometry, responded:

Researcher: “Do you think instructional practices contribute to mathematics anxiety in learning trigonometry?”

Teacher A: “Yes, the instructional practice is teacher-centred, learners are bored and it leads to mathematics anxiety.”

Teacher B: “Yes, learners need instructional practices that will make them to be involved.”

Both teachers used teacher-centred strategies in their lessons, and learners were passive participants. When instruction left little room for questions, practice, or visual support, anxious learners withdrew further, and those already unsure of basics struggled to re-enter the lesson.

Taken together, these socio-emotional and contextual factors help explain why anxiety persisted beyond single lessons. Limited home support, pressure from peers, test histories, and teacher-centred delivery worked together to lower confidence and reduce participation. This theme responds directly to Research Question 2 by showing how context shapes learners’ anxiety during trigonometry.

4.3.3 Theme 3: Performance-Related Factors Contributing to Anxiety

This theme focuses on how performance demands—understanding content, managing multi-step work, and writing tests—contributed to learner anxiety. The evidence comes from lesson observations, diagnostic scripts, and learner/teacher questionnaires.

4.3.3.1 Cognitive Overload

In this study, cognitive overload arose when tasks or explanations exceeded learners’ working memory limits. Overload was visible when learners had to process several new ideas at once or move too quickly from demonstration to independent work.

Lesson Evidence

In Lesson 4 at School B (application of triangle rules in navigation), 16 out of 20 learners were overwhelmed by the amount of new information (e.g., bearings and surveying contexts). The abstract framing made it hard for learners to link rules to procedures. In Lesson 4 at School A (applying triangle rules with numerical values), 15 out of 20 learners showed similar strain when sine and cosine relationships were introduced together.

Questionnaire support (selected examples, verbatim):

How is your confidence in the learning of trigonometry?

LA 12: "I feel uncomfortable because I am not good at mathematics."

LB 5: "I am worried that I cannot pass trigonometry, but I have encouraged myself that I can do it even if it is hard."

LB 8: "I feel so stressed much about headache because I don't achieve well."

Diagnostic evidence (Q2.2: proving trigonometric identities):

In School A, six out of 20 learners displayed procedural errors: they began with correct computations but did not use factorisation or standard identities to complete the proof. This is shown in Figure 13 (LA 17).

2.2 $\frac{1}{\tan^2 x} = \cos^2 x = \frac{\cos^4 x}{\sin^2 x}$

RHS $\frac{1}{\frac{\sin^2 x}{\cos^2 x}} = \cos^2 x$

$\frac{1}{\sin^2 x} = \frac{\cos^4 x}{\sin^2 x}$

$\frac{1 - \cos^2 x}{\sin^2 x}$

$\frac{\cos^4 x}{\sin^2 x}$

RHS = LHS

Figure 13: Diagnostic Test Q2.2 (School A)—Learner LA 17's Written Response

Figure 13 above, reveals that the learner used the correct common denominator, but the application of algebraic rules was incorrect. The learner failed to simplify to the stage of factorisation, which is why it was difficult to proceed with the proof.

Researcher: “Do you normally get anxious or worried when learning trigonometry? If so, why?”

LA 17 (interview): “Sometimes when I face some difficult aspect in trigonometry, I do not participate in the lesson.”

LA 7: “I am not good in mathematics and it is difficult.”

In School B, four out of 20 learners displayed procedural errors on Q2.2. Learners followed early steps but faltered when multiple identities were required. This is shown in Figure 14 (LB 4).

2.2 LHS = $\frac{1}{\tan^2 x} - \cos^2 x$
 $= \frac{1}{\frac{\sin^2 x}{\cos^2 x}} - \cos^2 x$
 $= \frac{\sin^2 x}{\cos^2 x} - \cos^2 x$

The student's work shows several procedural errors. In the second line, the denominator $\cos^2 x$ is crossed out and a '1' is written in a circle. In the third line, the expression is written as $\frac{\sin^2 x}{\cos^2 x} - \cos^2 x$, which is incorrect because the denominator $\cos^2 x$ should be distributed to both terms in the numerator, resulting in $\frac{\sin^2 x - \cos^4 x}{\cos^2 x}$. The final line shows the student's incorrect result.

Figure 14: Diagnostic Test Q2.2 (School B)—Learner LB 4’s Written Response

As shown in Figure 14 above, the learner correctly used the correct common denominator, but the application of algebraic rules was incorrect. The learner failed to simplify the expression to the stage of factorisation, which led to the incorrect answer.

Researcher: “Do you normally get anxious or worried when learning trigonometry? And if so, why?”

LB 4 (interview): “It is hard to understand in terms of finding solutions, I am always focused but not understanding.”

LB 20: “I practise a lot and I do not get marks I expect.”

4.3.3.2 *Conceptual Uncertainty*

Uncertainty about fundamental ideas (triangle types, when to use trigonometric ratios vs. sine/cosine rules, and basic Pythagoras) contributed to anxiety.

Lesson Evidence

In Lesson 1 at School B (solving triangles with no right angles), 11 out of 20 learners lacked prior knowledge about triangle types, and 12 out of 20 mixed up the sine and cosine rules. Teaching aids were not used, and the lesson was teacher-centred. In Lesson 1 at School A, 12 out of 20 learners showed uncertainty about Pythagoras' Theorem and the basics of right-angled triangles, including identifying triangle types and finding the length of missing sides.

Teacher Perspectives

When do learners normally get anxious when learning trigonometry? Is it during lessons? Or when writing class activities and tests?

TA (questionnaire): "Learners often mix trigonometric ratios with trigonometric rules and formulas."

TB (questionnaire): "A weak foundation in other sections like algebra can play a part."

How is the language used in the teaching of trigonometry contributing to mathematics anxiety?

TA (interview): "Learners struggle to understand trigonometric concepts."

TB (interview): "It takes time for learners to understand what is being taught and asked, because they are not familiar with the language of trigonometry."

Learner questionnaire support (verbatim):

How do you feel when you study trigonometry?

LA 10: "I am stressed due to lack of knowledge and understanding."

LA 20: "I feel bad because when the teacher teaches trigonometry, I don't hear anything."

LB 10: "I feel nervous because I don't fully understand."

LB 13: "I don't feel good because it is one of the chapters that I really struggle with."

LB14: "I am confused because I don't understand trigonometry."

Observed Reactions

Some learners did not answer questions and remained silent; 12 out of 20 showed visible frustration, looked down, and did not persevere with difficult problems. Task avoidance included not writing and staring at books until the end of the lesson; restlessness was noted.

Diagnostic evidence (Q2.1: special angles)

In School A, 14 out of 20 learners made conceptual errors, sometimes using calculators instead of special-angle values (see Figure 15, LA 7). In School B, seven out of 20 learners made conceptual errors by mixing special angles (see Figure 16, LB 20).

The image shows a student's handwritten work on lined paper. The work is for a problem labeled '21'. The student has written several lines of trigonometric expressions, some of which are crossed out with red lines. The expressions are:

$$\begin{aligned} & 21. \frac{-\cos 210^\circ \cdot \tan 135^\circ}{\sin(-60^\circ) \cdot \cos 420^\circ} \\ &= \frac{-\cos(180+30) \cdot \tan(180+35)}{-\sin(90-30) \cdot \cos(360+60)} \\ &= \frac{-\cos 30 \cdot \tan 35}{\sin 30 \cdot \cos 60} \\ &= \frac{-\frac{\sqrt{3}}{2} \cdot 0,70\dots}{\frac{1}{2} \cdot \frac{1}{2}} \\ &= \frac{-0,606397516}{\frac{1}{4}} \\ &= -2,43 \end{aligned}$$

Red annotations include a circle around the number '0' in the decimal '0,70...', a red arrow pointing to the decimal '0,70...', and a red arrow pointing to the fraction '1/4' in the denominator of the final step. The final answer '-2,43' is also crossed out with a red line.

Figure 15: Diagnostic Test Q2.1 (School A)—Learner LA 7's Written Response

As can be seen from Figure 15 above, the learner made a conceptual error by using a calculator instead of special-angle values. The learner confused special angles, which led to an incorrect answer with a decimal number.

Researcher: “How do you view the study of trigonometry? When you think about a test that you failed, does that motivate you to do better, or does that make you scared of trigonometry?”

LA 7 (interview): “Trigonometry is difficult and I am not good in it.”

LA 17: “I am afraid of trigonometry.”

The image shows handwritten work on lined paper for a diagnostic test. The student has written two main calculations, both of which are crossed out with red lines. A red circle with the letter 'C' is drawn to the right of the work.

Calculation 1 (crossed out):

$$\frac{-\cos 210^\circ \cdot \tan 135^\circ}{\sin(-60^\circ) \cdot \cos 420^\circ}$$

Calculation 2 (crossed out):

$$\frac{-\cos 150^\circ \cdot \tan 225}{\sin 60 \cdot -\cos 60}$$

Below these, the student has written two simplified answers, also crossed out:

$$= \frac{-\sqrt{3}}{2\sqrt{3}} = \frac{-1}{2}$$

$$= \frac{-3}{2}$$

Figure 16: Diagnostic Test Q2.1 (School B)—Learner LB 20’s Written Response

Figure 16, above, reveals that the learner demonstrated a lack of understanding of the numerical reductions with special angles. He mixed up special angles, which is why he got incorrect answers.

Learners perceived trigonometric concepts as difficult. Learners reported anxiety when they could not decide which formula or rule to use.

Researcher: “Do you normally get anxious or worried when learning trigonometry? And if so, why?”

LB1 (interview): “I get anxious when I face difficult aspect in trigonometry.”

How do you feel when you study trigonometry?

Learner questionnaires (selected): LA 2: “Tired and anxious”; LA 6: “I feel nervous”; LA 10: “I am stressed due to lack of knowledge and understanding”; LA 14: “I feel nervous”; LB 2: “Sad but sometimes enjoy it”; LB 5: “I am worried that I cannot pass trigonometry but I have encouraged myself that I can do it even if it is hard”; LB 12:

“I am nervous”; LB 13: “I don’t feel good because it is one of the chapters that I really struggle with”.

Teacher illustration and activity (non-right-angled triangles).

The teacher demonstrated solving a non-right-angled triangle using the sine rule (Figure 17), followed by an individual activity where two sides and an opposite angle were given and learners had to determine the missing angle (Figure 18). A sample learner response is shown in Figure 19.

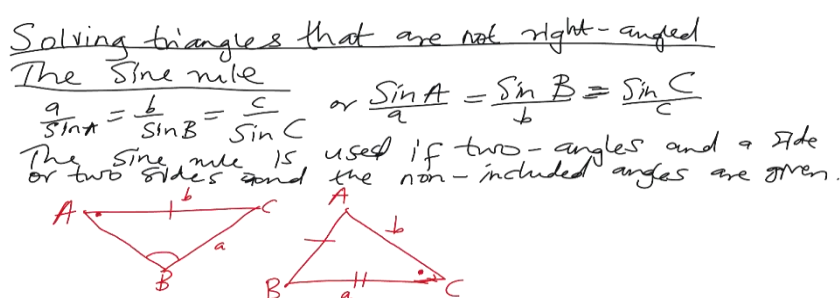


Figure 17: Teacher’s Illustration—Solving Triangles that are not Right-Angled (Sine Rule).

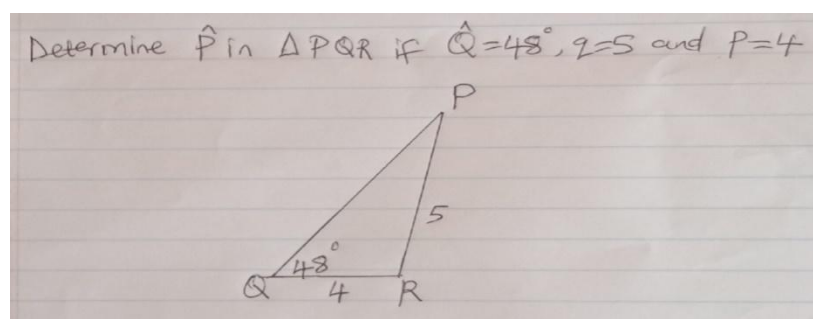


Figure 18: Learner Activity—Solving a Triangle with no Right Angle by Applying the Sine Rule

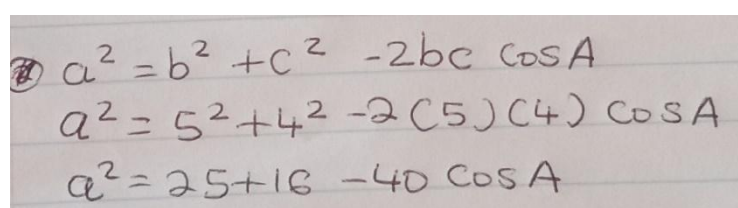


Figure 19: Learner Response—Applying the Sine Rule to a Non-Right-Angled Triangle

Table 3: Summary of Learner Challenges

Challenge faced	Explanation
Determining which rule to use	Difficulty in knowing when to use the sine or cosine rule
Using the cosine rule when the sine rule was applicable	Learners incorrectly chose the cosine rule when they had two sides and an angle opposite one of those sides
Problem solving challenge	Difficulty in visualising the problem into 2D space and lack of understanding of the real-world applications of trigonometry

4.3.3.3 Test Pressure

Signs of anxiety were visible during tests. Learners showed careless errors in calculation, hesitation at the start of the paper, and periods of inactivity.

Diagnostic evidence (Q1.3).

In School B, three out of 20 learners made careless errors by misreading and subtracting 73.74 from 360 before taking the sine ratio (see Figure 17, LB 11).

Researcher: “What is your view on understanding and managing behaviour and reactions when learning trigonometry in a classroom that can lead to mathematics anxiety?”

LB 11 (interview): “My view is that if I do not practise mathematics, I will start to worry a lot.”

LB 20: “Trigonometry is not simple, but it makes me to practise or revise those questions that I got wrong.”

$$1.3 \sin \alpha i 7 \theta + \alpha = 360^\circ$$

$$\sin \gamma = 360^\circ - \theta$$

$$= 360 - 73.74$$

$$= 286.26$$

Figure 20: Diagnostic Test Q1.3 (School B)—Learner LB 11's Written Response

As can be seen from Figure 20, the learner misinterpreted the question, and it led to a careless error. He provided the solution incorrectly by subtracting 73.74 from 360 and taking the sine ratio of the result, using a calculator when it was not supposed to be used.

In School A, three out of 20 learners made careless errors on Q1.3 by skipping steps or misinterpreting information (see Figure 18, LA 11).

Researcher: "How do you view the study of trigonometry? When you think about a test that you failed, does that motivate you to do better, or does that make you scared of trigonometry?"

LA 11: "Trigonometry is difficult and it makes me to be scared."

LA 17: "I am afraid and worried of trigonometry."

$$\begin{aligned}
 1.3 \quad \sin \alpha + \theta &= 360^\circ \\
 \sin \alpha &= 360 - \theta \\
 \sin \alpha &= 360 - 46 \\
 \alpha &= \sin^{-1}(314) \\
 \therefore &= 0.76
 \end{aligned}$$

Figure 21: Diagnostic Test Q1.3 (School A)—Learner LA 11's Written Response

As shown in Figure 21 above, learner made a careless error by skipping important steps. The learner misinterpreted the information in the question and that is why he answered the question by writing content that was not asked and rushed towards the incorrect answer.

These findings show that test conditions heightened stress, reduced accuracy, and encouraged avoidance.

Taken together, cognitive overload, conceptual uncertainty, and test pressure constrained performance and contributed to anxiety during trigonometry. This theme responds to Research Question 2 by showing how performance demands in classwork and tests shaped learners' anxious responses.

4.3.4 Theme 4: Instructional Strategies That Reduce Anxiety

This theme presents classroom practices that, in this study, were associated with lower anxiety and greater willingness to participate. Evidence came from observations, learner questionnaires, and teacher interviews. Where lessons were highly teacher-centred and abstract, learners mixed up rules, withdrew, or worked passively. Conversely, when teachers offered encouragement, were accessible in order to help, used clearer language and visual aids, as well as giving concrete examples, participation improved.

4.3.4.1 Supportive Feedback and Reinforcement

During 2D problem-solving, the teacher affirmed correct attempts (e.g., by saying “good work”). Learners reported that praise and acknowledgement encouraged them to ask questions and try. Some examples from the questionnaires are as follows:

Do you feel encouraged to ask questions and seek help in your maths class?

LA 1: “As learners we ask for help.”

LA 5: “I am encouraged to ask questions where I am not understanding.”

LA 15: “Our teacher encourages us by good words.”

LB 1: “There are others who can help me, or I could ask my teacher so that I have to know.”

LB 2: “I am encouraged to seek help in my mathematics class.”

LB 7: “I feel encouraged.”

LB 9: “Our teacher doesn’t mind; he makes sure that by the end of the lessons all of us have raised our concerns and where we struggle and no one leaves the room struggling.”

LB 10: “I feel so much free because he can be able to talk in a nice way and always find a way to make us understand.”

From the two selected schools, eight out of 40 learners reported that praise and encouragement helped them participate in trigonometry lessons.

These statements indicate that positive feedback and an open attitude from the teacher reduced fear of making mistakes and supported participation. These data show that simple, specific praise reduced fear of error and increased participation.

4.3.4.2 Learner–Teacher Relationship and Access to Help

Learners highlighted access to help and approachability as important. They were more willing to participate when they could seek clarification without being judged. Questionnaire and interview data showed learners felt able to ask questions and get

follow-up support. These findings align with observations, where encouragement led to more learner attempts during activities.

The following are examples from the questionnaires:

How does your maths teacher support or hinder your confidence in maths?

LA 6: "He always ask after every lesson if we understand."

LA 11: "He always tell us to be confident on ourselves, study and not looking down on ourselves."

LA 13: "My mathematics teacher teaches us even on extra time during studies."

LA 15: "He encourages us by good words."

LB 4: "As a learner who is confident, he will help you fully understand along with those who do not understand."

LB 8: "Our teacher allows us to attend Saturday classes for free and teaching us during afternoon studies time until 16H30."

LB 13: "He is very supportive, and he insists to help us one on one if we are not understanding in the classroom."

LB 17: "He support us by encouraging and guiding us that we must do well."

LB 19: "When I need help in mathematics, he always helps me."

LA 8: "My teacher is best in teaching mathematics, and he makes me feel like I am good in mathematics."

LA 19: "He makes things simple to us."

LB 9: "The way our teacher teaches is good and understandable."

LB 13: "He is very supportive, and he insists to help us one on one if we are not understanding in the classroom."

LB 12: "He always tries to give many examples to make us understand."

LB 15: "He is a good teacher and he teaches us in a good way."

LB 19: "When I need help in mathematics, he always helps me."

From the two selected schools, 16 out of 40 learners reported that their teacher was approachable or that they sought extra help.

Access to help and an approachable teacher coincided with more attempts by learners during activities.

4.3.4.3 Positive Learning Environment

Anxiety increased when lessons were abstract, fast-paced, or offered little interaction; however, anxiety decreased when explanations were paced, opportunities to practise were provided, and learners' concerns were acknowledged. In Lesson 2 at School B (application of sine, cosine and area rules), the lesson was teacher-centred and learners were not given an activity before the end of the explanation. The teacher illustrated when to apply each rule.

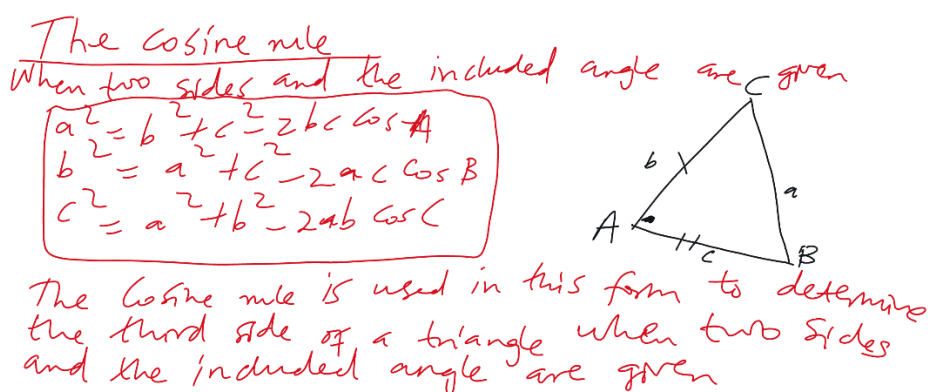


Figure 22: Teacher's Illustration—Cosine Rule (Non-Right-Angled Triangle).

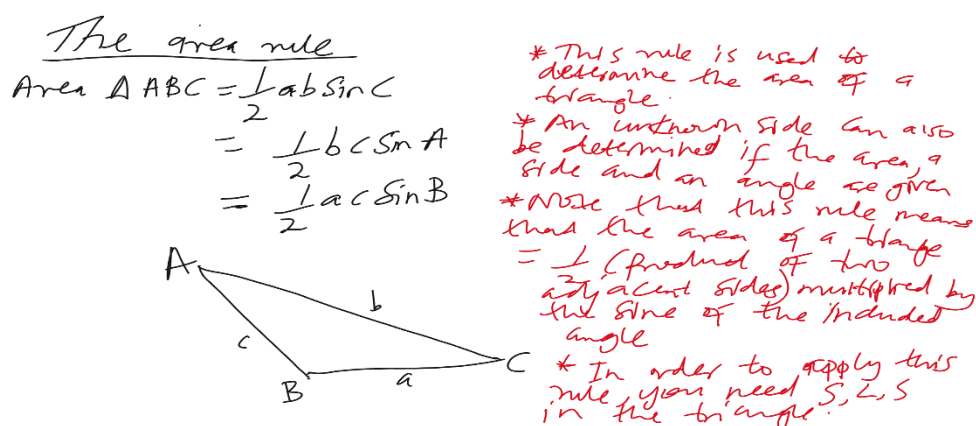


Figure 23: Teacher's Illustration—Area Rule (Non-Right-Angled Triangle)

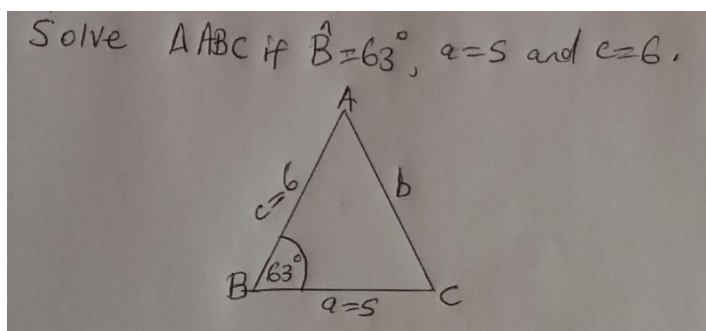


Figure 24: Learner Activity—Solving a Triangle with no Right Angle by Applying the Area Rule

Figure 25: Learner Response—Area Rule Activity (Misapplied Sine Rule where Area Rule was Required)

The learner response in Figure 25 shows rule-mixing. Providing guided practice steps and checking rule selection before calculation would support accuracy and reduce anxiety during such tasks. Paced explanations plus immediate practice aligned with higher willingness to try problems.

4.3.4.4 Use of Real-World Examples and Teaching Aids

Learners reported that a lack of visual aids and real-world connections made trigonometry feel abstract. Suggestions from the data included connecting problems to familiar triangular shapes (e.g., road signs such as the yield sign) to make ideas concrete. Learners and teachers also noted the absence of basic resources.

Researcher: “What is your view on the use of teaching resources in learning trigonometry?”

LA 2: “There are no teaching and learning resources in our school.”

LA 3: “Our school does not have teaching resources.”

LB 1: “Our school does not have teaching resources that are used in the class.”

From the two selected schools, three out of 40 learners reported a lack of resources as a barrier to learning trigonometry, according to the questionnaire.

There were no visual aids in any of the lessons that were presented in both the selected schools, but the teachers gave examples drawn from learners’ daily lives. For example, the design of a building with a triangular roof, or in surveying when a surveyor measures the distances between three points on a map.



Figure 26: Classroom Context—Empty Whiteboard and Walls Without Trigonometry Diagrams/Posters

Concrete examples and basic aids helped make trigonometry feel less abstract.

4.3.4.5 Clarity of Language and Terminology

Learners described the language of trigonometry as confusing and asked for clearer explanations; some requested the use of their home language to support understanding. Some of the selected responses were:

LA 13: “It is a confusing language.”

LA 14: “Some of the terminologies are hard to understand.”

LA 15: “I don’t get what a teacher is trying to say in trigonometry.”

LA 17: “It is difficult to understand the language which is used.”

LB 4: “As a learner, I am used to my home language and I don’t understand. I feel like a teacher should also explain in my home language so that I can fully understand.”

LB 7: “The language is too difficult.”

LB 17: “The language affects my learning because I don’t understand trigonometry.”

From the two selected schools, seven out of 40 learners cited language and terminology as barriers to learning trigonometry.

These statements point to a practical strategy: reduce anxiety by simplifying terms, unpacking new vocabulary, and, where appropriate, offering brief explanations in the home language. Clearer language and a brief use of the home language where appropriate can reduce confusion.

4.3.4.6 Structured Examples, Guided Practice, and Rule Choice

Where learners confused rules (e.g., using the sine rule instead of the area rule), a short sequence of modelling, then guided practice, then independent practice can help. The observed sequence in Lesson 2 (School B) included board explanations and a later activity; however, giving brief, immediate practise after each illustration would allow the teacher to check rule choice before learners proceed.

Additionally, the lesson sequence included a teacher activity on 2D problems using sine, cosine and area rules (Figure 27), an individual learner activity with numerical values (Figure 28), and a sample learner response (Figure 29). Learners were given a problem to solve individually without assistance from peers.

Two-dimensional Problems using Sine, Cosine and Area rules

- Sine, Cosine and area rules will be applied to two-dimensional problems.
- The angles of elevation and depression are the angles between the line of sight and the horizontal.

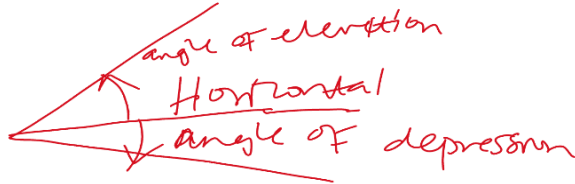


Figure 27: Illustration of Teacher's Activity on Two-Dimensional Problems Using Sine, Cosine and Area Rules

In the diagram AB represents a vertical cliff which is 120 m high. An observer at A sees two boats on the sea below. The angle of depression from A to boat C is 72° and from A to boat D is 65° .

The boats are in the same horizontal plane as B, the foot of the cliff. AX is parallel to BCD.

Calculate the horizontal distance between the two boats.

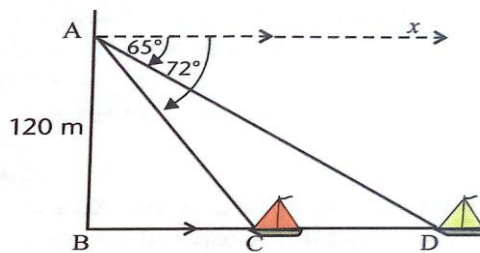


Figure 28: Illustration of Learner's Activity on the Application of Triangle Rules by Using Numerical Values

$$\begin{aligned}
 \textcircled{+} \quad \hat{C}AO &= 72^\circ - 65^\circ = 7^\circ \\
 \hat{A}CB &= 72^\circ \\
 \text{In right-angled } \triangle ABC: \frac{120}{AC} &= \sin 72^\circ \\
 \therefore AC &= \frac{120}{\sin 72^\circ} \\
 &= 126.18 \text{ m} \\
 \text{In } \triangle ACD: \frac{CD}{\sin 7^\circ} &= \frac{AC}{\sin 65^\circ} \\
 \therefore CD &= \frac{AC \sin 7^\circ}{\sin 65^\circ} \\
 &= \frac{126.18 \cdot \sin 7^\circ}{\sin 65^\circ} \\
 &= 16.97 \text{ m}
 \end{aligned}$$

Figure 29: Illustration of Learner's Response on the Application of Triangle Rules by Using Numerical Values

Checking rule choice during guided practice reduced rule-mixing before independent work.

Taken together, encouragement, approachable support, clearer language, and concrete or visual resources were associated with greater participation and lower anxiety. These findings respond to Research Question 3 by identifying classroom practices that can help reduce mathematics anxiety during trigonometry.

4.3.5 Theme 5: Supportive Teaching Strategies and Diverse Instructional Methods Reduce Anxiety

This theme focuses on supportive teaching practices that reduced mathematics anxiety during trigonometry lessons. The evidence shows how positive feedback, strong learner–teacher relationships, engaging instructional techniques, and a positive classroom climate encouraged participation and reduced fear. Data were drawn from classroom observations, learner questionnaires, and teacher interviews.

4.3.5.1 Supportive Feedback Strategies

In Lesson 4 of School B (application of triangle rules in navigation), learners were expected to apply sine, cosine, and area rules to solve surveying and navigation problems. The teacher explained bearings as angles measured clockwise from north and guided learners through how to identify triangles, measure sides and angles, and apply the correct rule to find unknown values.

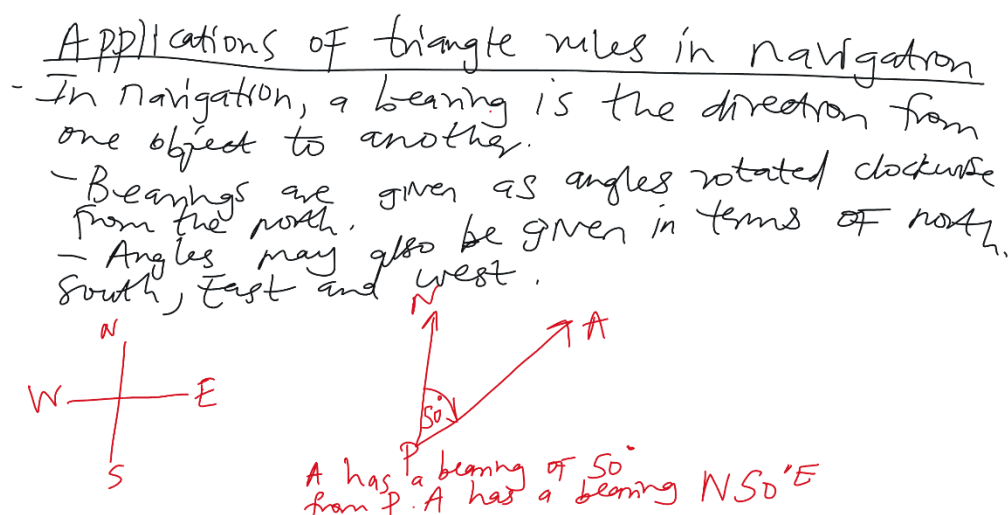


Figure 30: Teacher's Activity on the Application of Triangle Rules in Navigation

Learners completed individual activities requiring them to identify the triangle formed by landmarks, measure angles with a compass or protractor, calculate sides, and then apply the appropriate rule. The teacher encouraged correct attempts with positive reinforcement, for example saying, "Keep it up." This created a supportive classroom environment where learners were confident and motivated to attempt more questions.

Bandura's (1986) concept of self-efficacy explains how such reinforcement builds belief in one's ability, while Skinner's behavioural framework highlights that positive reinforcement strengthens desirable behaviours. In this lesson, encouragement increased learners' confidence and willingness to engage, thereby reducing anxiety.

An aeroplane flies from Q for 300 km at a bearing of 310° . It changes its course to a bearing of 200° .

- 1 How far is the plane from its starting point after travelling 450 km on this new course?
- 2 What is the bearing of the plane from its starting point (that is, what is the bearing of Q from P?)

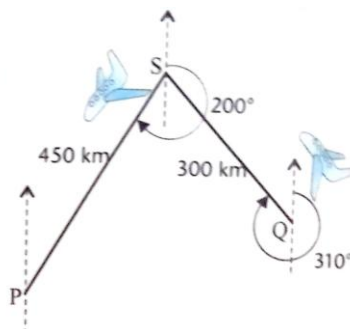


Figure 31: Learner Activity on the Application of Triangle Rules in Navigation

1. $PQ^2 = 300^2 + 450^2 - 2(300)(450)\cos 70^\circ$
 $PQ = \sqrt{200154,5613}$
 $= 447,39 \text{ km}$

2. $\frac{\sin \hat{S}PQ}{300} = \frac{\sin 70^\circ}{447,39}$
 $\sin \hat{S}PQ = \frac{300 \sin 70^\circ}{447,39}$
 $= 0,63$
 $\hat{S}PQ = 39,06^\circ$
 $\hat{S}PN_2 = 20^\circ$
 $\therefore \text{The bearing of Q from P is } 59,06^\circ$

Figure 32: Learner Response to the Application of Triangle Rules in Navigation

Learner responses confirmed the importance of feedback:

LA 1: "My teacher tells me to study hard and believe in myself."

LA 10: "Our teacher encourages us to work hard."

LB 2: "I am encouraged to seek help in my mathematics class."

LB 7: "He always give me hope that I will be somebody. Even when I get zero in mathematics test, he shows me my mistakes and I work on my mistakes."

LB 9: "He tell us that trigonometry needs practice and, as for him, he sees it as an easy chapter."

LB 13: "He is very supportive and he insists to help us one on one if we are not understanding in the classroom."

LB 17: "He support us by encouraging and guiding us that we must do well."

Interview responses supported this:

LA 1: "I am encouraged learners to do mathematics."

LB 1: "When I have failed a test, I am motivated to do better than what I did, and I learn from my mistakes."

Teachers also reinforced correct efforts with gestures such as thumbs-up and cheerful smiles, which created a welcoming environment where learners felt comfortable to ask questions without fear.

Additional questionnaire responses highlighted this:

LA 1: "As learners we ask for help."

LA 5: "I ask question where I am not understanding."

LA 9: "When we ask the teacher make sure that he repeats until we get it."

LB 1: "There are others who can help me or I could ask my teacher so that I have to know."

LB 2: "I am encouraged to seek help in my mathematics class."

LB 10: "I feel free to ask a question from the teacher because he talks in a good way and always find a way to make us understand."

LB 13: "Our teacher is very supportive and he insists to help us one on one if we are not understanding in the classroom."

Lesson 4 at School A was about the application of triangle rules using numerical values. The teacher used positive and encouraging non-verbal cues to help reduce anxiety in learners. The teacher gave a thumbs up as a sign of approval when learners answered the question correctly and when they tried to answer, in order to reinforce learners with positive feedback. The teacher displayed cheerful smiles when interacting with the learners. This indicated that he was happy and enthusiastic about teaching and being around the learners. Again, it created a pleasant environment in the classroom.

Supportive strategies are important in reducing mathematics anxiety in learners because they help learners build confidence, develop a growth mindset and overcome negative emotions associated with mathematics.

4.3.5.2 Learner–Teacher Relationships and Interactions

In Lesson 2 at School A (solving triangles with no right angles), the teacher encouraged participation and made himself available to assist learners during and after class. His approach was confirmed in the teacher questionnaires:

TA: “Make a classroom a safe place.”

TA: “Praise effort, point out progress and make it real.”

TA: “I build a positive relationship through communication. I stay connected to learners.”

TB: “I tell learners about exciting courses that depend on mathematics.”

Learners supported this through their responses:

LA 6: “He always ask after every lesson if we understand.”

LA 11: “He always tell us to be confident on ourselves, study and not looking down on ourselves.”

LA 13: “My mathematics teacher teaches us even on extra time during studies.”

LA 15: “He encourages us by good words.”

LB 4: “As a learner who is confident, he will help you fully understand along with those who do not understand.”

LB 8: “Our teacher allows us to attend Saturday classes for free and teaching us during afternoon studies time until 16H30.”

LB 13: “He is very supportive and he insists to help us one-on-one if we are not understanding in the classroom.”

LB 17: “He support us by encouraging and guiding us that we must do well.”

LB 19: “When I need help in mathematics, he always helps me.”

Additional interview responses reinforced this approach:

TA: “I tell them that mistake is part of learning and praise them for answering questions whether it is right or wrong.”

TB: “I encourage them that even if they answered a question incorrectly, they must take it in a constructive way.”

In Lesson 1 at School B (solving triangles with no right angles), the teacher was approachable. Every learner was free to ask a teacher whenever they faced challenges during the teaching and learning of trigonometry. He was available for learners who needed extra help during class activities so that he could help and support them.

From the classroom lesson observation in School A, Lesson 2, the availability of the teacher to offer extra help to the learners during class activities made them fully engaged. The learner–teacher interaction helped reduce anxiety because learners felt supported as they received better explanations for the questions asked during the lesson.

From the classroom lesson observation in School B, Lesson 1, the teacher’s approachable nature made learners feel free to ask for help when they faced challenges during the teaching and learning of trigonometry. This helped in reducing mathematics anxiety.

4.3.5.3 Engaging Teaching Techniques

In Lesson 3 at School B (application of triangle rules using numerical values), learners practised applying the sine and cosine rules. The teacher linked tasks to real-life contexts such as building triangular roofs and surveying land. This made the lesson less abstract and encouraged learner engagement, even in the absence of technology.

Teacher perspectives included:

TB: “I create things like rhymes that make them memorise certain things.”

TB: “I tell learners how mathematics is related to the real world.”

Learner responses supported this:

LA 1: “Teaching resources encourage learners to participate in the lesson.”

LA 8: “My teacher is best in teaching mathematics and he makes me feel like I am good in mathematics.”

LA 9: “Our teacher also uses easy language so that we can understand better.”

LA 11: “It gives me the attitude of learning and doing better in mathematics.”

LB 1: “The language used by a teacher is perfect for learning about trigonometry.”

LB 3: “Teaching resources are good things to use.”

LB 9: "The language is good and understandable."

LB 19: "The language is good."

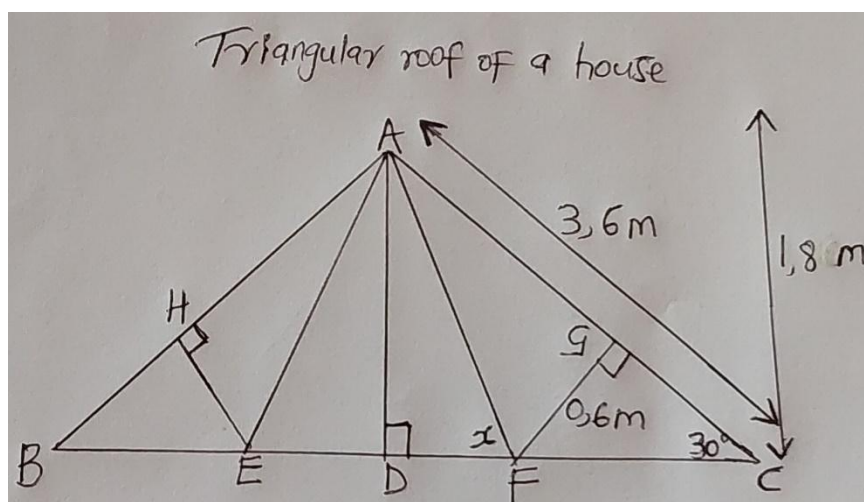


Figure 33: Real-Life Examples Used in Lesson 3, School B.

Lesson 4 at School A was about the application of triangle rules using numerical values. Learners were required to solve different triangles by applying the sine or cosine rule depending on where and when to use a specific rule to solve the problem. Even though no technology was available, the teacher gave examples of the things that learners come across in their real life.

The use of teaching and learning resources in mathematics instruction helped reduce mathematics anxiety because the lesson became learner-centred, related to daily encounters, and allowed learners to actively engage and participate. Again, daily life examples and applications of trigonometric concepts made the subject more relevant and less abstract.

4.3.5.4 Creating a Positive Learning Environment

In Lesson 1 of School A (solving right-angled triangles), learners were taught how to identify the hypotenuse, opposite, and adjacent sides and apply Pythagoras' Theorem. When learners struggled, the teacher used diagrams to explain again and emphasised the basic definitions of sine, cosine, and tangent.

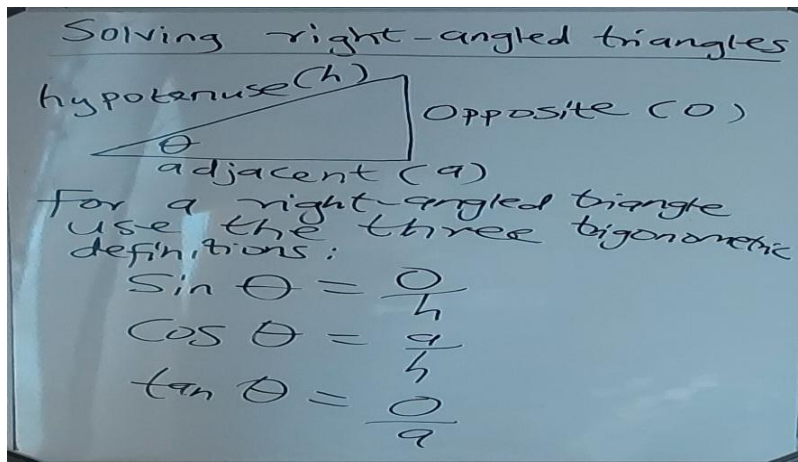


Figure 34: Teacher's Use of Diagrams to Explain Right-Angled Triangles

Learners confirmed this through questionnaires:

LA 1: "As a learner, I ask for help."

LA 5: "I ask question where I don't understand."

LA 7: "Our teacher always tells us to practice every day."

LA 8: "When we ask question, he make sure that he repeats until we get it."

LB 2: "I am encouraged to seek help in my mathematics class."

LB 6: "Our teacher repeats what we do not understand."

LB 11: "He always make sure that we understand and always repeats when we do not understand."

LB 12: "He explains everything we do not understand."

Teachers supported this view:

TA: "Mistake is part of learning, and I praise learners for answering question whether it is right or wrong."

TB: "I encourage learners to answer a question even when they answered it wrongly, they must take it in a constructive way."

Lesson 1 of School B focused on how to solve triangles with no right angles where the emphasis was on applying the acute-angled triangle and obtuse-angled triangle to prove sine and cosine rules. The teacher created a supportive environment where learners felt comfortable expressing thoughts and asking questions. Again, he created the environment where making mistakes was seen as a natural part of learning. This created a pleasant environment in the classroom for effective teaching and learning.

A positive learning environment had a profound emotional impact on learners by helping to reduce mathematical anxiety in learning trigonometry and promoting a more enjoyable and effective learning experience. Learners felt free and were encouraged to ask questions. They viewed mistakes as an opportunity for growth and learning. Additionally, the positive learning environment helped learners feel seen, heard and valued by allowing them to build confidence, and develop a love for learning trigonometry.

4.4 Quantitative Results

This section presents the quantitative findings from the learner questionnaires and mathematics test results. The analysis is descriptive and structured around three main factors contributing to mathematics anxiety: personal, environmental, and behavioural factors. For clarity, questionnaire items under each factor are combined into a single table. Each table is followed by a summary of the main trends and an integration with the qualitative themes.

4.4.1 Personal Factors

Personal factors included learner confidence in mathematics, worry about tests, and fear of failure. Table 4 summarises responses to these items.

Table 4: Responses to Personal Factors

Item	Strongly Agree	Agree	Not Sure	Disagree	Strongly Disagree	Total (n)	Key Trend
I feel confident in mathematics	3 (7.5%)	5 (12.5%)	15 (37.5%)	12 (30%)	5 (12.5%)	40	Low confidence (42.5% lacked confidence)
I worry about mathematics tests	18 (45%)	10 (25%)	5 (12.5%)	5 (12.5%)	2 (5%)	40	High test-related worry (70% agreed)
I fear failing mathematics	16 (40%)	12 (30%)	6 (15%)	4 (10%)	2 (5%)	40	Strong fear of failure (70% agreed)

Personal factors were strongly linked to mathematics anxiety. Over 70% of learners reported test-related worry and fear of failure, while only 20% expressed confidence.

These results support Theme 1 (Observable Signs) and Theme 3 (Performance-Related Factors), where learners showed low confidence, nervousness, and fear of failure during class and tests.

4.4.2 Environmental Factors

Environmental factors included peer judgement, parental support, and teacher-related influences. Table 5 summarises responses to these items.

Table 5: Responses to Environmental Factors

Item	Strongly Agree	Agree	Not Sure	Disagree	Strongly Disagree	Total (n)	Key Trend
I feel anxious because of peer judgement	14 (35%)	10 (25%)	6 (15%)	6 (15%)	4 (10%)	40	60% agreed peer judgement causes anxiety
I lack parental support in mathematics	12 (30%)	8 (20%)	10 (25%)	6 (15%)	4 (10%)	40	50% agreed parental support is lacking
My teacher's strategies make mathematics more difficult	10 (25%)	12 (30%)	8 (20%)	6 (15%)	4 (10%)	40	55% saw teaching as contributing to anxiety

Environmental factors also contributed to mathematics anxiety. Peer judgement (60%), lack of parental support (50%), and ineffective teaching strategies (55%) were frequently reported as causes of stress.

These results support Theme 2 (Socio-emotional and Contextual Factors) and Theme 4 (Instructional Strategies), where peer influence, parental support, and teaching approaches shaped learners' anxiety.

4.4.3 Behavioural Factors

Behavioural factors included avoidance, hesitation, and giving up easily during mathematics lessons. Table 6 summarises responses to these items.

Table 6: Responses to Behavioural Factors

Item	Strongly Agree	Agree	Not Sure	Disagree	Strongly Disagree	Total (n)	Key Trend
I avoid participating in mathematics lessons	15 (37.5%)	8 (20%)	7 (17.5%)	6 (15%)	4 (10%)	40	57.5% avoid participation
I hesitate to answer questions in mathematics	14 (35%)	12 (30%)	6 (15%)	5 (12.5%)	3 (7.5%)	40	65% hesitate to answer
I give up easily when I find mathematics difficult	12 (30%)	10 (25%)	8 (20%)	6 (15%)	4 (10%)	40	55% give up easily

Behavioural factors reflected common classroom challenges. More than half of the learners reported avoiding participation, hesitating to answer questions, or giving up when facing difficulties.

These results support Theme 1 (Observable Signs) and Theme 2 (Socio-emotional Factors), confirming that avoidance, hesitation, and frustration were key indicators of mathematics anxiety.

Results of reliability analysis of questionnaires

The Cronbach's alpha coefficients obtained for each subscale were as follows: personal factors: $\alpha \approx 0.78$, environmental factors: $\alpha \approx 0.73$ and behavioural factors: $\alpha \approx 0.76$

Interpretation

All three subscales yielded Cronbach's alpha values above the commonly accepted threshold of 0.70, indicating acceptable internal consistency. This suggests that the

items within each subscale are sufficiently correlated and reliably measure their respective constructs:

The personal factors scale reliably captures learners' confidence, test anxiety, and fear of failure. The environmental factors scale consistently reflects the influence of peer judgement, parental support, and teaching strategies. The behavioural factors scale demonstrates reliable measurement of observable behaviours such as avoidance, hesitation, and giving up easily.

Overall, the reliability results indicated that the questionnaire was consistent and dependable instrument for assessing factors contributing to mathematics anxiety.

4.4.4 Summary Chart of Anxiety Factors

To provide a visual overview, Figure 35 below presents the top reported anxiety factor under each of the three categories (personal, environmental, behavioural).

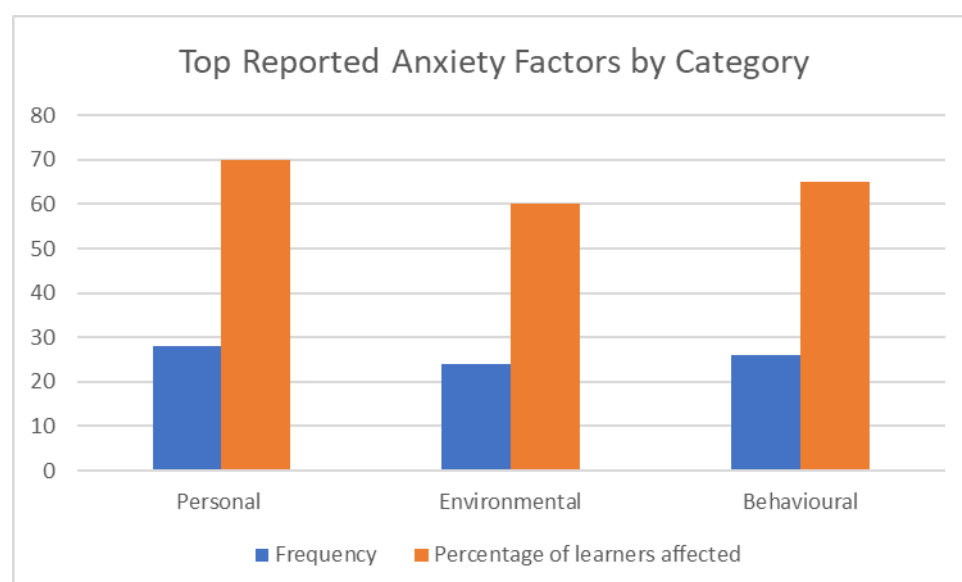


Figure 35: Top Reported Anxiety Factors by Category

The chart shows that personal test-related worry and fear of failure affected about 70% of learners (28 in number), making personal factors the strongest contributor to

mathematics anxiety. Behavioural hesitation to answer questions was also very high at 65% (26 learners), showing how personal fears translate into classroom behaviours. Environmental peer judgement was reported by 60% of learners (24 in number), reinforcing anxiety through social pressure. Overall, this indicates that mathematics anxiety is shaped by the interaction of personal, environmental, and behavioural elements, which aligns with the qualitative themes of observable signs, socio-emotional and contextual factors, and performance-related anxiety.

4.4.5 Overall Test Performance

Learners completed a trigonometry test as part of the study. Table 7 summarises the distribution of scores.

Table 7: Distribution of Scores

Score Range	Frequency	Percentage
0–19%	8	20%
20–39%	12	30%
40–59%	10	25%
60% and above	10	25%

Half of the learners (50%) scored below 40%, showing weak conceptual understanding and possible effects of test anxiety. Only 25% scored 60% and above.

This supports Theme 3 (Performance-related Factors), where learners reported nervousness during tests, fear of failure, and difficulty applying formulas under pressure.

4.4.6 Types of Errors and Error Analysis

Learners' test scripts were analysed to identify common errors. Errors were classified into four categories: conceptual, procedural, careless, and no error, following Hodes and Nolting (1998). Tables 8 and 9 show the percentage distribution of errors per test item for School A and School B respectively.

Table 8: Distribution of Errors in School A by Test Item

Item	Conceptual %	Procedural %	Careless %	No Error %
1.1	30	50	0	20
1.2	25	45	5	25
1.3	35	40	10	15
1.4	20	55	5	20
2.1	40	45	0	15
2.2	30	50	10	10
2.3	45	40	5	10

Table 9: Distribution of Errors in School B by Test Item

Item	Conceptual %	Procedural %	Careless %	No Error %
1.1	5	95	0	0
1.2	20	65	5	10
1.3	30	55	5	10
1.4	25	60	5	10
2.1	35	50	5	10
2.2	40	50	5	5
2.3	45	40	5	10

School A showed a balance of conceptual and procedural errors across items, with procedural errors slightly more dominant. In contrast, School B displayed very high levels of procedural errors, particularly in Item 1.1 where 95% of learners made mistakes. Careless errors were rare in both schools, and only a small percentage of learners answered items without error. This suggests that difficulties were not due to

simple mistakes but deeper challenges in conceptual understanding and procedural application.

These findings reinforce Theme 3 (Performance-related Factors) and Theme 4 (Instructional Strategies). They show that learners often confused formulas, misapplied rules, or struggled under test conditions, which mirrors the qualitative evidence of cognitive overload, conceptual uncertainty, and test pressure.

4.4.7 Anxiety Indicators

In addition to test performance and errors, the questionnaire captured learners' self-reported indicators of mathematics anxiety. Tables 10 and 11 show the frequency and percentage of learners reporting common anxiety indicators in School A and School B.

Table 10: Reported Anxiety Indicators in School A

Indicator	Frequency	Percentage
Worry about mathematics tests	14	70%
Fear of being mocked by peers	8	40%
Avoidance of participation	9	45%
Loss of confidence	7	35%

Table 11: Reported Anxiety Indicators in School B

Indicator	Frequency	Percentage
Worry about mathematics tests	14	70%
Fear of being mocked by peers	12	60%
Avoidance of participation	9	45%
Loss of confidence	9	45%

Both schools showed high levels of reported anxiety indicators. Test-related worry was the most common in both schools (around 70%), followed by fear of peer judgement, avoidance of participation, and loss of confidence. School B learners reported slightly higher levels of fear of being mocked and loss of confidence than School A.

These results support Theme 1 (Observable Signs of Anxiety) and Theme 2 (Socio-emotional and Contextual Factors), confirming that anxiety manifests in learners' behaviours and emotions, such as worry, avoidance, and reduced confidence.

4.4.8 Learners' Feedback Trends

The diagnostic test and questionnaire responses also revealed common trends in learners' feedback regarding their difficulties with trigonometry. Tables 12 and 13 summarise the feedback trends reported in School A and School B.

Table 12: Learners' Feedback Trends in School A

Feedback Trend	Frequency	Percentage
Lack of conceptual understanding	6	30%
Difficulty with trigonometric ratios	9	45%
Difficulty with mathematical manipulations and calculations	3	15%
Misconceptions about trigonometry ratios	10	50%
Challenges with problem interpretation	14	70%
Challenges with algebraic manipulations	6	30%
Difficulty in connecting concepts	6	30%

Table 13: Learners' Feedback Trends in School B

Feedback Trend	Frequency	Percentage
Lack of conceptual understanding	19	95%
Difficulty with trigonometric ratios	11	55%
Difficulty with mathematical manipulations and calculations	3	15%
Misconceptions about trigonometry ratios	15	75%
Challenges with problem interpretation	7	35%
Challenges with algebraic manipulations	14	70%
Difficulty in connecting concepts	4	20%

Both schools showed major challenges in problem interpretation and misconceptions about trigonometric ratios. School B reported far higher levels of conceptual misunderstanding (95%) compared to School A (30%). Difficulties with algebraic manipulations were also significant in both schools, especially in School B (70%).

In School A, learners often confused trigonometric ratios (Item 1.2) and failed to draw diagrams correctly when interpreting problems (Item 2.1). In School B, many learners relied on calculators incorrectly (Item 1.4), producing decimals instead of working conceptually with fractions. Others struggled with algebraic manipulation (Item 2.2), failing to apply identities and factorisation.

These trends reinforce the findings from the error analysis, confirming that learners' struggles were rooted in weak conceptual understanding, misuse of trigonometric ratios, and difficulty interpreting and connecting concepts. This supports Theme 3 (Performance-related Factors) and Theme 4 (Instructional Strategies).

4.4.9 Conclusion of Quantitative Findings

The quantitative analysis provided a descriptive picture of mathematics anxiety among learners. Questionnaire results showed that personal factors such as test-related worry and fear of failure were the most common, while environmental influences like peer judgement and lack of parental support also contributed significantly. Behavioural signs such as hesitation to answer questions and avoidance of participation were widely reported, confirming the observable manifestations of anxiety in the classroom.

Test performance data revealed that half of the learners scored below 40%, showing weak conceptual understanding and possible effects of test anxiety. Error analysis further demonstrated that both schools struggled with conceptual and procedural application, with School B showing particularly high levels of procedural errors. Anxiety indicators reinforced these findings, as learners frequently reported test-related worry, fear of being mocked, and loss of confidence.

Learners' feedback trends echoed the error analysis, identifying recurring challenges such as misconceptions about trigonometric ratios, difficulties with problem interpretation, and struggles with algebraic manipulation. These patterns were more severe in School B, but present in both contexts. The summary chart of anxiety factors confirmed that personal, environmental, and behavioural dimensions of anxiety were interlinked and mutually reinforcing.

Overall, the quantitative findings triangulate strongly with the qualitative themes. They confirm that observable signs of anxiety, socio-emotional and contextual influences, and performance-related struggles are interdependent. Together, the two strands of

analysis provide a comprehensive understanding of how mathematics anxiety manifests and the factors that sustain it in the learning of trigonometry.

4.5 Summary of Findings in Relation to Research Questions

4.5.1 Research Question One

What are signs of mathematics anxiety in selected Grade 11 learners learning trigonometry?

The findings revealed clear signs of mathematics anxiety among learners. Qualitative evidence from observations and interviews showed behavioural signs such as avoidance of teacher engagement, passive participation, and even disengagement to the point of sleeping in class. Learners also avoided eye contact during lessons.

In terms of social distress, learners reported reluctance to answer questions because of fear of being mocked or judged by their peers. Emotional and cognitive signs included frustration, low participation, and negative attitudes such as openly saying “trigonometry is difficult.”

These patterns were strongly supported by the quantitative data. From the questionnaires, 70% of learners reported test-related worry, 50% reported fear of peer judgement, 45% avoided participation, and 40% indicated loss of confidence. Test performance data also confirmed these signs: half of the learners scored below 40%, highlighting the impact of anxiety on learning outcomes.

4.5.2 Research Question Two

What are factors that contribute to anxiety when learning trigonometry?

Key contributing factors were socio-emotional, performance-related, and instructional. Qualitative data indicated that lack of parental support, fear of peer judgement, and predominantly teacher-centred instruction negatively affected learners. The traditional teaching approaches observed often made learners passive, limiting conceptual understanding.

Performance-related factors were also significant. Learners expressed confusion over when to apply sine and cosine rules, uncertainty in basic triangle properties and Pythagoras' theorem, and difficulties under test pressure. Observations and interviews highlighted feelings of helplessness and panic during assessments.

The quantitative findings reinforced these insights. Error analysis showed that most learners committed conceptual and procedural mistakes, such as mixing sine and cosine rules, misinterpreting diagrams, and misusing calculators. In School B, 95% of learners made procedural errors on Item 1.1, while in School A, conceptual and procedural errors were more balanced. Learners' feedback trends further indicated widespread misconceptions (50% in School A, 75% in School B) and challenges with problem interpretation (70% in School A).

Importantly, the summary chart of anxiety factors (Section 4.4.4) showed that personal factors (such as test-related worry and fear of failure) were the most common contributors to anxiety, followed by environmental factors (peer judgement, lack of support), and finally behavioural factors (avoidance, hesitation). This confirms that anxiety was driven more by learners' internal feelings than by external or behavioural influences alone.

4.5.3 Research Question Three

What measures can help address or reduce mathematics anxiety to promote higher achievement?

The findings indicated that supportive and engaging teaching strategies are key in reducing mathematics anxiety. Qualitative evidence showed that learners benefitted when teachers offered encouragement, praise, and clarification on challenging concepts. Learners felt free to ask questions, and teacher availability for extra help improved participation. Positive learner-teacher relationships and interactive lessons helped reduce anxiety.

Even though resources and technology were limited, teachers attempted to make trigonometry relevant by using real-life examples. This created a positive learning environment where learners were more engaged and motivated.

The quantitative findings supported these observations. Learners reported valuing supportive feedback, with over 70% confirming that encouragement and extra help reduced their test-related worry. Anxiety indicators also showed that learners felt less anxious when teachers promoted a safe, positive classroom climate. Overall, the integration of supportive feedback, interactive teaching, and real-life applications contributed to reducing mathematics anxiety.

4.6 Conclusion

This chapter presented the findings of the study through thematic analysis of qualitative data, supported and complemented by quantitative data that were used to support and quantify the themes to enhance interpretation. Signs of anxiety were evident in behavioural, social, and emotional reactions, while multiple contributing factors—including socio-emotional influences, performance-related challenges, and teacher-centred instructional methods—exacerbated learners' difficulties. Supportive strategies and positive classroom environments were shown to mitigate anxiety.

The integration of quantitative and qualitative findings strengthens these conclusions: both strands confirm that mathematics anxiety in trigonometry is multi-dimensional, with observable, contextual, and performance-related aspects. The next chapter discusses these findings in relation to the literature and theoretical framework.

Chapter 5

Discussion of Findings, Conclusion and Recommendations

5.1 Introduction

This chapter interprets the findings in relation to the research questions, the theoretical framework (Social Cognitive Theory), and prior literature, highlighting consistencies, contradictions, and contributions. It integrates qualitative themes with quantitative evidence to explain how and why mathematics anxiety manifested in trigonometry learning.

5.2 Discussion of Research Question One

RQ1: What are signs of mathematics anxiety among selected Grade 11 learners learning trigonometry?

The findings of this study revealed that observable signs of mathematics anxiety contributed negatively to learners' ability to learn trigonometry. **Behavioural signs** such as lack of focus in the class, avoidant behaviours and avoiding eye contact were widely reported in the classroom lesson observations. For example, about 45% of learners displayed avoidant and disengaged behaviours during lesson interactions. This made learners hesitant to answer questions and less likely to participate. Interpreted through Bandura's social cognitive theory, reduced self-efficacy likely suppressed participation and reinforced avoidance, while achievement emotions theory (Pekrun) explains how sustained test-related worry translated into lower engagement and performance. Recent empirical studies (Barroso et al., 2021; Luttenberger et al., 2018) further indicate that mathematics anxiety is strongly associated with avoidance behaviours, reduced working memory capacity, and lower academic performance, particularly in cognitively demanding mathematical domains.

Social distress signs were significant in contributing negatively to the ability of learners to engage with trigonometry. Many learners expressed hesitation in answering questions due to fear of being mocked by their peers. Quantitative learners' questionnaires supported this: in both schools 65% of learners hesitated to answer questions because they were afraid of judgement by their peers. This finding is consistent with Garba et al. (2020), who found that negative peer behaviours—

such as disruptive actions by poor performing learners and the dominance of intelligent students in the classroom, as well as negative speech, including frightening and discouraging statements—directly intensified mathematics anxiety. By contrast, Moliner and Alegre (2020) found that peer tutoring reduced school learners' mathematics anxiety regardless of their gender or age. Fear of peer judgement led many learners to avoid answering questions, confirming the role of social distress in sustaining anxiety.

Emotional reactions and cognitive signs also contributed negatively to the learning of trigonometry in learners. Anxiety indicators supported this: the avoidance of participation was about 45% in both selected schools. Consistent with Namkung et al. (2019), learners facing mathematical challenges often exhibit negative emotions. Pekrun (2006) shows that learners' emotional states have profound effects on learning processes and performance.

Both schools showed high levels of reported anxiety indicators. Test-related worry was the most common in both schools (around 70%), followed by fear of peer judgement, avoidance of participation, and loss of confidence. School B learners reported slightly higher levels of fear of being mocked and loss of confidence than School A. These results support Theme 1 (Observable Signs of Anxiety) confirming that anxiety manifests in learners' behaviours and emotions, such as worry, avoidance, and reduced confidence. Emotional reactions such as frustration and negative attitudes ("trigonometry is difficult") were also evident, limiting engagement. Bandura's theory explains how low self-efficacy suppressed participation, while Pekrun's achievement emotion framework shows how sustained test-related worry translated into low engagement and performance. These findings align with SCT's view that personal factors, such as low self-efficacy and heightened emotional arousal, directly influence learners' behaviours of avoidance and disengagement in trigonometry. In addition, Huang et al. (2022) found that self-efficacy significantly mediates the relationship between mathematics anxiety and achievement, suggesting that learners with low confidence are more likely to disengage and underperform.

5.3 Discussion of Research Question Two

RQ2: What are factors that contribute to anxiety when learning trigonometry?

Key contributing factors were socio-emotional, performance-related, and instructional.

Socio-emotional influences such as lack of parental support and fear of peer judgment were widely reported in interviews and questionnaires. For example, quantitative results indicated that 50% of learners were afraid of peer judgement and 50% lacked parental support. Garba et al. (2020) highlighted the role of disruptive peer behaviour and discouraging speech in intensifying anxiety; however, my focus emphasises peer judgement specifically. Munje and Mncube (2018) reported limited parental involvement, while Fantuzzo et al. (2020) showed that parental involvement (e.g. helping with assignments and projects) improved learners' responsibility and task completion. In my study, about half of the learners reported limited parental support. Shamaki (2015) also reported differences linked to classroom climate.

Performance-related factors were also significant. Error analysis showed widespread conceptual and procedural challenges, particularly in School B, where 75% of learners showed misconceptions and 95% made procedural errors. These findings confirmed qualitative accounts of confusion in applying trigonometric rules. Learners' feedback trends further indicated widespread misconceptions (50% in School A, 75% in School B) and challenges with problem interpretation (especially in School A with 70%). For the performance-related issues, the results of the study indicated that cognitive overload arose when tasks or explanations exceeded learners' working memory limits. Overload was visible when learners had to process several new ideas at once or move too quickly from demonstration to independent work. Sweller (1988) argued that cognitive overload occurs when learners are presented with too much information, which can exceed working memory capacity, leading to decreased performance and increased errors. Contemporary applications of cognitive load theory (Paas & van Merriënboer, 2020; van Gog, 2021) emphasise that poorly structured instruction in complex topics can increase extraneous cognitive load, thereby intensifying learner anxiety and limiting conceptual understanding.

There was consistent confusion between trigonometric rules, uncertainty about triangle properties and Pythagoras' theorem, and difficulties under test pressure. Observations and interviews also highlighted feelings of helplessness and anxiety during assessments. Hiebert and Lefevre (1986) revealed such conceptual errors as failure to understand the concepts or connections among them.

Test pressure was associated with careless errors (e.g., arithmetic or calculator slips), hesitation at the start of the paper, and periods of inactivity. While prior syntheses (e.g., Koch, 2014) discuss careless errors in general, our data point to their frequent occurrence during calculation under time pressure.

Instructional factors also played a key role. Qualitative data indicated that predominantly teacher-centred instruction negatively affected learners. The traditional teaching approaches observed often made learners passive, limiting conceptual understanding. Quantitative data also indicated ineffective teaching strategies (about 55%) as a source of stress. This finding is consistent with Amedume et al. (2022), who reported that traditional approaches tended to dominate classroom interactions, limiting learners' opportunities to actively engage with concepts and share ideas. Furthermore, with the traditional approach, learners were expected to play a more passive role, with teachers providing substantial information without encouraging meaningful contributions from students, effectively hindering the development of conceptual understanding. Similarly, Attard and Holmes (2020) and OECD (2021) highlight that learner-centred and interactive pedagogies are associated with reduced mathematics anxiety and improved learner participation and conceptual understanding.

Lessons were predominantly teacher-centred, limiting learners' active construction of meaning. From a constructivist perspective (Piaget, 1964), learners actively construct knowledge; however, teacher-centred delivery with limited scaffolding can overload working memory (Sweller, 1988). In the classes I studied, this likely contributed to conceptual and procedural errors. Vygotsky (1978) emphasised the social context of learning; fear of peer judgement plausibly reduced help-seeking and participation. As SCT suggests, the interaction of personal factors (self-efficacy), behavioural patterns

(errors, avoidance), and environmental influences (teacher-centred instruction, peer judgement) helps explain why anxiety persists in Grade 11 trigonometry.

5.4 Discussion of Research Question Three

RQ3: What measures can help address or reduce mathematics anxiety to promote higher achievement?

The findings revealed that supportive feedback strategies, positive learner-teacher relationships and interactions, engaging teaching techniques, and creating a positive learning environment are key to reducing mathematics anxiety. **Supportive feedback strategies** that were reported by the qualitative evidence showed that learners benefitted when teachers offered encouragement, praise, and clarification on challenging concepts. Learners felt free to ask questions, and teacher availability for extra help improved participation. Consistent with Pastera et al. (2018), both intrinsic and extrinsic motivation related to performance in mathematics. In my setting, incorporating supportive feedback strategies, such as encouragement, praise, and clarification, coincided with a greater willingness to ask questions and participate. Recent evidence (Wisniewski et al., 2020) confirms that process-oriented and timely feedback plays a critical role in enhancing learners' motivation, self-efficacy, and reducing mathematics anxiety.

Engaging teaching techniques were highlighted as a strategy to reduce anxiety. In trigonometry, strategies with diagrams, CAST reasoning, and bearings/navigation contexts were particularly effective at reducing abstraction and supporting rule selection. This finding is in alignment with Brijlall and Niranjana (2015), who revealed that manipulatives were important mediating tools in the development of conceptual and procedural understanding of mathematical concepts. This is also consistent with Chinweoke's study (2016), which revealed that learners taught with ICT achieved significantly better than their counterparts taught using conventional lecture methods. In addition, recent studies (Bicer et al., 2020) demonstrate that the use of visual representations, multiple solution strategies, and technology-enhanced instruction can significantly reduce abstraction and improve learners' confidence in topics such as trigonometry.

The **positive learning environment** was also highlighted as a strategy to reduce anxiety. A classroom that normalises error (Maslow, 1943—psychological safety), frames difficulty as improvable (Dweck, 2006—growth mindset), and builds mastery experiences (Bandura, 1997—self-efficacy) can plausibly reduce anxiety and increase participation. This was linked with Maslow (1943), who indicated the importance of meeting learners' needs for esteem, love, belonging, safety and self-actualisation in order to promote motivation and reduce mathematics anxiety. Furthermore, Yeager and Dweck (2012) showed that supportive feedback can promote motivation, self-efficacy and a growth mindset. More recent large-scale studies (OECD, 2021) show that psychologically safe and supportive classroom environments are strongly associated with reduced anxiety and increased persistence in mathematics learning.

According to Maslow (1943), learners' basic needs, such as safety and security, must be met before they can focus on higher-level needs, such as self-actualisation. In a mathematics classroom, this can be achieved by creating a supportive climate that fosters a sense of belonging and reduces anxiety. Similarly, Rogers (1961) emphasised the importance of a person-centred approach, which focuses on the learner's personal growth and development. In a mathematics classroom, this can be achieved by providing learners with choices, encouraging self-directed learning and promoting a growth mindset.

Critically, while past studies have shown the benefits of feedback in general mathematics instruction, few have examined its effectiveness within the specific domain of trigonometry. The current study contributes by applying feedback in trigonometry classrooms and assessing its direct impact on reducing anxiety. However, most existing studies explore this teacher-learner relationship in mathematics generally, not in Grade 11 trigonometry. The current study expands on existing work by investigating how teacher-learner rapport influences anxiety in a high-cognitive-load subject, potentially offering more targeted pedagogical insights. In trigonometry, where concepts often feel disconnected from real-world contexts, the current study incorporated visual aids and real-life applications to foster deeper understanding and lessen abstraction-related anxiety.

While prior literature emphasised the value of engagement broadly, the current study refines this application by tailoring techniques specifically to the unique demands of trigonometry. This represents a critical advancement in aligning content-specific pedagogy with anxiety-reduction strategies. Unlike prior studies, which often considered classroom climate as a background variable, the current study explicitly integrates it as a core strategy aimed at reducing anxiety in a high-pressure topic like trigonometry. This helped isolate its unique impact and understand its interaction with content complexity.

In summary, while previous literature provided strong support for strategies used in the current study, they largely addressed them in the context of mathematics in general. The current study's contribution lies in applying these strategies specifically to the teaching and learning of trigonometry—a topic that presents unique cognitive and affective challenges. By doing so, it addresses a significant gap in the literature and offers practical, evidence-based approaches for reducing mathematics anxiety in this critical domain. Consistent with SCT, positive environmental factors such as supportive feedback and constructive teacher–learner interactions can disrupt the negative cycle of anxiety, enabling learners to build self-efficacy and re-engage with trigonometry.

5.5 Integration Across Findings

The qualitative and quantitative descriptive findings were aligned, and reinforced each other across signs, contributing factors, and strategies for addressing mathematics anxiety.

Peer Effects and Test-Related Worry

Learners' reluctance to answer questions due to fear of ridicule was observed in class and confirmed by surveys, where 40% of learners in School A and 60% in School B reported fear of peer judgement. Similarly, test-related worry consistently emerged as the most common personal factor and was reflected in lower performance.

Conceptual and Procedural Difficulties

Finally, the findings paint a detailed picture of the conceptual and procedural challenges learners face in trigonometry. Confusions observed during classroom lessons mirrored questionnaire data, which indicated high rates of misconceptions:

50% in School A and 75% in School B. Additionally, 70% of learners reported difficulties in interpreting problems. Error analysis further confirmed this, with procedural errors reaching as high as 95% on item 1.1 in School B, illustrating that many learners struggled to apply rules correctly even when they knew the formulas.

Together, the data support a pathway in which emotional and instructional barriers interact: internal worry leads to avoidance, which increases procedural slips, triggering negative feedback cycles that are amplified further by peer context and limited scaffolding.

Taken together, the descriptive findings from both strands indicate that mathematics anxiety in trigonometry arises from the interaction of personal worry, peer pressure, and instructional practices, with consistent patterns across qualitative and quantitative evidence. This alignment echoes previous research which also found peer judgement and conceptual difficulties to be key triggers of mathematics anxiety.

5.6 Implications of the Findings

5.6.1 For Practice

There is a need for classroom strategies that directly address widespread misconceptions and learner anxiety in trigonometry. Motivational strategies such as recognition of effort and constructive feedback may allow teachers to normalise errors and surface misconceptions early, especially since research indicates that 50–75% of learners struggle with fundamental trigonometric concepts. By regularly using these formative assessments, teachers are encouraged to identify specific misunderstandings before they become entrenched, providing timely corrective instruction. Furthermore, the high rate of procedural errors (95% on item 1.1 in School B) underscores the importance of explicitly teaching rule selection, such as when to use sine versus cosine, with the inclusion of tools like the CAST diagram to clarify quadrant-specific signs. Modelling worked examples followed by faded scaffolding supports learners in transitioning from guided practice to independent problem-solving. In addition, the adoption of feedback routines that are specific, timely, and process-focused is essential, particularly since over 70% of learners report that such feedback reduced test-related worry. Feedback that targets learners' problem-solving strategies rather than just correctness encourages deeper engagement and a growth mindset. Finally, to encourage fuller participation, especially among learners who are afraid of peer judgement (40–60%), teachers are encouraged to foster participation

safety through techniques such as no-hands questioning and think-pair-share activities. These approaches may create a classroom environment where learners feel psychologically safe to contribute without fear of embarrassment, thereby promoting active learning and reducing avoidance behaviours.

5.6.2 For Policy

There is a need for the DBE to invest in trigonometry-specific resources that contribute to hands-on learning and conceptual understanding. This will include the provision of bearing charts, protractors, clinometers, and scientific calculators to schools, particularly those in under-resourced areas. These tools can help learners visualise and apply trigonometric concepts in real-life contexts, making the subject more accessible and engaging. Additionally, there is a critical need to fund continuing professional development (CPD) focused on trigonometric representations and the translation of problems from abstract mathematical language into visual or practical formats. CPD can better equip teachers to handle common learner difficulties and diverse classroom needs. Furthermore, policymakers should consider strengthening support for teacher coaching on interactive pedagogy and strategies for checking understanding. Coaching programmes should recognise ongoing mentorship and collaborative learning opportunities, helping teachers implement research-informed practices effectively and adapt to the realities of their classrooms.

5.6.3 For Future Research

Future research should build on a comprehensive understanding of the affective and contextual factors influencing trigonometry learning. One important thing is to trial brief mindset and self-efficacy interventions within trigonometry units, aimed at boosting learners' confidence and reducing test anxiety. The high test-related anxiety negatively impacts participation and achievement; evaluating the effectiveness of such interventions may provide evidence-based strategies for classroom application. Future research should also design studies that not only measure immediate changes in anxiety and engagement but also track longer-term impacts on performance and retention. Additionally, further research is needed to compare different school contexts, such as School A versus School B, to isolate environmental contributions to learner results. This comparative approach may help disentangle the influence of factors like resource availability, teacher quality, and school climate on learner success in trigonometry. Understanding these environmental dynamics is of

great importance in tailoring interventions and policies that address equity and contextual challenges.

5.7 Conclusion

The study demonstrates that mathematics anxiety in Grade 11 trigonometry is multi-dimensional. The integrated qualitative and quantitative results indicate that supportive strategies can help reduce its impact.

5.8 Recommendations

The study achieved its aim; namely, to evaluate whether Grade 11 learners that study trigonometry report or show signs of mathematics anxiety, identify its causes, and examine the measures that teachers use to curb or address it. Based on the results, the recommendations are presented:

5.8.1 Recommendations for Mathematics Teachers

Teachers play a significant role in shaping how learners experience trigonometry, either as an abstract and intimidating topic, or as a logical and engaging mathematical tool. To address widespread learner difficulties with rule application, conceptual understanding, and confidence, it is recommended that mathematics teachers implement recognition of effort, constructive feedback, and encouragement throughout instruction. These strategies may also help normalise errors and reduce performance anxiety, creating a classroom culture that values thinking over perfection.

In addition, teachers are encouraged to shift from a purely procedural approach to one that explicitly teaches rule selection, especially when deciding between sine, cosine, or tangent. This may include consistent use of the CAST diagram, which helps learners understand the signs of trigonometric ratios in each quadrant. It is also recommended that teachers offer process-focused feedback, which emphasises learner thinking and strategy rather than just correctness. Lastly, grounding trigonometric problems in real-life contexts, such as measuring the height of a tree or determining direction using bearings, can make the subject more tangible and engaging. Using diagrams and practical applications also aids visualisation, a skill that many learners struggle with in trigonometry.

5.8.2 Recommendations to the DBE

The findings highlight the importance of the DBE providing CPD that focuses specifically on trigonometry representations and identities. Teachers may need deep

content knowledge and pedagogical tools to teach trigonometric concepts like graphs and identities. CPD sessions may support teachers through being hands-on, collaborative, and focused on common learner misconceptions, equipping teachers to deliver conceptually rich lessons that extend beyond memorisation.

In addition to training, the DBE may supply visual resource kits and calculators to under-resourced schools. These kits could include items like protractors, triangle models, bearing maps, and clinometers, which allow learners to explore trigonometric principles through measurement and exploration. Without these tools, many learners are confined to textbook diagrams only. Importantly, the DBE may also invest in ongoing, in-class coaching on interactive pedagogy. The coaching sessions could also address teacher isolation, allowing for peer learning and collaborative problem-solving.

5.8.3 Recommendations for Future Research

Future researchers have a critical role to play in testing and refining interventions that address the affective dimensions of trigonometry learning, particularly self-efficacy, mindset, and anxiety. These emotional barriers can lead to avoidance, reduced effort, and disengagement from class activities. Beyond the intervention itself, future research may also track downstream impacts, examining whether changes in self-efficacy or mindset leads to improved participation, reduced anxiety, and better performance over time. In doing so, future studies could generate actionable evidence for teachers, policymakers, and curriculum developers to draw on when designing supports for struggling learners.

5.9 Limitations of the Study

This study has the following limitations:

- Due to financial constraints, the study was restricted to two secondary schools in the Nzhelele East Circuit, Vhembe West District in Limpopo Province. If more schools had been involved in the study, different findings might have emerged within the same circuit. Another limitation of the study was the withdrawal of participation by one of the schools.
- The study was only conducted in Nzhelele East Circuit, Vhembe West District in Limpopo Province. Different findings might have been obtained at the provincial level if the study had been extended to other districts of Limpopo Province. Therefore, the results of the study should not be generalised to a larger, provincial based population.
- Nzhelele East Circuit represents a rural area, and findings therefore are limited to a rural setting.
- Quantitative analysis was descriptive; therefore, the percentages should not be generalised beyond the sample.
- No longitudinal follow-up was conducted to assess the long-term effects of the strategies implemented.

References

- Abín, A., Núñez, J. C., Rodríguez, C., Cueli, M., García, T., & Rosário, P. (2020). Predicting mathematics achievement in secondary education: The role of cognitive, motivational, and emotional variables. *Front. Psychol.*, *11*, 876.
- Achuodho, P. L., Raburu, P. A., & Mwebi, B. M. (2020). Relationship between attitude and choice of mathematics related courses among female students in technical training institutes in Western region of Kenya. *International Journal of Research and Review*, *7*(11), 486–495.
- Adao, R. M, Bueno, M. B, Perssia, J. M., & Landicho, L. C. (2015). Academic motivation among college students with math anxiety: Basis for an enhancement program. *Asian Pacific Journal of Education, Arts and Sciences*, *2*(3), 58–62.
- Adimora, D. E., Nwokenna, E. N., Omeje, J. C., & Eze, U. N. (2015). Influence of socio-economic status and classroom climate on mathematics anxiety of primary school pupils. *Procedia-Social and Behavioural Sciences*, *205*, 693–701.
- Akbar, Z. (2015). Achievement motivation, self-efficacy, and mathematics anxiety among students in elementary school. *PalArch's Journal of Archaeology of Egypt*, *17*(10), 2004–2013.
- Akin, A., & Kurbanoglu, I. N. (2011). The relationships between math anxiety, math attitudes, and self-efficacy: A structural equation model. *Studia Psychologica* *53*(3), 263–273.
- Alanazi, H. M. N. (2019). The effects of active recreational math games on maths anxiety and performance in primary school children: An experimental study. *Multidisciplinary Journal for Education, Social and Technological Sciences*, *6*(1), 1–25.
- Ali, N. A. M., & Hassan, N. C. (2019). Mathematics anxiety and mathematics motivation among students in the Faculty of Science of a public university in Malaysia. *International Journal of Academic Research in Progressive Education and Development*, *8*(4), 952–963.

- Aliyu, G. (2021). *Impact of inquiry and problem-solving strategies on attitude, retention, and performance in trigonometry among senior secondary school students' in Zamfara State, Nigeria*. [PhD dissertation. Ahmadu Bello University, Zaria].
- Alshehri, M. A. (2016). The impact of using (5e's) instructional model on achievement of mathematics and retention of learning among fifth grade students. *IOSR Journal of Research & Method in Education*, 6(2), 43–48.
- Aluyor, P., & Matibemu, B. D. (2022). The effect of classroom overcrowding and social distance among secondary school students in Edo State. *African Scholars Journal of Education Research and Library Practice*, 26(8), 38–46.
- Amedume, L. K., Bukari, H. I., & Mifetu, R. F. (2022). Effect of problem-based learning approach on students' achievement in trigonometry. *International Journal of Trends in Mathematics Education Research*, 5(4), 348–357.
- Amer, L. A. Y., & Amalia, Y. S. (2021). Overcrowded classrooms at Yemeni basic schools: Teachers' perspectives. *Journal of English Language Teaching and Applied Linguistics*, 7(2), 92–99.
- Amiruddin, N. S. H. B., Ahmad, N. B., & Mamat, S. S. B. (2022). Exploring students' self-efficacy and anxiety towards mathematics problem solving during open and distance learning (ODL). *Mathematical Sciences and Informatics Journal*, 3(1), 39–55.
- Anouti, M. F., Shehayeb, S., & Mchiek, M. (2018). The effect of math anxiety on students' performance in the intermediate and secondary classes. *International Journal of Science and Research*, 8(9), 739–745.
- Arslan, Ç. (2020). Examining the relationship between 5-8th grade students' test anxiety and mathematics anxiety. *Acta Didactica Napocensia*, 13(1), 127–137.
- Atnafu, M. (2014). Secondary school mathematics teachers' attitude in teaching mathematics. *International Electronic Journal of Mathematics Education*, 9(1/2), 59–74.

- Attard, C., & Holmes, K. (2020). Blended learning in secondary mathematics classrooms. *Mathematics Education Research Journal*, 32(4), 719–740.
- Aunola, K., & Nurmi, J. E. (2005). The role of parenting styles in children's problem behaviour. *Child Development*, 76(6), 1144–1159.
- Awang, N., Ilias, M. R., Hussain, W. S. E. C., & Mokhtar, S. F. (2013). Students' attitude towards calculus subject: Bumiputera case-study. In *Proceedings of the 20th National Symposium on Mathematical Sciences* (Vol. 1522, pp. 392–395). AIP Conf. Proc.
- Ayara, N. J., Oton, M. G., & Udo, O. F. (2024). Activity based teaching method and students' academic achievement and retention in graphical solution in mathematics in Onna educational area. *International Journal of Research Publication and Reviews*, 5(2), 446–453.
- Ayub, A., Saud, S., & Akhtar, S. (2018). Overcrowded classrooms and teaching learning process: Analysis of elementary public sector schools of Quetta City. *Pakistan Journal of Educational Research*, 1(1), 49–69.
- Azizah, S. N., & Suhendra, S. (2020). Mathematics anxiety of senior high school students based on extrovert and introvert personality types. *Journal of Physics Conference Series*, 1521(3), 032047.
- Bakar, N. A., Ayub, A. F. M., Ahmad, N. A., & Abdullah, S. I. S. (2021). Mathematics achievement. The relationship between student engagement, parental involvement, and peer influence. *International Journal of Academic Research in Business and Social Sciences*, 11(5), 496–513.
- Balali, M., Sadeghi, J., & Homayouni, A. (2023). The intermediating role of self-regulation in the relationship between math educational beliefs and students' math anxiety. *Iranian Journal of Learning and Memory*, 6(21), 60–67.
- Bandura, A. (1969). *Principles of behaviour modification*. Holt, Rinehart, and Winston.
- Bandura, A. (1977). *Social learning theory*. Prentice Hall.
- Bandura, A. (1986). *Social foundations of thought and action: A social cognitive theory*. Prentice Hall.

- Barroso, C., Ganley, C. M., McGraw, A. L., Geer, E. A., Hart, S. A., & Daucourt, M. C. (2021). A meta-analysis of the relation between math anxiety and math achievement. *Psychological Bulletin*, 147(2), 134–168.
- Bartley, S. R., & Ingram, N. (2017). Parental modelling of mathematical affect: Self-efficacy and emotional arousal. *Mathematics Education Research Journal*, 30, 277–297.
- Baruiz, M. J. C., & Dioso, E. D. (2023). The use of manipulatives and its effects on the students' mathematics achievement: An experimental study. *International Journal of Environmental Economics, Commerce and Educational Management*, 10(8), 55–65.
- Bedada, T. B., & Machaba, F. (2022). The effect of Geogebra on STEM students learning trigonometric functions, *Cogent Education*, 9(1), 1–18.
- Bekele, G., & Yalew, A. (2023). The impact of students' attitude and previous achievement on mathematics anxiety: Evidence from Ethiopian high schools. *Bahir Dar Journal of Education*, 23(1), 55–72.
- Bicer, A., Capraro, R. M., & Capraro, M. M. (2020). STEM PBL and mathematics anxiety. *International Journal of Mathematical Education in Science and Technology*, 51(5), 1–17.
- Boakye, S., & Nabie, M. J. (2022). The effect of using the 5E instructional model of students' performance in and motivation to learn sine rule and its applications. *International Journal of Current Education Studies (IJCES)*, 1(1), 14–35.
- Bornaa, C. S., Rahaman, H. A., & Iddrisu, A. B. (2023). Mathematics anxiety and academic performance of senior high school students in Sagnarigu Municipality, Ghana. *East African Journal of Education Studies*, 6(2), 347–366.
- Bottge, B. A., Ma, X., Gassaway, L., Toland, M. D., Butler, M., & Cho, S. (2014). Effects of blended instructional models on math performance. *Exceptional Children*, 80(4), 423–437.

- Brijalall, D., & Niranjana, C. (2015). Using manipulatives to support an embodied approach to learning trigonometry in a South African school: A case study. *African Education Reviews*, 12(3), 361–380.
- Buckley, S., Reid, K., Goos, M., Lipp, O. V., & Thomson, S. (2016). Understanding and addressing mathematics anxiety using perspectives from education, psychology and neuroscience. *Australian Journal of Education*, 60, 157–170.
- Çağırğan, D., & İlker Soytürk, İ. (2021). The relationship between math anxiety, student engagement in mathematics and responsibilities towards learning among middle school students. *Elementary Education Online*, 20(1), 456–467.
- Çelik, H. C. (2018). The effects of activity-based learning on sixth grade students' achievement and attitudes towards mathematics activities. *EURASIA Journal of Mathematics, Science and Technology Education*, 14(5), 1963-1977.
- Chama, C., Sampa, R. L., Mutambo, D., Musonda, A., & Musonda, F. F. (2023). Learners' perceptions and attitudes towards learning of calculus in secondary schools: The case of three selected secondary schools in a district of the Northern Province of Zambia. *Journal of Advanced Research in Education*, 2(3), 68–75.
- Chigonga, B. (2016). Learners' errors when solving trigonometric equations and suggested interventions from grade 12 mathematics teachers. In *Proceedings: Towards Effective Teaching and Meaningful Learning in Mathematics, Science and Technology*. ISTE International Conference on Mathematics.
- Chikiwa, C. (2015). *Teaching trigonometry in grade 11 multilingual mathematics class: A focus teacher code switching practices*. [Master's thesis, Department of Education, Rhodes University, South Africa].
- Chikiwa, C., & Schäfer, M. (2018). *Promoting critical thinking in multilingual mathematics classes through questioning: Are teachers truly cultivating it?* Rhodes University, South Africa.

- Chikiwa, C., & Schäfer, M. (2019). Teachers' use of verbal language to evoke visualizations in multilingual mathematics classes. *Perspectives in Education*, 37(2), 124–140.
- Chinweoke, F. U. (2016). Effect of use of information, communication and technology (ICT) on secondary school students' achievement in trigonometry mathematics. *International Journal of Social Sciences and Humanities Reviews*, 6(3), 243–248.
- Chirimbana, M., Makaka, B., & Haimbodi, F. (2023). Effectiveness of differentiated instruction in alleviating math anxiety in grade 11, in Ompundja Circuit Oshana Region. *Open Journal of Social Sciences*, 11(12), 57–71.
- Chirimbana, M., Nghipandulwa, L. T., & Kamati, F. N. (2022). An investigation of the factors that contribute to poor problem-solving skills in grade 8 mathematics learners in Namibia. *Open Journal of Social Sciences*, 10, 614–628.
- Cohen, L., Manion, L., & Morrison, K. (2018). *Research methods in education* (8th ed.). Routledge.
- Creswell, J. W. (2007). *Qualitative inquiry and research design: Choosing among five approaches* (2nd ed.). Sage.
- Creswell, J. W. (2008). *Educational research: Planning, conducting, and evaluating quantitative and qualitative research* (3rd ed.). Pearson Education.
- Creswell, J. W. (2009). *Research design: Qualitative and mixed methods approach*. Routledge.
- Creswell, J. W. (2010). *Educational research—Planning, conducting, and evaluating quantitative and qualitative research* (4th ed.). Pearson Merrill, Prentice Hall.
- Creswell, J. W. (2018). *Research design: Qualitative, quantitative, and mixed methods Approaches*. Sage.
- Creswell, J. W., & Plano Clark, V. L. (2011). *Designing and conducting mixed methods research* (2nd ed.). Sage.

- Creswell, J. W., & Plano Clark, V. L. (2015). *Design and execution of mixed researches*. Sage.
- Creswell, J. W., & Plano Clark, V. L. (2018). *Designing and conducting mixed methods research* (3rd ed.). Sage.
- Denscombe, M. (2014). *The good research guide: For small-scale social research projects* (5th ed.). Open University Press.
- Department of Basic Education South Africa. (2011a). *National Curriculum Statement (NCS). Curriculum and Assessment Policy Statement: FET Phase. Grade 10-12. Mathematics*.
- Department of Basic Education (DBE). (2011b). *Report on the Annual National Assessment of 2011*.
- Department of Basic Education (DBE). (2017). *National Senior Certificate Examinations Diagnostic Report of 2017*.
- Department of Basic Education (DBE). (2022). *National Senior Certificate Examinations Diagnostic Report of 2022*.
- Department of Basic Education (DBE). (2023). *National Senior Certificate Examinations Diagnostic Report of 2023*.
- Department of Basic Education (DBE). (2024). *National Senior Certificate Examinations Diagnostic Report of 2024*.
- Deringöl, Y. (2022). Parents' mathematics anxiety and their contribution to mathematics education. *International Journal of Psychology and Educational Studies*, 9(1), 12–21.
- Dodongan, E. B. (2022). Math anxiety, learning engagement and perceived usefulness of technology as predictors to mathematics performance of students. *International Journal of Trends in Mathematics Education Research*. 5(1), 12–18.
- Dossel, S. (2016). Maths anxiety. *Australian Mathematics Teacher*, 72(3), 40–44.

- Dowker, A., & Sheridan, H. (2022). Relationships between mathematics performance and attitude to mathematics: Influences of gender, test anxiety, and working memory. *Front. Psychol.*, 13, 814992. Doi: 10.3389/fpsyg.2022.814992
- Dweck, C. S. (2006). *Mindset: The new psychology of success*. Random House.
- Eagly, A.H., & Chaiken, S. (1993). *The psychology of attitudes*. Harcourt Brace Jovanovich.
- Eastern Cape Department of Education. (2019). *National Senior Certificate Examination Chief Marker Report (Mathematics) of 2019*.
- Eastern Cape Department of Education. (2020). *National Senior Certificate Examination Chief Marker Report (Mathematics) of 2020*.
- Eidlin-Levy, H., Avraham, E., Fares, L., & Rubinstein, O. (2023). Math anxiety affects career choices during development. *International Journal of STEM Education*. Prentice Hall. <https://doi.org/10.1186/s40594-023-00441-8>
- Espino, M., Pereda, J., Recon, J., Perculeza, E., & Umali, C. (2017). Mathematics anxiety and its impact on the course and career choice of grade 11 students. *International Journal of Education, Psychology and Counselling*, 2(5), 99–119.
- Essuman, S. A., Nyarko, J., & Frimpong, K. (2021). Impact of mathematics anxiety on the academic performance of junior high school pupils in the Bongo District of Ghana. *International Journal of Social Sciences and Humanities Invention*, 8, 6562–6569.
- Estonanto, A. J., & Dio, R. V. (2019). Factors causing mathematics anxiety of senior high school students in calculus. *Asian Journal of Education and e-Learning*, 7(1), 37–47.
- Fantuzzo, J., Tighe, E., & Childs, S. (2000). Family involvement questionnaire: A multivariate assessment of family participation in early childhood education. *Journal of Educational Psychology*, 92(2), 367–376.

- Ferguson, A. M., Maloney, E. A., Fugelsang, J., & Risko, E. F. (2015). On the relation between math and spatial ability: The case of math anxiety. *Learning and Individual Differences*, 39, 1–12.
- Gafoor, K. A., & Kurukkan, A. (2015). Student attitudes towards mathematics: An examination of factors affecting student perceptions and engagement. *Educational Studies in Mathematics*, 89(2), 191–209.
- Ganiyatu, A., Kajuru, Y. K., & Bolaji, C. (2022). Impact of inquiry and problem-solving strategies on performance and attitude in trigonometry among senior secondary school students in Zamafara State, Nigeria. *Journal of Science Technology and Education*, 10(1), 128–135.
- Garba, A., Ismail, N., Osman, S., & Rameli, M. R. M. (2020). Exploring peer effect on mathematics anxiety among secondary school students of Sokoto State, Nigeria through photovoice approach. *Eurasia Journal of Mathematics, Science and Technology Education*, 16(2).
- García, T., Rodríguez, C., Betts, L., Areces, D., & González-Castro, P. (2016). How affective-motivational variables and approaches to learning predict mathematics achievement in upper elementary levels. *Learning and Individual Differences*, 49, 25–31.
- Gegbe, B., Sundai, A., & Sheriff, V. K. (2015). Factors contributing to students' poor performance in mathematics at West Africa Senior School Certification Examination (A case study: Kenema City, Eastern Province Sierra Leone). *International Journal of Engineering Research and General Science*, 3(2), 1040–1055.
- Gerhana, M. T. C., Mardiyana, M., & Pramudya, I. (2017). The effectiveness of project-based learning in trigonometry. *Journal of Physics: Conference Series*, 895(1), 012027.
- Glover, T. A., Nugent, G. C., Chumney, F. L., Ihlo, T., Guard, E. S. S. K., & Bovaird, N. K. J. (2016). Investigating rural teachers' professional development, instructional knowledge, and classroom practice. *Journal of Research in Rural Education*, 31(3).

- Haase, V. G., Guimarães, A. P. L. & Wood, G. (2019). Mathematics and emotions: The case of math anxiety. In A. Fritz, V. G. Haase, & P. Rasanen (Eds.), *International handbook of mathematical learning difficulties* (pp. 469–503). Springer.
- Haciomeroglu, G. (2017). Reciprocal relationships between mathematics anxiety and attitude towards mathematics in elementary students. *Acta Didactica Napocensia*, 10(3), 60–68.
- Hannan, S., Juan, A., & Harvey, J. (2024). Fostering self-efficacy: Understanding South African grade 9 students' confidence in their mathematics abilities. *African Journal of Research in Mathematics, Science and Technology Education*, 28(2).
- Hernandez, M. (2014). The relationship between mathematics achievement and socio-economic status. *E-Journal of Educational Policy*, 2014(1), 1–12.
- Hiebert, J., & Lefevre, P. (1986). Conceptual and procedural knowledge in mathematics. An introductory analysis. In J. Hiebert (Ed.), *Conceptual and procedural knowledge: The case of mathematics* (pp. 1–27). Lawrence Erlbaum.
- Hill, F., Mammarella, I. C., Devine, A., Caviola, S., Passolunghi, M. C., & Szűcs, D. 2016. Maths anxiety in primary and secondary school students: Gender differences, developmental changes and anxiety specificity. *Learning and Individual Differences*, 48, 45–53.
- Hodes, E., & Nolting, P. (1998). *Winning at Mathematics*. SBCC Mathematics Department, Academic Success Press.
- Hoferichter, M. C., Kulakow S., & Hufenbach, M. C. (2021). Support from parents, peers, and teachers is differently associated with middle school students' well-being. *Front. Psychol.*, 12, 758226. doi: 10.3389/fpsyg.2021.758226
- Huang, X., Zhang, J., & Hudson, L. (2022). Self-efficacy and mathematics anxiety: A meta-analysis. *Educational Psychology Review*, 34, 1–25.

- Imtiaz, S. (2014). Exploring strategies for English language teaching of Pakistani students in public sector colleges. *Research Journal of English Language and Literature (RJELAL)*, 2(2), 247–253.
- Irhamna, I., Amry, Z., & Syahptura, H. (2020). Contribution of mathematical anxiety, learning motivation and self-confidence to student's mathematical problem solving. *Budapest International Research and Critics in Linguistics and Education (BirLE) Journal*, 3(4), 1806–1813.
- İşleyen, T. (2015). The relationship between secondary school students' mathematics anxiety and self-regulation. *Educational Research and Reviews*, 10(5), 684–690.
- Ismail, N., Garba, A., Osman, S., Ibrahim, N. H., & Bunyamin, M. A. H. (2022). Exploring teacher effects on intensifying and minimizing mathematics anxiety among students in Sokoto State, Nigeria. *International Journal of Evaluation and Research in Education*, 11(1), 161–171.
- Jamieson, J. P., Peters, B. J., Greenwood, E. J., & Altose, A. J. (2016). Reappraising stress arousal improves performance and reduces evaluation anxiety in classroom exam situations. *Social Psychological and Personality Science*, 7, 579–587.
- Kagenyi, D. G. (2016). *Pedagogical factors affecting the learning of trigonometry in secondary schools in Gatundu North Sub-County, Kiambu County, Kenya* [Master's thesis, Kenyatta University].
- Kahreh, S. V., Imani, S., Haseli, Y. M., & Mansour, F. K. (2018). Study of effectiveness of self-regulated learning strategies on math anxiety of dependent cognitive style of school students. *International Journal of Educational and Psychological Researches*, 4(2), 89.
- Kamina, P., & Iyer, N. N. (2009). From concrete to abstract: Teaching for transfer of learning when using manipulatives. *NERA Conference Proceedings*.
- Karikari, A., Kumi, E. O., Achiaa, E. A., & Adu, J. (2022). The impact of using mother tongue as instructional languages in teaching and learning of mathematics in rural primary schools (A case study of four selected schools

- in Sefwi Akontombra District, Ghana). *International Journal of Novel Research in Education and Learning*, 9(1), 26–38.
- Kesici, A., & Bindak, R. (2019). Does mathematics anxiety have any impact on secondary school pupils' friend choices? *International Journal of Educational Methodology*, 5(1), 123–130.
- Kitto, K., & Knitt, S. (2019). Practical ethics for building learning analytics. *British Journal of Educational Technology*, 50(6), 2855–2870.
- Kivunja, C., & Kuyini, A. B. (2017). Understanding and applying research paradigms in educational contexts. *International Journal of Higher Education*, 6, 26–41.
- Koch, M. A. (2014). *The relationship between peer coaching, collaboration and collegiality, teacher effectiveness and leadership* [Doctoral dissertation, Walden University].
- Kumar, N., & Aurora, P. (2017). Association of student achievement with home environment. *Scholarly Research Journal for Humanity Science & English Language*, 4(21), 4850–4855.
- Kumari, S. (2015). An investigation into mathematical anxiety among students at senior secondary level. *Indian Streams Research Journal*, 5(7).
doi:10.9780/22307850
- Larbi, E., & Mavis, O. (2016). The use of manipulatives in mathematics education. *Journal of Education and Practice*, 7(36), 53–61.
- Lavasani, M. G., & Khandan, F. (2011). The effect of cooperative learning on mathematics anxiety and help seeking behaviour. *Procedia-Social and Behavioural Sciences*, 15, 271–276. doi: 10.1016/j.sbspro.2011.03.085
- Li, Q., Cho, H., Cosso, J., & Maeda, Y. (2021). Relations between students' mathematics anxiety and motivation to learn mathematics: A meta-analysis. *Educational Psychology Review*, 33, 1017–1049.
- Likuru, L. C., & Mwila, P. M. (2022). Overcrowded classrooms: Effect on teaching and learning process in public secondary schools in Ilemela Municipality, Tanzania. *Asian Journal of Education and Social Studies*, 30(2), 75–87.

- Lincoln, Y. S., Lynham, S. A., & Guba, E.G. (2011). Paradigmatic controversies, contradictions, and emerging confluences, revisited. In N. Denzin, & Y.S. Lincoln (Eds.), *The Sage handbook of qualitative research* (4th ed., pp. 97–128). Sage.
- Luu-Thi, H-T., Ngo-Thi, T-T., Nguyen-Thi, M-T., Thao-Ly, T., Nguyen-Duong, B-T., & Tran-Chi, V-L. (2021) An investigation of mathematics anxiety and academic coping strategies among high school students in Vietnam: A cross-sectional study. *Front. Educ.* 6, 742130. doi: 10.3389/feduc.2021.742130
- Mabena, N., Mokgosi, P. N., & Ramapela, S. S. (2021). Factors contributing to poor learner performance in mathematics: A case of selected schools in Mpumalanga province, South Africa. *Problems of Education in the 21st Century*, 79(3), 451–466.
- Mack, L. (2010). The philosophical underpinnings of educational research. *Polyglossia*, 19, 5–11.
- Mahigir, F., Venkatesh Kumar, G., & Karimi, A. (2012). Parent's socio-economic background, mathematics anxiety and academic achievement. *International Journal of Education Administration and Policy Studies*, 4(8), 177–180.
- Makofane, M. P., & Maile, S. (2019). Factors influencing poor performance in grade 12 mathematics: A case study of Bohlabela Cluster of Limpopo. Pretoria, *World Journal of Educational Research*, 6(1), 37–47.
- Malik, S., & Manaf, U. K. (2018). The effect of orientation and mobility curriculum on the academic achievement of visually impaired children among public and private institutions of Lahore. *Multilingual Academic Journal of Education and Social Sciences*, 6(1), 66–75.
- Maloney, E. A., Ramirez, G., Gunderson, E. A., Levine, S. C., & Beilock, S. L. (2015). Intergenerational effects of parents' math anxiety on children's math achievement and anxiety. *Psychological Science*, 26(9), 1480–1488.
- Maloney, E. A., Schaeffer, M. W., & Beilock, S. L. (2013). Mathematics anxiety and stereotype threat: Shared mechanisms, negative consequences and

- promising interventions. *Research in Mathematics Education*, 15(2), 115–128. DOI: 10.1080/14794802.2013.797744
- Mamiala, D., Mji, A., & Simelane-Mnisi, S. (2021). Exploring students' anxiety about the learning understanding of geometry in high school. In L. Gómez Chova, A. López Martinez, & I. Candel Torres (Eds.), *EDULEARN21 Proceedings: 13th International Conference on Education and New Learning Technology* (pp. 8051–8058). IATED.
- Maphutha, K., Maoto, S., & Kibirige, I. (2022). The effect of the activity-based approach on grade 11 learners' performance in solving two-dimensional trigonometric problems. *EURASIA Journal of Mathematics, Science and Technology Education*, 18(10), 1–14.
- Maphutha, K., Maoto, S., & Mutodi, P. (2023). Exploring Grade 11 learners' mathematical connections when solving two-dimensional trigonometric problems in an activity-based learning environment. *Journal on Mathematics Education*, 14(2), 293-310.
- Marais, P. (2016). "We can't believe what we see": Overcrowded classrooms through the eyes of student teachers. *South African Journal of Education*, 36(2), 1–10.
- Marianne, B., Dagaylo, A. N., & Noel, P. T. (2016). Mathematics anxiety and the academic performance of the freshmen college students of the Naval State University. *International Journal of Engineering Sciences & Research Technology*, 5(1), 1–7.
- Maslow, A. H. (1943). A theory of human motivation. *Psychological Review*, 50(4), 370–376.
- Mauliyda, M. A., Hidayanto, E., & Rahardjo, S. (2019). Representation of trigonometry graph function college students using GeoGebra. *International Journal of Trends in Mathematics Education Research*, 2(4), 193–196.
- May, V., & Courtney, S. (2016). Developing meaning in trigonometry. *Illinois Mathematics Teacher*, 63(1), 25–33.

- McMillan, J. H., & Schumacher, S. (2010). *Research in Education—Evidence-Based Inquiry*. (7th ed.). Pearson Education.
- McNeal, R. B. (2014). Parent involvement, academic achievement and the role of student attitudes and behaviours as mediators. *Universal Journal of Educational Research*, 2(8), 564–576.
- Mizala, A., Martinez, F., & Martinez, S. (2015). Pre-service elementary school teachers' expectations about student performance: How their beliefs are affected by their mathematics anxiety and student's gender. *Teaching and Teacher Education*, 50, 70–78.
- Mokotjo, L. G., & Mokhele, M. L. (2021). Challenges of Integrating Geogebra in the teaching of mathematics in South Africa high schools. *Universal Journal of Educational Research*, 9(5), 963–973.
- Moliner, L., & Alegre, F. (2020). Peer tutoring effects on students' mathematics anxiety: A middle school experience. *Frontiers in Psychology*, 11, Article 1610.
- Mosese, N., & Ogbonnaya, U. I. (2021). Geogebra and students' learning achievement in trigonometric functions graphs representations and interpretations. *Cypriot Journal of Educational Science*, 16(2), 827–846.
- Mpiti, P. T., & Wambu, Z. Y. (2023). An investigation into the determinants of underperformance in mathematics among grade 12 learners in a high school in the Eastern Cape. In D. Ortega-Sánchez (Ed.), *Education Annual Volume 2023*. IntechOpen. Doi:10.5772/Intechopen.109014
- Munje, P. N., & Mncube, V. (2018). The lack of parental involvement as hindrance in selected public primary schools in South Africa: The voices of educators. *Perspectives of Educators*, 36(1), 80–83.
- Mutengi, C. M., Gitonga, C. M., & Rugano, P. (2021). Mathematics anxiety, attitude and performance among secondary school students in Kenya. *Educational Research and Reviews*, 16(6), 213–221.
- Mutlu, Y. (2019). Math anxiety in students with and without math learning difficulties. *International Journal of Elementary Education*, 11(5), 471–475.

- Mutodi, P., & Ngirande, H. (2014). The impact of parental involvement on student performance: A case study of a South African secondary school. *Mediterranean Journal of Social Sciences*, 5(8), 279–289.
- Naidoo, J., & Govender, R. (2014). Exploring the use of a dynamic online software programme in the teaching and learning of trigonometric graphs. *Pythagoras*, 35(2), 1–13.
- Namkung, J. M., Peng, P., & Lin, X. (2019). The relation between mathematics anxiety and mathematics performance among school-aged students: A meta-analysis. *Review of Educational Research*, 89(3), 459–496.
- Ngussa, B. M., & Mbuti, E. E. (2017). The influence of humour on learners' attitude and mathematics achievement: A case of secondary schools in Arusha City, Tanzania. *Journal of Educational Research*, 2(3), 170–181. Retrieved from <https://www.researchgate.net/publication/315776039>
- Niranjan, C. (2013). *Using artefacts to support an embodied approach to learning trigonometry: A case of grade 10 learners* [M.Ed. dissertation. University of KwaZulu-Natal].
- Nowell, L. S., Norris, J. M., White, D. E., & Moules, N. J. (2017). Thematic analysis striving to meet the trustworthiness criteria. *International Journal of Qualitative Methods*, 16(1), 160940691773384. doi: 10.1177/1609406917733847
- Nwoke, B. I. (2021). Enhancing primary school pupils' mathematics creative ability through activity-based learning approach. *Malikussaleh Journal of Mathematics Learning (MJML)*, 4(2), 70–76.
- O'Donoghue, T. (2018). *Planning your qualitative research thesis and project: An introduction to interpretivist research in education and the social sciences*. Routledge.
- OECD. (2021). *PISA results and mathematics performance*. Paris: OECD.

- Ojonubah, J. O. (2015). Impacts and solutions of overcrowded mathematics class on students' achievement in schools. *Journal of Resourcefulness and Distinction*, 11(1), 1–14.
- Olango, M. (2016). Mathematics anxiety factors as predictors of mathematics self-efficacy and achievement among freshmen science and engineering students. *African Educational Research Journal*, 4(3), 109–123.
- Omotayo, S. A., & Adeleke, J. O. (2017). The 5E instructional model: A constructivist approach for enhancing students' learning outcomes in mathematics. *JISTE*, 21(2), 15–26.
- Oribhabor, C. B. (2020). Evaluating the effect of activity-based method of teaching mathematics on Nigerian secondary school students' achievement in mathematics. *Puissant—A Multidisciplinary Journal*, 1, 77–78.
- Oxford Learner's Dictionaries. (2023). *Anxiety*. In *Oxford Learner's Dictionaries*. Oxford University Press.
- Paas, F., & van Merriënboer, J. (2020). Cognitive load theory. *Educational Psychology Review*, 32, 1–24.
- Padmavathy, R. D., & Mareesh, K. (2013). Effectiveness of problem-based learning in mathematics. *International Multidisciplinary e-Journal*, 2(1), 45–51.
- Pastera, L. J. S., Guay, J. M., Cortez, M. V., & Doloriel, N. S. (2018). Modelling students' performance in plane trigonometry with their levels of intrinsic and extrinsic motivations. *SDSSU Multidisciplinary Research Journal (SMRJ)*, 6(1), 5–9.
- Pekrun, R. (2006). The control-value theory of achievement emotions: Assumptions, corollaries, and implications for educational research and practice. *Educational Psychology Review*, 18(4), 315–341.
- Piaget, J. (1964). Part I: Cognitive development in children: Piaget development and learning. *Journal of Research in Science Teaching*, 2(3), 176–186.
- Picaza, R. R. (2023). Geogebra application for trigonometry subject: A quasi-experimental research. *East Asian Journal of Multidisciplinary Research (EAJMR)*, 2(5), 2145–2164.

- Polit, D. F., & Beck, C. T. (2014). *Essentials of nursing research: Appraising evidence for nursing practice* (8th ed.). Lippincott Williams & Wilkins.
- Poth, C., & Munce, S. E. P. (2020). Commentary—Preparing today's researchers for a yet unknown tomorrow: Promising practices for a synergistic and sustainable mentoring approach to mixed methods research learning. *International Journal of Multiple Research Approaches*, 12(1), 56–64.
- Psychology Dictionary Online. (2018). *Self-confidence*. *Positive Psychology Program*. Retrieved from: <http://positivepsychologyprogram.com/self-confidence>
- Quintero, M., Hasty, L., Li, T., Song, S., & Wang, Z. (2021). A multi-dimensional examination of math anxiety and engagement on math achievement. *British Journal of Educational Psychology*, 92(3), 955–973.
<https://doi.org/10.1111/bjep.12482>
- Radišić, J., Videnović, M., & Baucal, A. (2015). Math anxiety—Contributing school and individual level factors. *European Journal of Psychology of Education*, 30(1), 1–20. <https://doi.org/10.1007/s10212-014-0224-7>
- Rahman, M. H. A., & Puteh, M. (2016). Learning trigonometry using Geogebra learning module: Are under achieve pupils motivated? *AIP Conference Proceedings*, 1750(1), 040001.
- Rajab, P., & Motileng, B. (2024). The predictive value of study orientations on mathematics performance in South African Grade 9 learners. *Pythagoras*, 45(1), a805.
- Ramirez, G., Chang, H., Maloney, E. A., Levine, S. C., & Beilock, S. L. (2016). On the relationship between math anxiety and math achievement in early elementary school: The role of problem-solving strategies. *Journal of Experimental Child Psychology*, 141, 83–100.
- Riboroso, R. A., Llagas Jr, R. M., & Taan, J. L. R. (2018). Mathematics self-efficacy and anxiety and mathematics performance of elementary education students. *International Journal of Scientific & Engineering Research*, 9(11), 671–687.

- Roberts, A. K., & Spangenberg, E. D. (2020). Peers tutors' views on their role in motivating learners to learn mathematics. *Pythagoras*, 41(1), a520.
- Rogers, C. R. (1961). *On becoming a person: A therapist's view of psychotherapy*. Houghton Mifflin.
- Rosli, R., Goldsby, D., & Capraro, M. M. (2015). Using manipulatives in solving and posing mathematical problems. *Scientific Research Publishing*. 2015(6), 1718–1725.
- Samante, J. L., & Alave, A. D. (2021). Anxiety and performance in mathematics of grade four pupils. *Globus Journal of Progressive Education*, 11(1), 1–6.
- Schukajlow, S., Rakoczy, K., & Pekrun, R. (2017). Emotions and motivation in mathematics education: theoretical considerations and empirical contributions. *ZDM*, 49(3), 307–322. <https://doi.org/10.1007/s11858-017-0864-6>
- Schunk, D. H., Pintrich, P. R., & Meece, J. L. (2008). *Motivation in education: Theory* (3rd ed.). Pearson Education.
- Segumpan, L. L. B., & Tan, D. A. (2018). Mathematics performance and anxiety of junior high school students in a flipped classroom. *European Journal of Education Studies*, 4(12), 1–15.
- Shamaki, S. K. (2015). The impact and role of the physical environment of the school in teaching and learning mathematics. *American School Board Journals*, 157(3), 179–187.
- Shishign, A. (2018). Mathematics anxiety and prevention strategy: An attempt to support students and strengthen mathematics education. *Mathematics Education Trends and Research*, 1, 1–11. <https://doi:10.5899/2018/metr-00096>
- Simbulas, V. G., Salva, E. T., & Simbulas, L. J. C. (2023). Online teaching competencies, attitude towards mathematics and academic achievement of grade 10 learners in geometry: A path analysis. *East Asian Journal of Multidisciplinary Research (EAJMR)*, 2(7), 3015–3038.

- Sinyosi, L. B. (2015). *Factors affecting grade 12 learners' performance in mathematics at Nzhelele East Circuit: Vhembe District in Limpopo* [M.Ed. dissertation. University of South Africa]. <http://hdl.handle.net/10500/20245>
- Siyang, E. L. T. (2018). The use of mother tongue in teaching mathematics. *International Journal of Education, Psychology and Counselling*, 3(20), 65–72.
- Skagerlund, K., Östergren, R., Västfjäll, D., & Träff, U. 2019. How does mathematics anxiety impair mathematical abilities? Investigating the link between math anxiety, working memory, and number processing. *PLoS ONE*, 14(1): e0211283.
- Soni, A., & Kumari, S. (2017). The role of parental math anxiety and math attitude in their children's math achievement. *International Journal of Science and Mathematics Education*, 15(2), 331–347. <https://doi.org/10.1007/s10763-015-9687-5>
- Sumantri, M. S., & Whardani, P. A. (2017). Relationship between motivation to achieve and professional competence in the performance of elementary school teachers. *International Education Studies*, 10(7), 118–125.
- Sundai, G. B., & Sheriff, V. K. (2015). Factors contributing to students' poor performance in mathematics at West African Senior School Certification Examination (A Case Study: Kenema City, Eastern Province Sierra Leone). *International Journal of Engineering Research and General Science*, 3(2), 1040–1055.
- Supekar, K., Luculano, T., Chen, L., & Menon, V. (2015). Remediation of childhood math anxiety and associated neural circuits through cognitive tutoring. *Journal of Neuroscience*, 35, 12574–12583. doi: 10.1523/JNEUROSCI.0786-15.2015
- Suren, N., & Kandemir, M. A. (2020). The effects of mathematics anxiety and motivation on students' mathematics achievement. *International Journal of Education in Mathematics, Science and Technology*, 8(3), 190–218.

- Sweller, J. (1988). Cognitive load during problem solving: Effects on learning. *Cognitive Science*, 12(2), 257–285.
- Syyeda, F. (2016). Understanding attitudes towards mathematics (ATM) using a multimodal model: An exploratory case study with secondary school children in England. *Cambridge Open-Review Educational Research e-Journal*, 3, 32–62.
- Tashakkori, A., & Teddlie, C. (2010). *SAGE handbook of mixed methods in social & behavioral research* (2nd ed.). Sage.
- Tella, A., Ayeni, C. O., & Popoola, S. O. (2007). Work motivation, job satisfaction, and organisational commitment of library personnel in academic and research libraries in Oyo State, Nigeria. *Library Philosophy and Practice (e-journal)*, 118.
- Tertsea, A. J. (2020). Effects of inquiry and problem-solving methods on students' attitude and performance in trigonometry among junior secondary schools in Benue State, Nigeria. *International Journal of Scientific and Engineering Research*, 11(4), 1166–1181.
- Tuna, A., & Kacar, A. (2013). The effect of 5E learning cycle model in teaching trigonometry on students' academic achievement and the permanence of their knowledge. *International Journal on New Trends in Education and their Implications*, 4(1), 73–90.
- Universities South Africa Report (2023). *High school learners underprepared for critical foundational university mathematics courses*.
- Van Damme, D. (2015). International learner mobility driven by imbalances in the global higher education system? *OECD International Journal of Adult Competences*, 3(4), 1–35.
- Van Gog, T. (2021). Cognitive load and learning. *Educational Psychology Review*, 33, 1–22.
- Vygotsky, L. S. (1978). *Mind in society*. Harvard University Press.
- Wang, Z., Lukowski, S. I., Hart, S. A., Lyons, I. M., Thompson, L. A., Kovas, Y., Mazzocco, M. M., Plomin, R., & Petrill, S. A. (2015). Is math anxiety always

- bad for math learning? The role of mathematics motivation. *Psychological Science*, 26(12), 1863–1876.
- Webb, L., & Webb, P. (2013). Teaching strategies in language-diverse mathematics classes: A case study. *Educational Research for Social Change (ERSC)*, 2(2), 31–42.
- Welford, M. (2013). *The power of self-compassion: Using compassion-focused therapy to end self-criticism and build self-confidence*. New Harbinger Publications.
- West, J., & Meier, C. (2020). 'Overcrowded classrooms—The Achilles heel of South African Education?', *South African Journal of Education* 10(1), a617.
- Wisniewski, B., Zierer, K., & Hattie, J. (2020). Feedback effects. *Frontiers in Psychology*, 10, 3087.
- Witzel, B. (2005). Using CRA to teach algebra to students with math difficulties in inclusive settings. *Learning Disabilities—A Contemporary Journal*, 3(2), 49–60.
- Xin, S., & Guo, Z. (2022). An analysis of the effect of teacher's behaviour on mathematics anxiety and the role of intervention programs. *Research Square*.
- Yadav, S., & Singh, P. N. (2018). A study on mathematics anxiety and mathematics achievement of secondary school students. *International Journal of Social sciences, Arts and Humanities*, 5(3), 52–57.
- Yeager, D. S., & Dweck, C. S. (2012). Mindsets that promote resilience: When students believe that intelligence is malleable. *Educational Psychology Review*, 24(2), 157–175.
- Yuliani, R. E., Suryadi, D., & Dahlan, J. A. (2019). Analysis of mathematics anxiety of junior high school students. *Journal of Physics: Conference Series*, 1157, 042053.
- Zakariya, Y. F., Ibrahim, M. O., & Adisa, L. O. (2016). Impacts of problem-based learning on performance and retention in mathematics among junior secondary school students in Sabon-Gari Area of Kaduna State.

International Journal for Innovative Research in Multidisciplinary Field, 2(9), 42–47.

Zhang, J., Zhao, N., & Kong, Q. P. (2019). The relationship between math anxiety and math performance: A meta-analytic investigation. *Front. Psychol.*, 10, 1613.

Appendices

Appendix A: Proof of Registration



2013

SIVHADA T MR
P O BOX 631
NZHELELE
0993

STUDENT NUMBER : 61956643
ENQUIRIES TEL : 0800 001 870
eMAIL : mandd@unisa.ac.za
2025-03-29

Dear Student

I hereby confirm that you have been registered for the current academic year as follows:

Proposed Qualification: MED MATHS EDUC (90061)			PROVISIONAL EXAMINATION	
CODE	PAPER	S NAME OF STUDY UNIT	NQF crdts	LANG. EXAM. DATE CENTRE (PLACE)
Study units registered without formal exams:				
DFMED96		MED - Mathematics Education (Dissertation)	**	E
# DFMED96		MED - Mathematics Education (Dissertation)	**	E
# Exam transferred from previous academic year				

You are referred to the "MyRegistration" brochure regarding fees that are forfeited on cancellation of any study units.

- # Your attention is drawn to University rules and regulations (www.unisa.ac.za/register).
- Please note the new requirements for reregistration and the number of credits per year which state that students registered for the first time from 2013, must complete 36 NQF credits in the first year of study, and thereafter must complete 48 NQF credits per year.
- Students registered for the MBA, MBL and DBL degrees must visit the SBL's ESOOnline for study material and other important information.
- Readmission rules for Honours: Note that in terms of the Unisa Admission Policy academic activity must be demonstrated to the satisfaction of the University during each year of study. If you fail to meet this requirement in the first year of study, you will be admitted to another year of study. After a second year of not demonstrating academic activity to the satisfaction of the University, you will not be re-admitted, except with the express approval of the Executive Dean of the College in which you are registered. Note too, that this study programme must be completed within three years. Non-compliance will result in your academic exclusion, and you will therefore not be allowed to re-register for a qualification at the same level on the National Qualifications Framework in the same College for a period of five years after such exclusion, after which you will have to re-apply for admission to any such qualification.
- Readmission rules for M&D: Note that in terms of the Unisa Admission Policy, a candidate must complete a Master's qualification within three years. Under exceptional circumstances and on recommendation of the Executive Dean, a candidate may be allowed an extra (fourth) year to complete the qualification. For a Doctoral degree, a candidate must complete the study programme within six years. Under exceptional circumstances, and on recommendation by the Executive Dean, a candidate may be allowed an extra (seventh) year to complete the qualification.

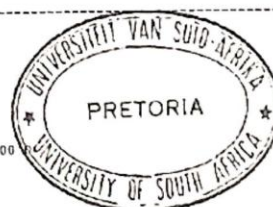
BALANCE ON STUDY ACCOUNT: 12760.00

Payable on or before:	2025/03/31:	0.00	2025/05/15:	6380.00	2025/08/15:	6380.00
Immediately:	0.00	2025/11/15:	0.00	2026/03/15:	0.00	

Yours faithfully,

Prof M M Sepota
Acting Registrar

0108 0 00



University of South Africa
Pretorius Street, Mutlalek Ridge, City of Tshwane
PO Box 392 UNISA 0003 South Africa
Telephone: +27 12 429 3111 Facsimile: +27 12 429 4150
www.unisa.ac.za

Appendix B: Ethical Clearance Certificate



UNISA COLLEGE OF EDUCATION ETHICS REVIEW COMMITTEE

Date: 2024/05/08

Ref: **2024/05/08/61956643/22/AM**

Name: Mr T Sivhada

Student No.: 61956643

Dear Mr T Sivhada

Decision: Ethics Approval from
2024/05/08 to 2027/05/08

Researcher(s): Name: Mr T Sivhada
E-mail address: tsivhada@gmail.com
Telephone: 076 640 2114

Supervisor(s): Name: Dr E.G Makwakwa
E-mail address: makwaeg@unisa.ac.za
Telephone: 012 429 4575

Title of research:

Mathematics anxiety of grade 11 learners in trigonometry in Vhembe West District, Limpopo Province

Qualification: MEd Mathematics Education

Thank you for the application for research ethics clearance by the UNISA College of Education Ethics Review Committee for the above mentioned research. Ethics approval is granted for the period 2024/05/08 to 2027/05/08.

*The **medium risk** application was reviewed by the Ethics Review Committee on 2024/05/08 in compliance with the UNISA Policy on Research Ethics and the Standard Operating Procedure on Research Ethics Risk Assessment.*

The proposed research may now commence with the provisions that:

1. The researcher will ensure that the research project adheres to the relevant guidelines set out in the Unisa Covid-19 position statement on research ethics attached.
2. The researcher(s) will ensure that the research project adheres to the values and principles expressed in the UNISA Policy on Research Ethics.



University of South Africa
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www.unisa.ac.za

3. Any adverse circumstance arising in the undertaking of the research project that is relevant to the ethicality of the study should be communicated in writing to the UNISA College of Education Ethics Review Committee.
4. The researcher(s) will conduct the study according to the methods and procedures set out in the approved application.
5. Any changes that can affect the study-related risks for the research participants, particularly in terms of assurances made with regards to the protection of participants' privacy and the confidentiality of the data, should be reported to the Committee in writing.
6. The researcher will ensure that the research project adheres to any applicable national legislation, professional codes of conduct, institutional guidelines and scientific standards relevant to the specific field of study. Adherence to the following South African legislation is important, if applicable: Protection of Personal Information Act, no 4 of 2013; Children's act no 38 of 2005 and the National Health Act, no 61 of 2003.
7. Only de-identified research data may be used for secondary research purposes in future on condition that the research objectives are similar to those of the original research. Secondary use of identifiable human research data requires additional ethics clearance.
8. No field work activities may continue after the expiry date **2027/05/08**. Submission of a completed research ethics progress report will constitute an application for renewal of Ethics Research Committee approval.

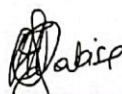
Note:

*The reference number **2024/05/08/61956643/22/AM** should be clearly indicated on all forms of communication with the intended research participants, as well as with the Committee.*

Kind regards,



Prof AT Motlhabane
CHAIRPERSON: CEDU RERC
motlhat@unisa.ac.za



Prof Mpine Makoe
EXECUTIVE DEAN
qakisme@unisa.ac.za



Approved - decision template – updated 16 Feb 2017

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Appendix C: Permission Letter to the District Director

Request for permission to conduct research at Mphephu, Mushaathoni and Tshifhena Secondary Schools, Vhembe West District in Nzhelele East Circuit.

Title: Mathematics anxiety of grade 11 learners in trigonometry in Vhembe West District, Limpopo Province

Date

Department of Education Limpopo

Vhembe West District Director

Dear _____

I, Sihhada Takalani, doing research under supervision of Dr Makwakwa E.G, a Senior Lecturer in the Department of Mathematics Education towards a M.Ed. at the University of South Africa. We request for permission to conduct research at Mphephu, Mushaathoni and Tshifhena Secondary Schools, Vhembe West District in Nzhelele East Circuit. The study entitled Mathematics anxiety of grade 11 learners in trigonometry in Vhembe West District, Limpopo Province. The aim of this study is to assess whether grade 11 learners studying trigonometry exhibit symptoms of mathematics anxiety, identify its underlying causes, and explore the strategies employed by educators to alleviate or mitigate this issue. Your district has been selected because it has sufficient number of learners doing mathematics and your school environment is conducive for learning.

I will be an observer for the trigonometry lessons for the period of four days (two days in term 2 and two days in term 3) as per Annual Teaching Plan. A semi-structured interview will be conducted with the participants after the classroom observation and writing a test at a time and the place that is convenient to both the participants and the researcher. The interview will be audio recorded for verbal transcription.

The benefits of this study are to help teachers and learners to reduce mathematics anxiety in learning trigonometry in Grade 11 mathematics classroom and improve performance.

There are no potential risks to participants. There will be no reimbursement or any incentives for participation in the research.

Feedback procedure will allow any learner to contact the researcher to access the research results.

Yours sincerely

_____ (Signature of researcher)

_____ (Name of the above signatory)

Appendix D: Permission Letter to the Circuit Manager

Request for permission to conduct research at Mphephu, Mushaathoni and Tshifhena Secondary Schools, Nzhelele East Circuit.

Title: Mathematics anxiety of grade 11 learners in trigonometry in Vhembe West District, Limpopo Province

Date

Department of Education Limpopo

Nzhelele East Circuit Manager

Dear _____

I, Sihhada Takalani, doing research under supervision of Dr Makwakwa E.G, a Senior Lecturer in the Department of Mathematics Education towards a M.Ed. at the University of South Africa. We request for permission to conduct research at Mphephu, Mushaathoni and Tshifhena Secondary Schools, Nzhelele East Circuit. The study entitled Mathematics anxiety of grade 11 learners in trigonometry in Vhembe West District, Limpopo Province. The aim of this study is to assess whether grade 11 learners studying trigonometry exhibit symptoms of mathematics anxiety, identify its underlying causes, and explore the strategies employed by educators to alleviate or mitigate this issue. Your circuit has been selected because it has sufficient number of learners doing mathematics and your school environment is conducive for learning.

I will be an observer for the trigonometry lessons for the period of four days (two days in term 2 and two days in term 3) as per Annual Teaching Plan. A semi-structured interview will be conducted with the participants after the classroom observation and writing a test at a time and the place that is convenient to both the participants and the researcher. The interview will be audio recorded for verbal transcription.

The benefits of this study are to help teachers and learners to reduce mathematics anxiety in learning trigonometry in Grade 11 mathematics classroom and improve performance.

There are no potential risks to participants. There will be no reimbursement or any incentives for participation in the research.

Feedback procedure will allow any learner to contact the researcher to access the research results.

Yours sincerely

_____ (Signature of researcher)

_____ (Name of the above signatory)

Appendix E: Permission Letter to the Principal (School A)

Title: Mathematics anxiety of grade 11 learners in trigonometry in Vhembe West District, Limpopo Province

Date

The Principal

Mphephu High School

Dear _____

I, Sihhada Takalani, doing research under supervision of Dr Makwakwa E.G, a Senior Lecturer in the Department of Mathematics Education towards a M.Ed. at the University of South Africa. We request for permission to conduct research at Mphephu High School, in Nzhelele East Circuit. The study entitled Mathematics anxiety of grade 11 learners in trigonometry in Vhembe West District, Limpopo Province. The aim of this study is to assess whether grade 11 learners studying trigonometry exhibit symptoms of mathematics anxiety, identify its underlying causes, and explore the strategies employed by educators to alleviate or mitigate this issue. Your school has been selected because it has sufficient number of learners doing mathematics and your school environment is conducive for learning.

The benefits of this study are to help teachers and learners to reduce mathematics anxiety in learning trigonometry in Grade 11 mathematics classroom and improve performance.

There are no potential risks to participants. There will be no reimbursement or any incentives for participation in the research.

Feedback procedure will allow any learner to contact the researcher to access the research results.

Yours sincerely

_____ (Insert signature of researcher)

_____ (Insert name of the above signatory)

Appendix F: Permission Letter to the Principal (School B)

Title: Mathematics anxiety of grade 11 learners in trigonometry in Vhembe West District, Limpopo Province

Date

The Principal

Mushaathoni Secondary School

Dear _____

I, Sivhada Takalani, am doing research under supervision of Dr Makwakwa E.G, a Senior Lecturer in the Department of Mathematics Education towards a M.Ed. at the University of South Africa. We request for permission to conduct research at Mushaathoni Secondary School, in Nzhelele East Circuit. The study entitled Mathematics anxiety of grade 11 learners in trigonometry in Vhembe West District, Limpopo Province. The aim of this study is to assess whether grade 11 learners studying trigonometry exhibit symptoms of mathematics anxiety, identify its underlying causes, and explore the strategies employed by educators to alleviate or mitigate this issue. Your school has been selected because it has sufficient number of learners doing mathematics and your school environment is conducive for learning.

The benefits of this study are to help teachers and learners to reduce mathematics anxiety in learning trigonometry in Grade 11 mathematics classroom and improve performance.

There are no potential risks to participants. There will be no reimbursement or any incentives for participation in the research.

Feedback procedure will allow any learner to contact the researcher to access the research results.

Yours sincerely

_____ (insert signature of researcher)

_____ (insert name of the above signatory)

Appendix G: Permission Letter to the Teacher (School A)

The Teacher

Mphephu High School

Nzhelele East Circuit

Subject: Request to conduct research in a school based in your circuit.

Dear Sir/Madam

My name is Sivhada Takalani and I am doing research under the supervision of Dr Makwakwa E.G, a Senior Lecturer in the Department of Mathematics Education towards a M.Ed. at the University of South Africa. We are inviting you to participate in a study entitled Mathematics anxiety of grade 11 learners in trigonometry in Vhembe West District, Limpopo Province. The aim of this study is to assess whether grade 11 learners studying trigonometry exhibit symptoms of mathematics anxiety, identify its underlying causes, and explore the strategies employed by educators to alleviate or mitigate this issue. Your school has been selected because it has sufficient number of learners doing mathematics and your school environment is conducive for learning.

I will be an observer for the trigonometry lessons for the period of four days (two days in term 2 and two days in term 3) as per Annual Teaching Plan. A semi-structured interview will be conducted with the participants after the classroom observation and writing a test at a time and the place that is convenient to both the participants and the researcher. The interview will be audio recorded for verbal transcription. The benefits of this study are to help teachers and learners to reduce mathematics anxiety in learning trigonometry in Grade 11 mathematics classroom and improve performance. There are no potential risks to participants. There will be no reimbursement or any incentives for participation in the research. Feedback procedure will allow any learner to contact the researcher to access the research results.

Yours sincerely

Name of researcher: Sivhada T

Signature of researcher:

Name of teacher:

Signature of teacher:

Appendix H: Permission Letter to the Teacher (School B)



The Teacher

Mushaathoni Secondary School

Nzhelele East Circuit

Subject: Request to conduct research in a school based in your circuit.

Dear sir/madam

My name is Sivhada Takalani and I am doing research under the supervision of Dr Makwakwa E.G, a Senior Lecturer in the Department of Mathematics Education towards a M.Ed. at the University of South Africa. We are inviting you to participate in a study entitled Mathematics anxiety of grade 11 learners in trigonometry in Vhembe West District, Limpopo Province. The aim of this study is to assess whether grade 11 learners studying trigonometry exhibit symptoms of mathematics anxiety, identify its underlying causes, and explore the strategies employed by educators to alleviate or mitigate this issue. Your school has been selected because it has sufficient number of learners doing mathematics and your school environment is conducive for learning.

I will be an observer for the trigonometry lessons for the period of four days (two days in term 2 and two days in term 3) as per Annual Teaching Plan. A semi-structured interview will be conducted with the participants after the classroom observation and writing a test at a time and the place that is convenient to both the participants and the researcher. The interview will be audio recorded for verbal transcription. The benefits of this study are to help teachers and learners to reduce mathematics anxiety in learning trigonometry in Grade 11 mathematics classroom and improve performance. There are no potential risks to participants. There will be no reimbursement or any incentives for participation in the research. Feedback procedure will allow any learner to contact the researcher to access the research results.

Yours sincerely

Name of researcher: Sivhada T

Signature of researcher:

Name of teacher:

Signature of teacher:

Appendix I: Permission Letter to Parents

Dear Parent

Your child is invited to participate in a study entitled Mathematics anxiety of grade 11 learners in trigonometry in Vhembe West District, Limpopo Province

I am undertaking this study as part of my master research at the University of South Africa. The aim of this study is to assess whether grade 11 learners studying trigonometry exhibit symptoms of mathematics anxiety, identify its underlying causes, and explore the strategies employed by educators to alleviate or mitigate this issue. I am seeking your permission to include your child in our study as they are a grade 11 mathematics student. We anticipate having a total of 20 participants from this school. Your child's participation would contribute significantly to our research objectives.

Any information gathered during this study that pertains to your child will be treated with strict confidentiality. Such information will only be disclosed with your explicit permission. Your child's responses will be anonymized and will not be associated with their name, your name, or the name of the school in any written or verbal reports derived from this study. These reports will be utilized solely for research purposes.

There are no foreseeable risks to your child by participating in the study. Your child will receive no direct benefit from participating in the study; however, the possible benefits this study are to help teachers and learners to reduce mathematics anxiety in learning trigonometry in Grade 11 mathematics classroom and improve performance.

Neither your child nor you will receive any type of payment for participating in this study.

Your child's participation in this study is voluntary. Your child may decline to participate or to withdraw from participation at any time. Withdrawal or refusal to participate will not affect him/her in any way. Similarly, you can agree to allow your child to be in the study now and change your mind later without any penalty.

The study will take place during regular classroom activities with the prior approval of the school and your child's teacher. In addition to your permission, your child must agree to participate in the study and you and your child will also be asked to sign the assent form which accompanies this letter. If your child does not wish to participate in the study, he or she will not be included and there will be no penalty.

The benefits of this study are learners' increased knowledge of learning trigonometry with conceptual understanding. There are no potential risks in this research study. There will be no reimbursement or any incentives for participation in the research.

If you have questions about this study, please ask me or my study supervisor, Dr Makwakwa E.G), Department of Mathematics, College of Education, University of South Africa. My contact number is 076 640 2114 and my e-mail is tsivhada@gmail.com. The e-mail of my supervisor is makwaeg@unisa.ac.za. The Ethics Committee of the College of Education, UNISA, has already given permission for the study.

You are making a decision about allowing your child to participate in this study. Your signature below indicates that you have read the information provided above and have decided to allow him or her to participate in the study. You may keep a copy of this letter.

Name of child:

Sincerely

Parent/guardian's name (print) Parent/guardian's signature:
Date:

Researcher's name (print) Researcher's signature Date:

Appendix J: Letter Requesting Assent from Learners

Title of my research is Mathematics anxiety of grade 11 learners in trigonometry in Vhembe West District, Limpopo Province

Dear _____

Date _____

I am doing a study on Master of Mathematics Education as part of my studies at the University of South Africa. Your principal has given me permission to do this study in your school. I would like to invite you to be a very special part of my study. I am doing this study so that I can find ways that your teachers can use to teach trigonometry better. This may help you and many other learners of your age in different schools.

This letter is to explain to you what I would like you to do. There may be some words you do not know in this letter. You may ask me or any other adult to explain any of these words that you do not know or understand. You may take a copy of this letter home to think about my invitation and talk to your parents about this before you decide if you want to be in this study.

I would like to ask you to answer interview questions about the learning of trigonometry. Answering the interview questions will take no longer than an hour.

I will write a report on the study but I will not use your name in the report or say anything that will let other people know who you are. Participation is voluntary and you do not have to be part of this study if you don't want to take part. If you choose to be in the study, you may stop taking part at any time without penalty. When I am finished with my study, I shall return to your school to give a short talk about some of the helpful and interesting things I found out in my study. The benefits of this study are helping you to adapt and see the benefits of cooperative learning in the mathematics classroom. There are no potential risks in this study. You will not be reimbursed or receive any incentives for your participation in the research.

If you decide to be part of my study, you will be asked to sign the form on the next page. If you have any other questions about this study, you can talk to me or you can have your parent or another adult call me at 076 640 2114. Do not sign the form until you have all your questions answered and understand what I would like you to do. Do not sign the written assent form if you have any questions. Ask your questions first and ensure that someone answers those questions.

WRITTEN ASSENT

I have read this letter which asks me to be part of a study at my school. I have understood the information about my study and I know what I will be asked to do. I am willing to be in the study.

_____	_____	
Learner's name (print):	Learner's signature:	Date:
_____	_____	
Witness's name (print)	Witness's signature	Date:

(The witness is over 18 years old and present when signed.)

_____	_____	
Parent/guardian's name (print)	Parent/guardian's signature:	Date:
_____	_____	
Researcher's name (print)	Researcher's signature:	Date:

Appendix K: Letter of Permission from Limpopo Provincial Government

CONFIDENTIAL



LIMPOPO
PROVINCIAL GOVERNMENT
REPUBLIC OF SOUTH AFRICA

OFFICE OF THE PREMIER

TO: DR MC MAKOLA

FROM: PROF I SWARTS

CHAIRPERSON: LIMPOPO PROVINCIAL RESEARCH ETHICS COMMITTEE (LPREC)

REVIEW DATE: 26 JUNE 2024

SUBJECT: MATHEMATICS ANXIETY OF GRADE 11 LEARNERS IN TRIGONOMETRY IN VHEMBE WEST DISTRICT, LIMPOPO PROVINCE

RESEARCHER: SIVHADA T

Dear Colleague

The above researcher's research proposal served at the Limpopo Provincial Research Ethics Committee (LPREC). The committee is satisfied with the methodological and ethical soundness of the proposed study.

Decision: The proposal is granted full approval and ethical clearance.

Regards

Chairperson: Prof I Swarts

Secretariat: Ms J Mokobi

Date: 11/07/2024

Appendix L: Limpopo Research Ethics Clearance

CONFIDENTIAL



LIMPOPO
PROVINCIAL GOVERNMENT
REPUBLIC OF SOUTH AFRICA

OFFICE OF THE PREMIER

Office of the Premier

Research and Development Directorate

Private Bag X9483, Polokwane, 0700, South Africa

Tel: (015) 230 9910, Email: mokobij@premier.limpopo.gov.za

LIMPOPO PROVINCIAL RESEARCH ETHICS COMMITTEE CLEARANCE CERTIFICATE

Review Date: 26 June 2024

Project Number: LPREC/52/2024: PG

Subject: Mathematics Anxiety of Grade 11 Learners in Trigonometry in Vhembe West District, Limpopo Province

Researcher: Sivhada T

Chairperson: Prof I Swarts

Chairperson: Limpopo Provincial Research Ethics Committee

Date: 11 July 2024

The Limpopo Provincial Research Ethics Committee (LPREC) is registered with National Health Research Council (NHREC) Registration Number REC-111513-038.

Note:

- i. This study is categorized as a Low Risk Level in accordance with risk level descriptors as enshrined in LPREC Standard Operating Procedures (SOPs)
- ii. Should there be any amendment to the approved research proposal; the researcher(s) must re-submit the proposal to the ethics committee for review prior data collection.
- iii. **The researcher(s) must provide annual reporting to the committee as well as the relevant department and also provide the department with the final report/thesis.**
- iv. The ethical clearance certificate is valid for 12 months. Should the need to extend the period for data collection arise then the researcher should renew the certificate through LPREC secretariat. PLEASE QUOTE THE PROJECT NUMBER IN ALL ENQUIRIES.

Appendix M: Permission to Conduct Research



LIMPOPO
PROVINCIAL GOVERNMENT
REPUBLIC OF SOUTH AFRICA

DEPARTMENT OF
EDUCATION
CONFIDENTIAL

Ref: 2/2/2 Enq: Makola MC Tel No: 015 290 9448 E-mail: MakolaMC@edu.limpopo.gov.za

Sivhada T
UNISA
tsivhada@gmail.com

RE: REQUEST FOR PERMISSION TO CONDUCT RESEARCH

1. The above bears reference.
2. The Department wishes to inform you that your request to conduct research has been approved. Topic of the research proposal: "Mathematics anxiety of grade 11 learners in trigonometry in Vhembe West District, Limpopo Province."
3. The following conditions should be considered:
 - 3.1 The research should not have any financial implications for Limpopo Department of Education.
 - 3.2 Arrangements should be made with the District or Circuit Office and the School concerned.
 - 3.3 The conduct of research should not in anyhow disrupt the academic programs at the schools.
 - 3.4 The research should not be conducted during the time of Examinations especially the fourth term.
 - 3.5 During the study, applicable research ethics should be adhered to; in particular the principle of voluntary participation (the people involved should be respected).
 - 3.6 Upon completion of research study, the researcher shall share the final product of the research with the Department.

REQUEST FOR PERMISSION TO CONDUCT RESEARCH : SIVHADA T Page 1

Cnr 113 Bliccard & 24 Excelsior Street, POLOKWANE, 0700, Private Bag X 9489, Polokwane, 0700
Tel: 015 290 7500/ 7702 Fax 086 218 0560

The heartland of Southern Africa-development is about people

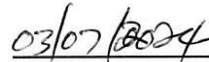
4 Furthermore, you are expected to produce this letter at Schools/ Offices where you intend conducting your research as an evidence that you are permitted to conduct the research.

5 The department appreciates the contribution that you wish to make and wishes you success in your investigation.

Best wishes.

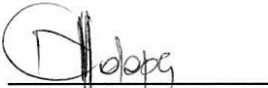


Makola MC (Ph.D)

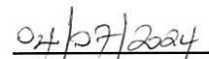


Date

Director: Integrated Planning, Research & Reporting



Mr. Molope NM



Date

ACTING DDG: CORPORATE SERVICES

REQUEST FOR PERMISSION TO CONDUCT RESEARCH : SIVHADA T Page 2

Cnr 113 Biccard & 24 Excelsior Street, POLOKWANE, 0700, Private Bag X 9489, Polokwane, 0700
Tel:015 290 7600/ 7702 Fax 086 218 0560

The heartland of Southern Africa-development is about people

Appendix N: Permission to Conduct Research



LIMPOPO
PROVINCIAL GOVERNMENT
REPUBLIC OF SOUTH AFRICA

DEPARTMENT OF
EDUCATION

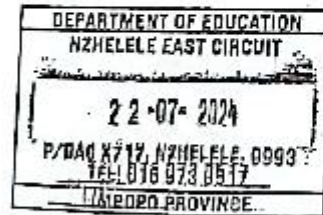
Enq: Malumedzha A.C. Tel : 0159730519 Email : cmalumedzha@gmail.com

Mr Sivhada T.

P.O.Box 631

NZHELEKE

0993



REQUEST FOR PERMISSION TO CONDUCT RESEARCH

1. The above matter refers.
2. This office wishes to inform you that your request to conduct research has been approved.
3. The following conditions should be considered:
 - 3.1 Arrangements should be made with the School concerned.
 - 3.2 The conduct of the research should not disrupt the academic programs at the schools.
 - 3.3 The research should not be conducted during the time of Examinations especially the fourth term.
4. Research should be conducted at the following schools.
 - 4.1 Mphephu
 - 4.2 Mushaathonl
 - 4.3 Tshifhena
5. You are expected to produce this letter together with the letter from the Department at schools where you will conduct your research as an evidence that you are permitted to conduct the research.
6. Hoping you will find this in order

CIRCUIT MANAGER: NZHELEKE EAST

22/07/2024
DATE

Appendix O: Permission to Conduct Research at School A

MPHEPHU HIGH SCHOOL



P.O. BOX 14, NZHELELE, 0993

TEL/FAX: 015-993 0155

EDUCATION FOR COMMUNITY EMPOWERMENT

Ref : 928330350

Enq : PRINCIPAL

Tel : 072 855 6775

ACCEPTENCE OF SIYHADA TAKALANI TO CONDUCT RESEARCH AT MPHEPHU HIGH SCHOOL.

1. The institution would like to indicate that Siyhada Takalani has been allowed to conduct Research in Grade 11 Mathematics in the institution.
2. Hoping the matter will receive your utmost attention.

Yours Faithfully

TSHIKOTA T.D. / PRINCIPAL



Appendix P: Permission to Conduct Research at School B

Mushaathoni Secondary School	
P.O. box 511, Nzhelele, 0993	Phone : 071 3314 184
Enquiries : Thiba F.M.	Fax : 086 6051 169
Circuit : Nzhelele East	E-Mail : secondarymushaathoni@gmail
District : Vhembe	Ems No : 928330442
	Centre No : 7051103

To: the supervisor
UNISA

Subject: Confirmation of permission for research

1. The above matter refers
2. The above-mentioned institution is confirming that Mr. Sivhada Takalani was granted permission to conduct a research on Mathematics anxiety of grade 11 learners in trigonometry in Vhembe West District.
3. He conducted his research on 24th /07/2024 until his last day at school of which he was satisfied by the way our learners were responding to him.
4. Hope for your cooperation and wish him good.

Principal

DEPARTMENT OF EDUCATION
MUSHAATHONI SEC SCHOOL
27/07-30
P.O. BOX 511, NZHELELE 0993
VHEMBE PROVINCE

PFUNZO NDI IFA

Appendix Q: Teacher Questionnaire

Teachers (observed signs of mathematical anxiety on learners)

School:

Date:

Time:

Participant Name:

Pseudonym:

1. Have you ever heard of being anxious of mathematics or mathematics anxiety?
How do you define mathematics anxiety?

2. From your observation, are grade 11 learners who study trigonometry anxious of mathematics?

3. When do learners normally get anxious when learning trigonometry? Is it during lessons? Or when writing class activities and tests?

4. Would you say that their being anxious of mathematics affects their performance in trigonometry? Why do you say so?

5. In your view, does their mathematics anxiety have a negative effect on their performance in trigonometry? Why do you say so?

6. Knowing that the poor performance of some of your learners studying trigonometry could be caused by maths anxiety, does that make you think of changing your teaching approach?

7. From your experience, would you say the strategies used by teachers in teaching trigonometry are effective in preventing maths anxiousness in learners? Why you say so?

8. From your experience, would you say the strategies you use in teaching trigonometry are effective in preventing maths anxiousness in learners? Why you say so?

9. Do you believe that learners' anxiousness about trigonometry is caused by other factors, not only by a maths teacher's approach? Why you say so?

10. What methods do you use to motivate students who struggle with maths (Trigonometry)?"

11. How do you address maths anxiety in your classroom?

12. Do you consciously try to create a positive environment for learning maths (trigonometry)? If so, how?

Appendix R: Learner Questionnaire

LEARNER QUESTIONNAIRE

Section A: Open-ended questions

1. How do you respond to other people when they talk about being anxious or worried of mathematics or mathematics anxiety?
2. How do you feel about your performance in a test in trigonometry?
3. What is the view of your parents, or guardians when you study mathematics?
4. How is the language used in the teaching of trigonometry affect your learning?
5. How is your confidence in the learning of trigonometry?
6. How do you feel when you study trigonometry?
7. Do you feel your maths teacher's teaching style impacts your attitude towards maths?
8. How does your maths teacher support or hinder your confidence in maths?
9. Do you feel encouraged to ask questions and seek help in your maths class?

Section S: Closed-ended Questions

For each question/statement below, please place a tick (✓) in the box of your choice on the five-point scale, according to your response.

PERSONAL FACTORS	Strongly Agree	Agree	Not Sure	Disagree	Strongly Disagree
I believe I am the kind of a person who is good in mathematics					
I am confident of myself when I do mathematics					
I worry that I will not be able to do well mathematics					
Doing mathematics makes me to be nervous and upset					

ENVIRONMENTAL FACTORS	Strongly Agree	Agree	Not Sure	Disagree	Strongly Disagree
Lack of professional development of educators in trigonometry affects learner performance					
The family assist me with trigonometry homework and assignments					
Socio-economic status of the family influences the learners' performance					
Educators' attitude towards trigonometry influence learner performance					
There are enough mathematics textbooks for learners in our classroom					
Learners' weakness in language of trigonometry					

BEHAVIOURAL FACTORS	Strongly Agree	Agree	Not Sure	Disagree	Strongly Disagree
I get tensed when I hear a mathematics related course					
I get nervous when I have to do mathematics course					
I feel confident when taking a mathematics related course					
I study mathematics on a regular basis					
I work hard to do well in mathematics					
Mathematics anxiety contributes to my poor performance					

Appendix T: Interview Guide—Learners

INTERVIEW

Interview guide – Learners (perceptions towards trigonometry)

1. What do you understand about mathematics anxiety? Have you heard other people talk about being anxious or worried of mathematics or mathematics anxiety? If you heard those people, who are they? and why do they say they are anxious of mathematics?
2. Do you normally get anxious or worried when learning trigonometry? and why so? Can you tell if a learner is anxious during the learning of trigonometry? have you seen a learner(s) who is anxious during the learning of trigonometry?
3. What is your view about parents, guardians, or teachers giving advice to learners not to study mathematics because it would spoil their matric certificate?
4. How do you view the study of trigonometry? When you think about a test that you failed, does that motivate you to do better, or does that make you scared of trigonometry?
5. What is your view on the instructional practices used by a teacher in trigonometry teaching that can contribute to mathematics anxiety?
6. What is your view on the use of teaching resources in learning trigonometry?
7. How do you view mathematics anxiety and the choice of mathematics related careers?
8. What is your view in understanding and managing behaviour and reactions when learning trigonometry in a classroom that can lead to mathematics anxiety?
9. Do you think mathematics anxiety affects learners' performance in trigonometry? How?

Appendix U: Interview Guide—Teachers

Interview guide – Teachers (behaviour of learners towards the branch of trigonometry in mathematics)

1. From your observation, do you think that in general, some learners have a bad attitude towards trigonometry?
2. In your view, do you think that in general, learners are afraid of learning trigonometry? Does it lead to mathematics anxiety? Why do you say so?
3. During lessons in trigonometry, what is your belief about some learners who become nervous about not understanding or not coping well?
4. Have you observed cases where some learners were afraid of answering a trigonometry question incorrectly? How do you encourage the learners to answer questions asked in the classroom?
5. How do you think it influences the confidence of learners when they are not able to answer a trigonometry question correctly in class? What do you think about learners not being able to answer trigonometry questions correctly or being picked to answer trigonometry questions causes a lack of confidence in learners?
6. In your view, do you think that learners are engaged in the learning of trigonometry?
7. Do you think that the number of learners in a classroom contributes to mathematics anxiety in learning of trigonometry? And how?
8. From your observation, do you think instructional practices contribute to mathematics anxiety in learning trigonometry?
9. How is the language used in the teaching of trigonometry contributes to mathematics anxiety?

Appendix V: Lesson Observation

OBSERVATION

LESSON OBSERVATION

Date: _____

Grade: _____

Number of learners: _____

Lesson: _____

Inventory information

1. Date:

2. Name of school:
.....

2. Name of subject:
.....

3. Subject section:
.....

5. Duration of lesson:
.....

Classroom interaction between learners: on-going lesson. Response to questions to be: yes, to some extent, not really, no.

1. Do learners actively participate in class discussions, asking questions, taking notes, and completing assignments?
2. Do learners arrive on time, staying focused during lessons, and avoiding distractions?
3. Are learners willing to attempt questions even if they are unsure of the answer, or do they avoid them altogether?
4. Do learners persevere through difficulties, or do learners become visibly frustrated or avoidant?
5. Are learners supportive of each other's learning, or do they exhibit competitive or dismissive behaviour?

6. Do learners feel comfortable seeking help from peers or the teacher when they encounter difficulties?
7. Do learners show signs of anxiety that include fidgeting, avoiding eye contact, or appearing tense?
8. Do learners have confidence or hesitation when students are asked to share their work or explain their thought process?

Classroom observation: the teachers: on-going lesson. Response to questions to be: yes, to some extent, not really, no

1. Does the teacher use positive and encouraging non-verbal cues to help reduce anxiety?
2. Does the teacher use instructions that indicate whether students are given enough time to process information or if the lesson is rushed, could increase anxiety?
3. Does the teacher use positive reinforcement such as praise or encouragement to create a supportive learning environment?
4. Does the teacher employ a variety of teaching methods to accommodate different learning styles and inclusivity to reduce anxiety for learners who may struggle with traditional approaches?
5. Does the teacher demonstrate awareness of individual learners' strengths, weaknesses, and learning preferences to tailor instruction and support to reduce anxiety?
6. Is the teacher approachable and available for extra help to supporting learners and reducing anxiety about understanding the material?
7. Does the teacher create an environment where making mistakes is seen as a natural part of learning and an opportunity for growth to help reduce anxiety related to fear of failure?

8. Does the teacher incorporate real-world examples and applications of maths (trigonometry) concepts to make the subject more relevant and less abstract, and potentially reducing anxiety for some learners?
9. Does the teacher utilize technology and visual aids effectively to enhance understanding and engagement to support diverse learning styles and reduce anxiety?

Appendix W: Diagnostic Test

DIAGNOSTIC TEST

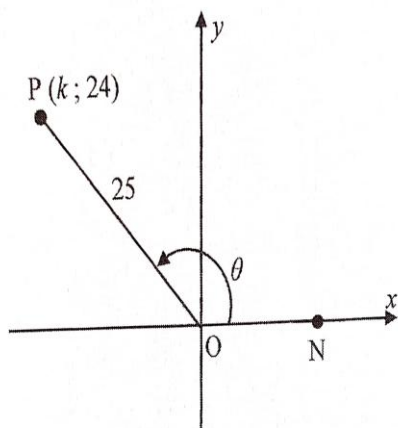
Marks: 24

Instructions

1. Answer all the questions
2. Write neatly and legibly

Question 1

In the diagram below, $P(k; 24)$ is a point in the second quadrant such that $OP=25$ units. N is a point on the positive x -axis and $\widehat{PON}=\theta$.



WITHOUT calculating the size of θ , determine the value of the following:

- 1.1 K (2)
- 1.2 $\tan \theta$ (1)
- 1.3 $\sin \alpha$ if $\theta + \alpha = 360^\circ$ (3)
- 1.4 $\cos^2 \theta - \sin^2 \alpha$ (3)

Question 2

- 2.1 Simplify WITHOUT using a calculator

$$\frac{-\cos 210^\circ \cdot \tan 135^\circ}{\sin(-60^\circ) \cdot \cos 420^\circ} \quad (5)$$

2.2 Prove the identity: (4)

$$\frac{1}{\tan^2 x} - \cos^2 x = \frac{\cos^4 x}{\sin^2 x}$$

2.3 Determine the general solution of: (6)

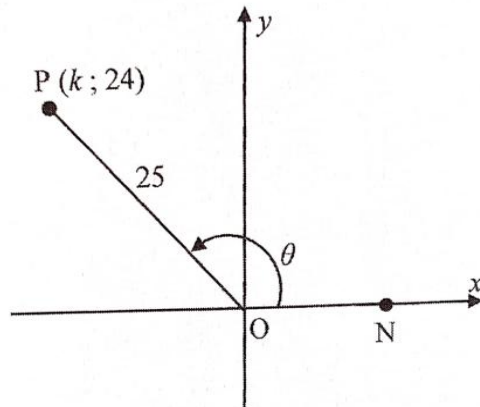
$$\sqrt{2} \sin x \cos x = \cos x.$$

TOTAL: 24 Marks

Appendix X: Marking Memorandum

MARKING MEMORANDUM

Question 1



1.1	$x^2 + y^2 = r^2$ $(k)^2 + (24)^2 = 25^2$ $k^2 = 49$ $k = -7$	✓ subst. ✓ answer (2)
1.2	$\tan \theta = -\frac{24}{7}$	✓ answer (1)
1.3	$\theta + \alpha = 360^\circ$ $\alpha = 360^\circ - \theta$ $\sin \alpha = \sin(360^\circ - \theta)$ $= -\sin \theta$ $= -\frac{24}{25}$	✓ $\sin \alpha = \sin(360^\circ - \theta)$ ✓ $-\sin \theta$ ✓ answer (3)

1.4	$\cos^2 \theta - \sin^2 \alpha$ $= \left(\frac{-7}{25} \right)^2 - \left(-\frac{24}{25} \right)^2$ $= \frac{-527}{625}$	✓✓ substitution. ✓ answer (3)
-----	---	---

Question 2

2.1	$\frac{\cos 210^\circ \cdot \tan 135^\circ}{\sin(-60^\circ) \cdot \cos 420^\circ}$ $= \frac{-\cos 30^\circ \cdot -\tan 45^\circ}{-\sin 60^\circ \cdot \cos 60^\circ}$ $= \frac{\left(-\frac{\sqrt{3}}{2} \right) (-1)}{\left(-\frac{\sqrt{3}}{2} \right) \cdot \frac{1}{2}}$ $= -2$	✓ $-\cos 30^\circ \cdot -\tan 45^\circ$ ✓ $-\sin 60^\circ \cdot \cos 60^\circ$ ✓ $\left(-\frac{\sqrt{3}}{2} \right) (-1)$ ✓ $\left(-\frac{\sqrt{3}}{2} \right) \cdot \frac{1}{2}$ ✓ answer (5)
-----	---	---

2.2	$\begin{aligned} \text{LHS} &= \frac{1}{\tan^2 x} - \cos^2 x \\ &= \frac{1}{\frac{\sin^2 x}{\cos^2 x}} - \cos^2 x \\ &= \frac{\cos^2 x}{\sin^2 x} - \cos^2 x \\ &= \frac{\cos^2 x - \cos^2 x \sin^2 x}{\sin^2 x} \\ &= \frac{\cos^2 x (1 - \sin^2 x)}{\sin^2 x} \\ &= \frac{\cos^2 x (\cos^2 x)}{\sin^2 x} \\ &= \frac{\cos^4 x}{\sin^2 x} \\ &= \text{RHS} \end{aligned}$	$\checkmark \frac{\sin^2 x}{\cos^2 x}$ $\checkmark \text{common denominator/}$ $\checkmark \text{factors}$ $\checkmark 1 - \sin^2 x = \cos^2 x$ (4)
-----	--	---

2.3	$\sqrt{2} \sin x \cos x = \cos x$ $\sqrt{2} \sin x \cos x - \cos x = 0$ $\cos x (\sqrt{2} \sin x - 1) = 0$ $\cos x = 0$ $x = 90^\circ + 360^\circ k, \quad k \in \mathbb{Z}$ or $x = 270^\circ + 360^\circ k, \quad k \in \mathbb{Z}$ or OR $x = 90^\circ + 180^\circ k, \quad k \in \mathbb{Z}$	$\sin x = \frac{1}{\sqrt{2}}$ $x = 45^\circ + 360^\circ k, \quad k \in \mathbb{Z}$ or $x = 135^\circ + 360^\circ k, \quad k \in \mathbb{Z}$
-----	--	---

✓ standard
form

✓ factors

✓ both equations

✓

$$x = 90^\circ + 360^\circ k, \quad k \in \mathbb{Z}$$

✓

$$x = 45^\circ + 360^\circ k, \quad k \in \mathbb{Z}$$

✓

$$x = 135^\circ + 360^\circ k, \quad k \in \mathbb{Z}$$

(6)

[24]

Appendix Y: Language editing certificate

Cell: 076 389 3246
gill.hannant@outlook.com

Mrs G C Hannant
28 Hillcrest Avenue
CRAIGHALL PARK
2196

28 October 2025

TO WHOM IT MAY CONCERN

I certify that I have edited the Master of Education dissertation

**MATHEMATICS ANXIETY OF GRADE 11 LEARNERS IN TRIGONOMETRY
IN VHEMBE WEST DISTRICT, LIMPOPO PROVINCE**

by

TAKALANI SIVHADA

However, the correction of all errors/missing information remains the responsibility of the author.



G.C. HANNANT (BA HED)

APPENDIX Z: Turnitin report

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