THE RELATIONSHIP BETWEEN ANXIETY, WORKING MEMORY AND ACHIEVEMENT IN MATHEMATICS IN GRADE 5 LEARNERS: A CASE STUDY OF TSHEPISONG SCHOOLS

by

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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.

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ABSTRACT

This study investigated the relationship between anxiety, working memory and achievement in mathematics in grade 5 learners at Tshepisong schools. A sample of 300 grade 5 learners from Tshepisong schools was selected using convenience sampling. The relationship between anxiety, working memory and achievement in mathematics were theoretically deliberated using the deficit theory and the two-component theories. The study adopted a quantitative approach that involved a correlational survey design. There were four research questions, and two hypotheses were tested at 5% level of significance. Data were collected using working memory and mathematics achievement tests, mathematics anxiety questionnaires and memory booster activities. These instruments were developed by the researcher. The reliability of mathematics anxiety questionnaire, determined using Cronbach's alpha, was found to be 0.716. The reliability of mathematics achievement test and memory booster activities determined using Pearson correlation coefficient was found to be 0.985 and 0.985, respectively. The results indicated that mathematics anxiety compromises the working memory capacity by causing intrusion thoughts and anxiety. This culminates into a reduction in mathematics achievement. The study recommended that instructional strategies such as use of visual strategies, explicitly teaching the mathematics vocabulary of a concept, and mental mathematics strategies must be implemented to reduce mathematics anxiety and developing intervention programs to address learners with high levels of mathematics anxiety.

Key Terms: Mathematics anxiety, working memory, mathematics achievement, Multiplication, visualisation, grade 5 learners, cognitive factors, memory boosters, memory, short-term, fractions, shapes.

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LIST OF ACRONYMS AND ABBREVIATIONS

Class	Classroom
Math	Mathematics
SPSS	Statistical Package for the Social Sciences

CHAPTER ONE: OVERVIEW OF THE STUDY

1.1 Introduction

Math difficulties are not only seen in children with specific math learning disabilities, but also in children with emotional problems such as math anxiety (Berlacon, 2017). Previous studies showed that persistent math anxiety creates a negative cycle in which these individuals often perform poorly on standardized math tests. On the other hand, the performance in mathematics has been attributed to the working memory of learners which underpins the processes of memory retrieval on how math problems are addressed (Beilock & Willingham, 2014). Given how math anxiety affects the emotional strength of the learners which may influence their mathematics performance, it remains fundamentally unexamined how math anxiety relates to the working memory of learners as far as math is concerned. Therefore, given the long-term damaging effects of math anxiety, it is important to understand how it affects and relates to mathematics achievement and working memory, while drawing inferences from the grade 5 learners in the Tshepisong Circuit.

The study commences with an introductory chapter where the researcher presented the background to the study, summary on literature review and the theoretical framework that underpinned this study, together with problem statement. This was followed by the aim, objectives, and research questions of the study. In addition, a summary of the methodology used in the study, reliability and validity together with the ethical issues were deliberated. Lastly, a definition of important terms in the study together with chapter outline was presented.

1.2 Background of the Study

A plethora of studies reached a general assessment that mathematics is built on multiple cognitive abilities implemented by extensive neural networks in the brain and affects through the emotional aspects such as apprehension, disgust, nervousness, worry, depression, and fear experienced while performing math tasks, which is called math anxiety (Trezise, Kelly, Reeve & Robert, 2016). Regarding the relationship between math anxiety and cognitive processes, previous studies have shown that individuals with limited working memory abilities may have difficulty regulating their anxiety levels and anxiety/worry may reduce their working memory resources (Berlacon, 2017). Cognitive skills such as working memory processing speed, attention, and inhibition are known to be important in addressing mathematics learning difficulties (Shen, Sung & Zhang, 2016). The cognitive consequences of mathematics achievement have also been characterized in several studies linking math achievement and impaired attentional abilities (Beilock & Willingham, 2014).

Tobias (2013) defines working memory as the part of short-term memory that is concerned with primary consciousness. The primary consciousness signifies the ability in learners to integrate observed events with memory to create an awareness of the present and immediate past of the learned mathematical aspects (Beilock & Willingham, 2014). For example, being mentally aware of mathematical concepts in the present without any sense of past and future; it is composed of mental images of formulae bound to a time around the measurable present. In that case, anxiety enhances the negative effect of a sustained unpleasant state on working memory capacity where it occupies working memory causing intrusive thoughts, worry, rumination and depression (Trezise, Kelly, Reeve & Robert, 2016). In this regard, the presence of anxiety compromises the immediate or primary consciousness. Therefore, working memory is often boosted or activated by strategies such as taking pictures of chalkboard explanations, recording lessons, using a formal program such as cogmed working memory training or jungle memory.

Theories on processing efficiency and attentional control suggest that working memory plays an important role in regulating cognitive performance (Shen, Sung & Zhang, 2016). According to Processing Efficiency Theory and Attentional Control Theory, worry is thought to require processing capacity, thereby reducing working memory capacity available for other tasks (Berlacon, 2017). In particular, the study by Alloway (2016) hypothesizes that anxiety interferes with the efficient functioning of the goal-directed attentional system and reduces attentional control; in other words, anxiety induces an individual's attention to threat-related stimuli. The negative effect of anxiety on processing efficiency thus stems from two executive functions involved in the control of attention: inhibition and transfer (Berlacon, 2017). This does not mean that the quality of an individual's performance is necessarily impaired, especially if their anxiety prompts the use of compensatory strategies such as more effort or more use of processing resources.

However, the complexity of the cognitive-emotional interaction also depends on the difficulty of the proposed math task. For example, in studying the effects of working memory on emotion regulation, different arithmetic tasks have been used to manipulate the load on working memory as well as mathematically specific anxiety is associated with decreased working memory abilities and slow and inaccurate processing of arithmetic problems. In particular, Owens et al. (2014) found that high anxiety in secondary learners negatively affects mathematical reasoning in individuals with relatively small numerical and spatial spans, whereas it positively affects reasoning abilities in individuals with high working memory spans.

The previous studies give a generalisation that the level of mathematics anxiety, working memory translates into either achievement or failure. Mathematics think-tanks such as Berlacon (2017) concede in the wake of 21st century that mathematics anxiety is rather a feeling of tension and anxiety that interferes with the computing of mathematical problems in many scenarios. For example, scenarios like mathematics examinations, homework and tests. Considering the above deliberation, the complexity of the discipline requires a working memory to store the essentials and underpinnings such as formulae, laws of mathematics and statistical principles of computing mathematical problems (Henry, Messer, & Nash, 2014). Therefore, in order to increase mathematics performance and decrease mathematics anxiety, working memory deficits must be addressed.

Surprisingly, little is known about the specific detrimental effects of math anxiety on learners in the primary schools such as grade 5 learners' academic performance. Most of the previous studies have been conducted on young adults or children in the secondary stages of mathematics learning while few studies have investigated the mathematics anxiety, working memory and mathematics achievement in solving multiplication problems on grade 5 learners.

Nevertheless, the relationships between mathematics anxiety, working memory and mathematics performance have been argued as very significant (Begley, 2014). Ashcraft and Kirk (2011) postulates that the increase of mathematics anxiety compromises the working memory of learners and that often leads to a decrease in mathematics performance. Conversely, the increasing mathematics performance builds on the decreasing mathematics anxiety which culminates into high working memory (Melby-Lervag & Hulme, 2013). For example, if a learner is quick to remember their timetables, the chances are high that mathematical anxiety is low and the working memory is effective. The learner will not be anxious about finding the factors of a particular number as the working memory allows the learner to divide and multiply concurrently.

It was therefore of interest to this study to establish the relationship between mathematics learners' anxiety, their working memory and their achievement in mathematics. The study seeks to ascertain the relationship between mathematics anxiety and working memory and mathematics achievement in grade 5 learners to fill the gaps in the previous literature. The thrust is to bring out how the adverse effects of mathematics anxiety relate specifically to math performance, but not reading and writing performance; and the relationship between mathematics and working memory, also considering the role of mitigating inhibitory processes with memory boosters at this specific developmental age.

Nevertheless, the deliberation in depth of these concepts were conducted in the literature review section.

1.3 Rationale of the Study

Given the context provisioned in the background section, the rationale of the study was to multiply the prevailing bodies of literature in bringing out the underlying aspects in mathematics achievement. The study assisted in addressing the gap between working memory and mathematics performance with a decreased mathematics anxiety.

Nevertheless, many mathematics studies on mathematics anxiety, working memory and mathematics achievement managed to bring out that mathematics anxiety can negatively affect the learners from high mathematics achievement (*The Debilitating Anxiety Model, 2014*). This emerges from high mathematics anxiety where learners avoid or not attempt mathematics problems such as elementary arithmetic where multiples of big numbers for grade 5 level learners such as (9×15; 21×17;312×9;432×31) may make them feel under-equipped, not competent and unprepared. For example, when calculating multiplication problems such as (3×3×3) where 3 numbers are involved or where 3-digit numbers are multiplied by 2-digit numbers such as (234×21). Against this background, the rationale behind this study is to show how the use of memory booster activities such as testing their recall, doing simple proportion or computing of shapes' areas and simple arithmetic in their head, to mention a few, can strengthen learners' working memory and in turn lower their mathematics anxiety and potentially yield higher learner achievement in mathematics.

Eventually, the study served as a reference for future studies interested in exploring further in the concept of mathematics anxiety, working memory and mathematics achievement in the intermediate phase.

1.4 Literature Review

This section briefly discussed the concepts to be reviewed in chapter 2. The concepts include mathematics anxiety, mathematics achievement and working memory. The relationship of the concepts used in this study, and the theoretical framework was reviewed in detail in the next chapter.

1.4.1 Mathematics Anxiety

According to Anas, & Sasangohar (2017), the concept of math anxiety and its interference with the ability to perform math tasks has recently received more attention in the literature. Various definitions are assigned and associated with Mathematics anxiety. Researchers Kargar, Tarmizi, and Bayat, (2010) define the concept as a feeling of insufficiency when an individual is supposed to deal with mathematics problems or calculations. For instance, grade 5 learners may feel insufficiency in dealing with long multiplication problems such as multiplying 3 digits by 2 digits (523 × 78) or to be able to structure them in the format $\begin{pmatrix} 523 \\ \times 78 \end{pmatrix}$ after visualising it. Such multiplication problems prompt anxiety in elementary learners which compromise the central executive aspect of the working memory which has a task to align focus and targets information, interlinking the short-term working memory and the long-term memory into operating together therefore assisting in breaking down the problem into (500+20+3)× (70+8).

In addition, Ashcraft and Moore (2009) defined mathematics anxiety as a feeling of mixed tension and anxiety that impedes the ability to temper with figures and computing of mathematical problems in the mathematics discourse. For instance, mathematics anxious grade five learners may find themselves lacking competencies and unpreparedness for basic facts of multiplication of numbers above 12 in mental mathematics such as (7×13; 8×14; 6×18; 7×17; 6×19). They start feeling threatened by mathematics and start to avoid math courses, do poorly in the few math classes they do take, and earn low scores on math-achievement tests. Anxiety makes them lack or be unable to recall conceptual understanding where they can only visualise the mathematical problem without actually computing it. In some instances, during mathematics classes they frequently ask to visit the bathrooms, play with their pens or rather scratch themselves without really concentrating. Consequently, Melby-Lervag & Hulme, (2013) postulates mathematics anxiety as a serious problem to learners as it bears mixed implications towards their achievement, success and efficiency in school. This topic was further elaborated on in chapter 2 under literature.

1.4.2 Working Memory

According to the Baddeley's multiple-components model, there are three components of working memory, namely visual spatial sketchpad, phonological loop and the central executive (Baddeley & Graham, 1974). The model was discussed in detail in chapter 2 of literature review; the study adopts the visual spatial sketchpad working memory which is vital for manipulation of mental images, symbols and shapes. Ideally, Alloway (2006) asserted working memory as an intellectual procedure that permits an individual to multitask or concurrently think about and hold information at the same time as performing various tasks and is responsible for temporarily storing and manipulating information. For instance, visual spatial sketchpad working memory allows fast and accurate remembering of how to compute mathematical visualised problems such as area of triangles where formula such as ($\frac{1}{2}$base × height) or rectangles where (L × B) is applied, or area of square where (side × side) is applied. The visual spatial sketchpad working memory allows the learners to recall the formulae after visualising the mathematic problem and to also recall how the formula can be applied.

Consequently, Cowan (2014) asserted that working memory is the procedure that allows human beings to mentally hold small volumes of data in a readily accessible state and to utilise such information in complex cognitive tasks. For example, 6×7 or

9×6 will be answered more slowly and less accurately than 2×3 or 3×3. The phonological loop aspect of the working memory enables learners to recall the speeches from the teacher and successfully work out the arithmetic problems. In visualising the mathematics problems, learners with high phonological loop working memory solved the mental math or arithmetic quicker than those with less. The result was high participation in the class on such topics or quick to raise their hands or a display of an excited face. This variable was further explored in the literature review chapter 2.

1.4.3 Achievement in Mathematics

Mathematics achievement is the positive result of the implementation of the ability to utilise or temper around numbers effectively (Tobias, 2013). In number operations in grade 5, learners are expected to understand the basic operations of simple arithmetic such as addition, subtraction, multiplication and division as postulated by the Curriculum Assessment Policy Statements. For example, grade 5 learners are expected to show competency and be prepared to address multiplication problems such as multiples of 5, (5×6; 5×10; 5×9) faster, accurately and with precision. In this regard, the episodic buffer working memory aspect denotes the ability to link information across domains to form integrated units of visual, spatial, and verbal information with time sequencing to imagine new concepts. The ability for learners to integrate units of information alleviates tension and high capacity of working memory and ability to apply the operations of elementary arithmetic in computing mathematical questions (Cowan, 2014). This indicates the ability, competency and preparedness to keep, recall and apply formula such as (L × B) used in finding area of rectangles or (S

× S) formula in finding square area. Learners will not find it difficult to know which side on a rectangle are the length and the breadth.

Holmes and Gathercole (2014) further relates mathematics achievement to be reflected by constant attendance of mathematics classes, high scores in mathematics tests and high passing marks. In this regard, mathematics achievement is the attainment of positive results, preparedness and competency in applying the multiplication principles in computing mathematics problems. For instance, grade 5 learners must be prepared to apply formula in computing area of shapes, address the multiplication tables and arithmetic. They should be prepared or competent enough to give 70 as (10 × 7), then 77 as (11 × 7), 84 as (12 × 7) and 91 as (13 × 7). This ability owes to the presence of the phonological loop which depicts a short-term phonological store with auditory memory traces that are subject to rapid decay and an articulatory rehearsal component that can revive the memory traces. Learners will show activeness in the class, regularly participate and be quick to solve certain mathematical problems. Therefore, it suffices to state that the failure of learners to master the operations of basic arithmetic is a guaranteed fail since every mathematical topic applies those operations.

1.4.4 Relationship between Mathematical Anxiety, Working Memory and Mathematical Achievement

This study ascertained the relationship between mathematical anxiety, working memory and mathematical achievement. Mammarella (2015) opines that the relationship between the three concepts indicate that learners with limited working memory may incur difficulties in managing their anxiety levels which directly affects their performance. In multiplication problems, the topic that was often used in this study, the relationship of the three concepts was unveiled. High mathematics anxiety is related to low capacity of working memory and the relationship drastically affects the mathematics achievement rate (Vukovic, 2013). Although the relationship between the three concepts has been deliberated, little is known about the emergence of math anxiety in grade five learners. Nevertheless, it remains relevant to examine the relationship between mathematical anxiety, working memory and mathematical achievement in intermediate phase learners such as Grade 5.

1.5 Theoretical Framework

This study was underpinned by the deficit theory and the Baddeley (2001) theory on working memory. The deficit theory deliberates the reasons why learners score lower marks in mathematics. The underlying assumption of the theory is that learners fail to score higher due to deficit in certain aspects, for instance material or resources (Lee, Lee & Bong, 2014). Accordingly, the deficit theory denotes that mathematics achievement is compromised by the deficit of working memory which thereby prompts mathematical anxiety (Beilock & Willingham, 2014). In addition, Baddeley (2001) notes that working memory is composed of the central executive, supplemented by the phonological loop, episodic buffer and visual-spatial sketchpad. In his theory, the central executive plays the coordinator role and distinguishes resources required for the cognitive task and then assigns subtasks to the three subsystems. Moreover, the visual-spatial sketchpad is responsible for the storage and articulation of visual-spatial information, while the phonological loop is responsible for verbal information. The episodic buffer assists in understanding working memory interaction with other types of memory, namely the long-term and the short-term memories. These theories were discussed in detail in chapter 2.

1.6 Problem Statement

In several instances, learners tend to not attempt mathematics problems because they feel under-equipped or not skilled enough to solve those given tasks. This then culminates in lower grade learners gradually losing interest to partake in mathematics lessons. They sometimes become anxious in for example, the learning of multiplication tables, such that their working memory becomes weak. In addition, several researchers document that high mathematics anxiety seriously affects the learners' working memory capacity. In essence, that usually culminates to low mathematics performance. Perhaps there are initiatives that can be adopted to strengthen the learners' working memory and in turn establish how mathematics anxiety potentially relates to working memory and mathematics achievement. This study therefore sought to establish the relationship between Anxiety, Working Memory and Achievement in Mathematics in Grade 5 learners by using multiplication as a topic.

1.6.1 Hypotheses of the Study

The following hypotheses were stated and tested at the 5% level of significance:

H_0: There is no relationship between mathematics anxiety, working memory and mathematics achievement when solving multiplication problems in Grade 5

H_1: There is a relationship between mathematics anxiety, working memory and mathematics achievement when solving multiplication problems in Grade 5

1.6.2 Aim and Objectives of the Study

The study aims to establish the relationship between learners' mathematics anxiety, their working memory and their achievement when solving multiplication problems in Grade 5. In essence the following are the objectives of the study:

- To determine how the memory booster activities improve learners' working memory capacity with respect to solving multiplication problems in Grade 5.
- To ascertain the relationship between learners' memory booster activities and their working memory capacity with respect to solving multiplication problems in Grade 5.
- To determine the effect of the incorporation of memory booster activities towards the learners' working memory capacity with respect to solving multiplication problems in Grade 5

1.6.3 Research Questions

1.6.3.1 Main Research Question

- What is the relationship between mathematics learners' anxiety, their working memory and their achievement with respect to solving multiplication problems in Grade 5?

1.6.3.2 Sub-questions

- How do memory booster activities improve learners' working memory capacity with respect to solving multiplication problems in Grade 5?

- What is the relationship between learners' memory booster activities and their working memory capacity with respect to solving multiplication problems in Grade 5?
- What is the effect of incorporating memory booster activities towards the learners' working memory capacity with respect to solving multiplication problems in Grade 5?

1.7 Research Methodology

This section deliberates the research methodology and design to be employed in conducting the study.

1.7.1 Research paradigm

This study opted for positivism research paradigm to generate knowledge in the research context.

The positivism paradigm was adopted as it extracts outcomes by means of experiments and scientific methods which offer vital insights and knowledge regarding the natural world of realism and truth (Shiraz, 2015). The adoption of positivism allows the utilization of several samples, measures, and designs to attain a valid perception of the relationship between mathematical anxiety, working memory and mathematical achievement. Nevertheless, the adoption of the positivism paradigm allowed the independence of all the impacts that may rise during the research process (Creswell, 2013).

1.7.2 Research approach and design

The nature of the study prompted an adoption of a quantitative approach (Creswell, 2014), which entails the use of a correlational study to comprehend the relationship between mathematics anxiety, working memory and mathematics achievement. In the same regard, a correlational survey design was adopted in the study as it allowed the determination of the relationship between mathematics anxiety, working memory and mathematics achievement in grade 5 learners.

1.7.3 Sampling

The target population was all the grade 5 learners at Tshepisong Schools. Grade 5 mathematics learners from two different schools were chosen for this study because the researcher is a primary school teacher and understands the teaching methods implemented at school, more especially in the lower grades. The six classrooms of Grade 5 learners that were chosen for this study were in the researcher's proximity and convenience. The number of learners per classroom range between 45 and 55, all the learners amounted to 315, but only 300 participated in the study. Therefore, the study consisted of a convenience sample of 300 learners.

1.7.4 Instruments

In line with the quantitative research approach chosen, the data was collected using mathematics anxiety questionnaires (refer to Appendix A1), mathematics achievement tests (refer to Appendix A2), memory booster activities and working memory tests (refer to Appendix A3).

1.7.5 Development of instruments

The study used the instruments that ascertained information on the concepts below:

1.7.5.1 Mathematics anxiety questionnaire

The study conducted a survey to gain information on the level of mathematics anxiety in the mathematics discourse. A single anxiety instrument was administered twice, once in the pre-test and again in the post-test. The difference in the results signified the relevance of the applied memory booster activities (refer to Appendix A1).

1.7.5.2 Memory booster activities

The study investigated the necessary memory booster activities plausible for adoption to deal with the mathematics anxiety. The booster activities such as overlearning multiplication concepts and formulae, use of multiplication tables, use of multimodal approaches such as taking pictures in class, verbal recording of lessons and creating visual representation of math problem were adopted after the pre-test to determine how they alleviated mathematics anxiety within the learners (refer to Appendix A3). The post-test results determined how the working memory of the learners had been improved.

1.7.5.3 Working memory test/achievement test

The working memory level of the learners was revealed by the variance that arose between the pre-test and the post-test conducted. The study established the working memory level from the results of the pre-test before applying memory booster activities and noted the results after applying them (refer to Appendix A2).

1.7.6 Data analysis and interpretation

The study adopted descriptive and inferential statistics. Pearson's correlation coefficient (two-tailed) was computed at 95% confidence interval between mathematics anxiety, working memory and mathematics achievement. Descriptive statistics (i.e., frequencies and percentages) were computed to analyse the data collected using questionnaires. Paired sample T-test was performed to determine if memory booster activities improve working memory capacity through mathematics achievement/working memory pre-and- post test scores.

1.7.7 Validity and Reliability

This study conducted a pilot study to measure consistency and determined the reliability of the instruments. The pilot study ensured the reliability of the questionnaire. The piloting was tested and retested in 2-week intervals to determine consistency. In this regard, the consistency in results showed that research instruments, booster activities and tests were reliable.

Face and content validity of the questionnaire was ensured by making an expert on the research subject review the instruments to determine if they measured the trait of interests. The research expert also assessed if the memory booster activities asserted were relevant for grade 5 learners to ensure validity of the questionnaire, booster activities and tests.

1.8 Ethical Issues

Firstly, permission was sought from institutions concerned to use the data (refer to Appendix B2). The Code of Ethics for University of South Africa was used to adhere to and address ethical considerations (refer to Appendix D). The researcher reported her findings in a complete and honest fashion, without misrepresenting the findings (Leedy and Ormrod, 2014). Learners' parents were informed of the study through consent letters, to ensure that no harm comes to the respondents, collected data remained confidential and respondents remained anonymous (Creswell, 2014) (refer to Appendix B1).

1.9 Definition of Terms

Mathematics Anxiety- Mathematics anxiety is a feeling of mixed tension and anxiety that impedes the ability to temper with figures and computing of mathematical problems in the mathematics discourse (Henry, Messer & Nash, 2014).

Working Memory- Working memory is the procedure that allows human beings to mentally hold small volumes of data in a readily accessible state and to utilise such information in complex cognitive tasks (Gathercole & Pickering, 2013).

Mathematics Achievement- Mathematics achievement is the attainment of positive result in the implementation of mathematical principles in solving mathematical problems (Tobias, 2013).

1.10 Chapter Organisation

The study was structured in 5 chapters as indicated below:

1.10.1 Chapter One: Introduction and Background

The first chapter set the overview of the study by introducing the study background, research problem, research objectives, research questions and the aim of the study. This served as the introduction of the study.

1.10.2 Chapter Two: Literature Review

Chapter two reviewed the literature by previous researchers on the same subject. This chapter deliberated the theoretical framework adopted by the study. The literature review assisted in the all-inclusive understanding of the study concepts.

1.10.3 Chapter Three: Research Methodology

The third chapter deliberated the chosen methodology on conducting the study.

1.10.4 Chapter Four: Data Analysis, Interpretation and Presentation

Chapter four analysed and interpreted the data and discussed the results in addressing the research questions.

1.10.5 Chapter Five: Conclusions and Recommendations

The fifth chapter discussed the conclusions attained in the entire study. The interrogation of the combined sources of data to address the research problem then lead to the recommendations of the study.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

This chapter deliberates the major concepts borrowing from previous researchers of the same subject. The study intends to create an all-inclusive empirical understanding of the mathematical discourse, across the lines of mathematics anxiety, working memory and mathematics achievement. The chapter commences by deliberating on the definitions of the major concepts of the study. The causes and effects of mathematics anxiety and working memory in relation to mathematics achievement together with related theories and relevant examples are presented. The chapter then concludes by a presentation on how the major concepts connect, activities to boost the working memory of the learners and the theoretical underpinnings of the relationship between the variables.

2.2 Definition of Concepts

The major concepts that inform this study are discussed in this section. Those concepts include mathematical anxiety, working memory and mathematical achievement. The thrust is to create a foundation of the discussion of how mathematical anxiety is related to working memory and mathematics achievement for grade 5 learners.

2.2.1 Mathematics Anxiety

Henry, Messer and Nash (2014) assert that the concept of mathematical anxiety has generally something to do with a sense of discomfort while required to work on mathematical problems and with fear and apprehension of specific math-related situations. Conversely, Stoehr (2017) define mathematics anxiety as a feeling of mixed tension and nervousness that impedes the ability to deal with mathematical problems. Melby-Lervag and Hulme (2013) further propounds that that mathematics anxiety is the feeling of insufficiency or readiness to solve mathematical problems. From the definitions given, mathematics anxiety can be posited as the negative feeling or tension towards attempting mathematical problems. For instance, when grade 5 learners are required to solve 4 digits by 3 digits multiplication, they may feel discomfort, inferior or insufficient to solve 4 by 3 multiplication problems such as (4352×435). On multiplying 4352×435, a learner is supposed to place 2 zeros as placeholders; on multiplying 4×5 where the value is above 10, learners are supposed to carry the tenth and enter the unit, which might arouse tension to those feeling inferior. After multiplying with all the values, the learner is required to add the three lines figures which are the value of (4352×4) + (4352×3) + (4352×5), which is a long process for a grade five learner, hence prompting mathematical anxiety. The anxieties that grip learners in mathematics lessons impede their conceptual understanding and make them feel insufficient and not ready to combine the multiplication and addition skills implicated in solving some of the mathematics problems presented above. Albeit that there are several definitions of mathematics anxiety, this study adopted Ashcraft and Moore's (2009) definition that mathematics anxiety is a feeling of mixed tension and anxiety that impedes the ability to temper with figures and computing of mathematical problems in the mathematics discourse. As can be noted in (4352×435), the inferiority feeling compromises knowledge on how to place zero placeholders, knowing which values to carry when the figure exceeds 10; such as when 4 is multiplied by 4 or 3 or 5, may affect their ability to temper with figures which thereby prompt mathematical anxiety.

According to Tobias (2013), mathematics anxiety causes some grade 5 learners to lose confidence, grow nervous and forget basic ways of dealing with mathematics. For instance, in my classroom, I often observed that learners may be frequently asking to leave the class during mathematics lessons than other subjects. In addition, Melby-Lervag and Hulme (2013) notes that mathematics anxiety culminates into low participation, growing nervousness and reflection of confusion when facing mathematical problems that require them to apply multiplying principles. In multiplication of fractions such as $(\frac{2}{3} \times \frac{4}{5})$, low self-esteem, confidence and efficacy is prompted in some grade 5 learners which culminates in emotional and physiological disruption. In solving the problem $(\frac{2}{3} \times \frac{4}{5})$learners will not be confident in multiplying the numerators 2×4 and or denominators 3×5. The learner combines the fear of failing to multiply, the uncertainty of being able to do the problem, and the urgency to get it done on time, all of which cause anxiety. It is against this background, mathematics anxiety posits the sense of discomfort while required to work on mathematical problems and with fear and apprehension to specific math-related situations. Thus, because of this anxiety, discomfort and fear some grade 5 learners tend to dodge mathematics classes due to self-consciousness about their poor performance.

2.2.2 Causes of Mathematical Anxiety to Children

Trezise, Kelly, Reeve and Robert (2016) assert that learners often develop mathematical anxiety from their teachers who often reflect anxiousness about their mathematical abilities in key areas. Those key areas include the approach to teaching, willingness and ability to give extra help to those who need it and the expectations of the teacher on his/her learners which may be quite unrealistic. Conversely, Beilock and Willingham (2014) attest that in some countries pre-service teachers are expected to attain a minimum of 51% in mathematics examinations. The failure of these pre-service teachers to cross the 51% mark reveals his/her lack of understanding of mathematics which is passed naturally to the learners. In this regard, some teachers are not equipped enough to teach some of the topics they struggled with during their training. Jansen (2013) articulates that teachers with such experience prompt negative school experiences for learners they teach and that may contribute to learners' development of mathematics anxiety. For instance, this may be displayed through teachers' threatening learners on the complexity of mathematics and authoritarian attitudes could lead to fearsome classroom climates where learners might hesitate to ask questions or answer the teachers' questions. Therefore, it suffices to state that mathematical anxiety in learners can be caused by the anxiousness of teachers in how they present their teaching techniques.

Mathematics anxiety can also be associated with learners' poor performance. Suárez-Pellicioni, Macarena, Núñez-Peña, María, Colomé (2016) indicate that learners sometimes have beliefs and expectations to perform poorly on mathematics problems. This can also culminate into mathematics anxiety. This could also be because learners sometimes perceive their performance in mathematics as a yardstick to measure their self-worth entirely. It sometimes seems to them as if they are losing value to the teachers and parents. For instance, a learner who is always getting less than 50% in mathematics examinations usually feels like they are not competent enough. In such instances, learners usually express themselves as "I can't do mathematics" or "I hate mathematics." Therefore, learners' belief about being poor in mathematics leads them to a great deal of stress and uneasiness towards mathematics, a feeling of inferior operation and inefficiency in the subject (Mammarella, Caviola & Dowker, 2019). This may also prompt mathematics anxiety.

Cowan (2014) notes that anxiety is a psychological state that consist of fear, worry, dread and tenseness. In doing mathematics, grade 5 learners may fear computing multiple digit problems. In addition, they might also worry about not succeeding in solving such problem. Sometimes they are dreadful of fraction multiplication. This usually results in them being tense towards the entire multiplication topic, preferring additions and subtractions or divisions. In this regard, Süren and Kandemir (2020) further asserts that anxiety is projected by learners' own fears of mathematics that erupts such that they have sensitive attitudes towards mathematics. For instance, no one can solve every mathematics problem and it is quite normal that children would at times make mistakes in doing mathematics computations. In this regard, Buchsbaum (2013) points to the fact that learners reflect negative reactions to errors or shortcomings they commit such that they then believe that they can't do or hate mathematics. Thus, mathematics anxiety in that way is associated with a psychological state towards mathematics coupled with fear, worry, dread and tenseness towards the subject. Therefore, it holds to state that mathematics anxiety is caused by a psychological state towards mathematics which culminates into fear, worry, dread and tenseness.

2.2.3 Working Memory

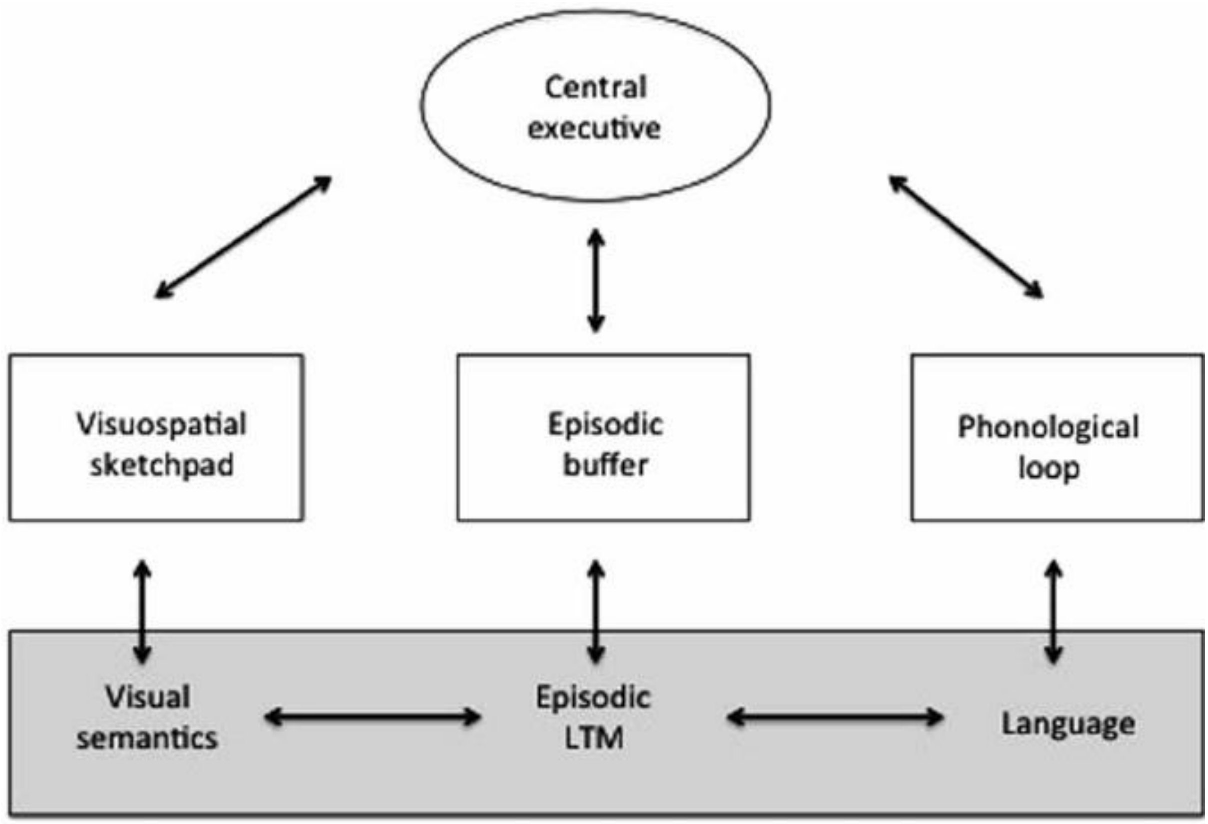
Baddeley and Graham (1974) depict three components of working memory, namely visual spatial sketchpad, phonological loop and the central executive in their multiple-components model. Although, this study adopted a visual spatial sketchpad working memory, it is vital to unpack other components for an all-inclusive understanding.

Generally, Miller, Lundqvist and Bastos (2018) define working memory as the small amount of information held in mind and utilised in the implementation of cognitive tasks. Cognitive tasks in grade 5 mathematics refer to mathematical undertakings that require a person to mentally process new information through acquiring and organising multiplication sequences, stages and allow them to recall and to use that information later. Also, according to Baddeley and Lieberman (2017) the working memory can be of low capacity or high depending on the complexities of the information to be stored in the mind. For example, in the multiplication of 2 digits by 2 digits in grade 5 the capacity to store 12×12 may be lower than storing 23×16. Conversely, Schweppe (2014) notes that the theorists who consider two distinctions of working memory, short memory and long memory accounted for the complexity of storing cognitive information for long or short period of time. According to that author, short memory denotes the short-term storage of information in the mind while long-term is the storage of information for a long term (Schweppe, 2014). Basically, working memory is vital for guidance in decision making and reasoning behaviour. This study utilises the short memory in line with the visual spatial sketchpad working memory in terms of mathematics for grade 5 learners. The visual sketchpad working memory refers to the storing and processing of information in visual or spatial form for use at a later stage.

2.2.3.1 The Baddeley's Multiple Components Model

The role of working memory and mathematical problem solving is best understood through the Baddeley's multiple components model (Baddeley, 2017). The Baddeley's Multiple Components Model is built by three components: visual–spatial sketchpad, phonological loop, and central executive.

Figure 2.1 below highlights the link between the multiple components of the model.



Source: Baddeley and Logie (1999)

Figure 2.1: Baddeley's Multiple Components Model

According to the diagram, the working memory has a central executive which connects the visuospatial sketchpad, episodic buffer and the phonological loop (Baddeley & Logie, 1999). This central executive represents the system that controls attentional processes rather than a memory store. In the same note, the episodic buffer depicts the temporary storage that integrates information from the other components and maintains timeous continuity of event sequences. The phonological loop represents the auditory information where words which can be heard and repeated in a loop are stored (Baddeley, 2019). These components contribute to the working memory of learners in mathematical problems. For instance, a learner can visualise a multiplication table after seeing a multiplication mathematical problem such as (9 × 7).

The visualisation draws from recalling the table and creates a visual of the figures where 9 and 7 meet on the table. The episodic buffer posits the collection of past personal experiences that occurred at a particular time and place (Swanson & Fung, 2016). Thus, in given a problem like 9 × 7, the learner can collect the multiples of 9 or the multiples of 7 to determine the answer. The phonological loop is important for the storage of text and verbal information, such as the story in a word problem (Oberauer, 2019). Thus, with regards to the problem (9 × 7), the verbal or auditory information stored during multiples practicing can be recalled and used in solving the sum. Therefore, these multiple components of the working memory assist learners on how they must see to visualise, recall to apply and remember to look for common factors in the numerators and denominators before they finish multiplication.

In the following sections each of the memories that make up the Baddeley and Logie model is discussed. The section resumes with discussions on the Phonological Loop Working Memory.

2.2.3.2 Phonological Loop Working Memory

According to Baddeley (2019) the phonological loop working memory is segmented into three measures; a) phonological memory, which involves coding and short-term storage of sound-based representations, b) phonological awareness and c) rate of access to phonological representations in long-term memory.

As shown in Figure 2.2, the phonological loop working memory covers the visual word presentations which are a reading process, auditory control process and the auditory word presentations which depict listening ability. These attributes feed to the phonological store.

Source: Prebler, & Hasselhorn (2013)

Figure 2.2: Phonological Loop Working Memory

According to Prebler and Hasselhorn (2013), the short-term memory denotes the ability to recall digits, letters, words and non-words in mathematical problem solving without interfering information and competing. Conversely, Purpura, Baroody and Lonigan (2013) assert that the phonological awareness is then measured using certain tasks that cover the response elicited from the learners who must initially attend to and manipulate the auditory of the teacher. Conversely, the indicators of articulation speed are then employed in evaluating the fluidity of access to the phonological representations in long-term memory (Kyttala & Bjorn, 2014). Therefore, it suffices to state that multiplication mathematical problems may use measures of digit span, articulation of speed of words and the phonemic deletion as measures of the phonological loop. The digit span, articulation speed and the phonemic deletion can be measured in mental arithmetic where multiplication problems such as (5×3; 4×4, 7×2) are asked to the learners and determine their speed in responding to the problems.

Furthermore, the Baddeley's Model acknowledges that the contribution of Working Memory on the learners' mathematical problem solving is primarily mediated by reading processes (Swanson & Fung, 2016). This is so since multiplication problems may be presented in a form of texts; and the phonological system allows the decoding and comprehension of texts. Given the following problem,

"Olivia took out 8 glasses and poured juice from the pitcher. The capacity of each glass is $\left(\frac{1}{4}\right)$ *litre. If there was enough juice for 6 glasses, how much juice was there?"*

The reading of the text, understanding the mathematical language, mediates the relationship between fraction multiplication of word problems and phonological working memory. Kyttala and Bjorn (2014) attests that the phonological process shares a substrate with the reading processes and increase the rapid speed of the sub vocal rehearsal process. This therefore reduces the demise of the memory items in the phonological store prior to output. The phonological working memory component allows the learner to name and structure the mathematical problem into a solvable state, encode and rehearse how it can be solved (Gray, Green, Alt, Hogan, Kuo, Brinkley & Cowan, 2017). For instance, on the word problem given above, the learner must recall that:

(i) 1 liter = 1000ml

(ii) Find ¼ of 1000 ml = 250ml

(iii) Multiply the ¼ i.e., 250ml by 6 to get 1500ml

(iv) Change 1500ml into liters to get 1.5L

The structuring may be as follows:

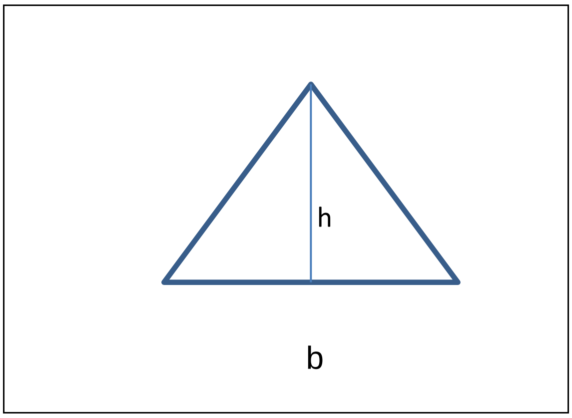
$$\left(\frac{1}{4}\right) \text{x } 1000\text{ml}(1\text{litre}) = 250 \text{ ml};$$

$$\text{then } 6\text{x}250\text{ml} = 1500 \text{ ml (hence the juice was } 1.5 \text{ liters)}$$

In this way, phonological working memory has a direct relationship with computing of multiplication word problems.

2.2.3.3 The Visual-spatial Sketchpad

Researchers, van den Berg, Edward and Ji, (2014) posit that the visual spatial sketchpad represents a temporal storage of visual and spatial information which is vital for the manipulation of mental images such as mathematical symbols and shapes (van den Berg, Edward & Wei Ji, 2014). This is line with the short-term working memory where information is stored for a short term. The visuo-spatial sketchpad working memory in mathematics posits the ability to remember the formulae after just visualising the mathematics problem. For instance, a learner may recall a formula (½ b × h) after visualising an instruction to calculate area of a triangle. A visualisation of the triangle is as illustrated below:



In the same note, mental visualisation of mathematics multiplication tables may be recalled in mental mathematics. For instance, a learner may visualise the table when dealing with multiples of certain numbers:

Table 2.1: Multiplication Table

×	1	2	3	4	5	6	7	8	9	10
1	1	2	3	4	5	6	7	8	9	10
2	2	4	6	8	10	12	14	16	18	20
3	3	6	9	12	15	18	21	24	27	30
4	4	8	12	16	20	24	28	32	36	40
5	5	10	15	20	25	30	35	40	45	50
6	6	12	18	24	30	36	42	48	54	60
7	7	14	21	28	35	42	49	56	63	70
8	8	16	24	32	40	48	56	64	72	80
9	9	18	27	36	45	54	63	72	81	90
10	10	20	30	40	50	60	70	80	90	100

Using this Table as a visual reference, learners can be able to see that:

(5×1=5; 5×2=10, 5×3=15; 5×4=20; 10 ×10 =100; 7 ×10 =70; 3 ×10 =30; 6 ×10 =60…)

From this deliberation, Cowan (2014)'s depiction of spatial visual sketchpad working memory can be adopted as it signifies the procedure that allows human beings to mentally hold small volumes of data in a readily accessible state and to utilise such information after a visualisation on a complex cognitive task.

In addition, the visual-spatial sketchpad working memory focuses on the storage of visual information for manipulation in mathematics. Wongupparaj, Kumari and Morris (2015) also state that the visuo-spatial sketchpad rather retains the visual and/or spatial information in brief periods of time. It enables human beings to instantly create and revert to a created mental image that can possibly be manipulated in complex responsibilities of spatial orientation. For instance, a learner may be able to compute 3 by 2 multiplications such as (345 × 34) with confidence, quickly and most importantly, accurately. A learner places a zero-place holder before multiplying 3 by 5, 4 and 3 through visualising their multiples from the multiplication table as a reference and move on to multiply 345 by 4 using the same reference of multiplication table. In this regard, Baddeley and Lieberman (2017) established the visual-spatial sketchpad as a subsystem that integrates visual-spatial information in the calculation of the problem, clearly show the visual part, the tactile part, kinaesthetic sources, and as such where the episodic and semantic long-term memory applies. Therefore, remembering the steps followed in doing a multiplication mathematics problem instantly from the temporary storage of visually and spatially coded information signifies the visual-spatial sketchpad working memory.

Furthermore, the visual spatial sketchpad working memory is confined in terms of capacity to three or four objects at a given time. Schweppe (2014) segmented the visual spatial sketchpad into two subcomponents; a visual storage component, the visual cache, used to store visual characteristics of objects and events; and a dynamic retrieval and rehearsal process. For example, when multiplying ¾ by 100, from the visual cache, it might be easy for a learner to the problem as 300 divided by 4. Another learner may visualise the same problem as 100 divided by 4 to get 25 and then multiply the result 25 by 3. In finding the solution to this problem, for the ability to remember when to multiply when there are several requirements, the learner must draw from the visual spatial sketchpad working memory. The inner scribe will be responsible for the rehearsal and transfer of information from the visual cache where the learner can see things to the central executive component in this case, the brain. Therefore, visual spatial sketchpad working memory may enable learners to instantly create and revert to a created mental image in their minds that can possibly be manipulated in complex responsibilities of spatial orientation.

2.2.3.4 Episodic Buffer

The Baddeley's model posits the episodic buffer component to depict the temporary storage system that can combine information from the loop, the sketchpad, long-term memory, or indeed from perceptual input, into a coherent episode (Baddeley & Lieberman, 2017). Klem, Melby-Lervag, Hagtvet, Lyster, Gustafsson and Hulme (2014) concede that the episodic buffer is controlled by the central executive which allows the component to integrate the unitary multi-dimensional episodic experience. This implies that the episodic buffer temporarily keeps the input from auditory, visual and spatial modalities before integrating it towards computing of mathematical multiplication problems. For instance, given a word problem such as:

"There are $\frac{7}{8}$ *kilograms of salt in the kitchen. Mrs. Jackson used* $\frac{2}{15}$ *of the salt when she was preparing dinner. How much salt did she use?"*

The learner must hear that of the 7/8 kg salt that was present, 2/15 were used by Mrs Jackson. It might be important for the learner to realise that when multiplying the two fractions, the 2 is a factor of 8 before multiplying numerators and denominators. In terms of spatial modalities, it might be interesting for the learner to see how eighths relate to fifteenths.

$$\frac{7}{8} \times \frac{2}{15} = \frac{7}{60}$$

She used $\frac{7}{60}$ of a kilogram of salt.

Therefore, the episodic buffer is seen to play an operational role that was initially assigned to the Baddeley's Model to the central executive component which ends up being a regulatory and attentional system. In the example given above, the central executive component regulates the deletion of words and replacement with numbers and attentional sequencing where numerators 7 and 2 are multiplied and denominators 8 and 15 are multiplied.

A mathematical problem such as 7 × 12 requires a learner to have relevant information in mind to be able to manipulate the information to solve the mathematical problem. In this regard, a learner can integrate the phonological memory, visual spatial sketchpad and the central executive to adopt a strategy of splitting the multiplication problem into sub-problems such as (7 × 10 and 7 × 2). A learner is required to keep the answer of the first sub problem (7 × 10 =70), then the second (7 × 2 =14) and to add the two results to find the actual answer to the problem. The episodic buffer as well requires a learner to use the unitary multi-dimensional episodic experience to borrow or carry a digit in any event when they are solving multi-digit multiplications. For instance, when multiplying problems such as: $\begin{pmatrix} 249 \\ \times\ 76 \end{pmatrix}$

Considering the mathematical problem above, a learner with high epidemic buffer memory can have the knowledge to integrate the relevant information and steps required in computing such a problem. The relevant information covers the actual multiplication of figures and knowing the steps such as multiplying 249 by 6 first, inserting a zero-place holder then multiplying 249 by 7 and then add the outcome. The working memory will allow the learner to keep track with carrying and manipulations for intermediate solutions. As illustrated in the example above, learners will remember that after multiplying the figures where (249 × 6= 1494) and (249 × 70= 17430), addition of the outcomes follows to produce the answer.

The working memory is explained by the Baddeley’s model as bearing three components that hold certain influence on the concept. It is the phonological loop that enables the learners to memorize the language of the mathematical discourse, the visuo-sketchpad visualizes the mathematical problems and solutions while the epidemic buffer integrates all the components in a unitary multi-dimensional experience (Baddeley & Lieberman, 2017). This study however used the visuo-sketchpad to indicate the relevance of the working memory in the mathematical discourse, unpacking how it relates to mathematical anxiety and mathematical achievement (Cowan, 2014). This was because learners in grade 5 visualize to remember after seeing the mathematical problem.

2.2.4 Achievement in Mathematics

According to Tobias (2013) mathematics achievement is the positive result of the implementation of the ability to solve mathematical problems successfully and accurately. Anbalagan (2021) further states that mathematics achievement can be measured by mathematics tests results, and quickness to deal with mathematical problems such as mental mathematics using multiples of numbers. In addition, Holmes and Gathercole (2014) assert that mathematics achievement is reflected by a comparison with other learners and the breaking of certain benchmarks. For instance, a learner who performs better in mathematics exams by scoring above 70 %, participates in class, is quick to react to teachers' questions and confident in approaching a mathematical problem signify a positive mathematical achievement. The study adopted Tobias' definition of mathematics achievement which suggests the attainment of positive results, positive reaction to multiplication problems, speed and accuracy in solving mathematics problems. This was because achievement in grade 5 learners is measured by the outcomes in tests and examinations.

Furthermore, mathematical achievement can be argued as the capacity to utilise or manipulate numbers effectively in mathematics problems (Berlacon, 2017). For instance, the ability to break down word problem such as:

"If there are four out of eight slices left over from the first pizza and six slices from the second pizza, how much pizza is left over?" into numbers $\left(\frac{4}{8}+\frac{6}{8}=\frac{10}{8}\right)$.

In the same case, the ability to compute mental math accurately and quickly such (4×6; 7×5; 9×7; 2×5; 7×8) or 4 by 3-digit multiplication problems such as $\binom{5234}{\times\ 235}$. The quickness and promptness in dealing with such mathematical problems signify mathematical achievement. The ability to solve these varying mathematical problems transforms into high scores in exams and self-confidence. Therefore, the improvement in results indicates that there is positive mathematical achievement whilst negative results show low mathematical achievement.

Furthermore, mathematics achievement denotes the knowledge of arithmetical facts, capability to execute arithmetical procedures, comprehend and apply arithmetical principles (British Columbia Ministry of Education, 2017). Conversely, mathematics achievement can be presented as outcomes related to conceptualisation of mathematical knowledge, capability to handle mathematical computations, the speed of making those mathematics computations, and language-based mathematics problem solving (Rahman & Ahmar, 2017). For instance, simple multiplication arithmetic involves knowing numbers in a particular multiplying sequence and how they can be arranged in the table (Jordan, Glutting, Dyson, Hassinger-Das, & Irwin, 2012). In a multiplication table, ($2\times1=2$; $2\times2=4$; $2\times3=6$; $2\times4=8$; $2\times5=10$…), a multiples sequence which a learner can recall in dealing with multiplication problems.

Mathematics achievement is also understood in the realm of accuracy when attempting mathematical problems (Saravanakumar, 2020). Berlacon (2017) argues that learners with mathematics achievement are more efficient over time in the utilisation of retrieval strategies of computing methods when implementing 2 digits multiplication problems. In this regard, accuracy is greater as well as the speed of retrieval when there is a strong association between calculations and accurate responses on learners learning mathematics. For instance, addressing mathematical problems such as:

$$\binom{39}{\times 23}$$

where additions when carrying is conducted as well as direct and cross multiplications of numbers is conducted. It is that ability to know that 3 multiplies 39 first, after placing a placeholder 2 multiplies 39 second and then add the outcomes where if accurate answers are elicited, it therefore signifies mathematical achievement. Malik and Rizvi (2018) further states that solving 2 digits or more mathematical problems builds on the understanding of the learner of the mathematical arithmetic principles, ability to process and comprehend verbally expressed propositions and the construction of a calculation procedure (Fuchs, Geary, Fuchs, Compton, & Hamlett, 2014). Therefore, that understanding of the learner may ensure getting accurate answers, positive marks in mathematics tests and examinations, signifying positive mathematics achievement.

2.3 Relationship between Mathematics Anxiety and Achievement

According to Ashcraft and Moore (2009), there is a negative correlation between mathematics anxiety and achievement or performance. This implies the previous studies by Cowan (2014) which shows a (-0.8) correlation between the two concepts depicting a strong degree of negative correlation between mathematics anxiety and achievement. The (-0.8) correlation shows that the increase in one variable, in this case mathematical anxiety, culminates to the decrease in the other variable, mathematics achievement. The measurement conceded that when the mathematics anxiety increases, the mathematics performance decreases. Conversely, Aldrup, Klusmann and Lüdtke (2020) argue that the increasing anxiety culminates to depression, tenseness, sad and low self-esteem towards mathematics. This then transpires into low mathematical performance. For instance, learners experiencing high mathematical anxiety begin to have a negative perception of their abilities in mathematics as a subject and start avoiding mathematics periods. In some instances, when you start teaching certain topics, they increasingly ask to use the bathroom which is apparently avoiding classes. This usually transpires on certain topics such as multiplication, fractions, long division, calculations of perimeter or areas where formulae such as (L×B) or ½ b×h apply. The feeling of insufficiency and inferiority directly translate into low performance which results into low mathematics achievement.

Zhang, Zhao and Kong (2019) established that in the history of mathematics anxiety, the nexus with personal and educational consequences negatively impacted on measures of performance. Anxious learners are challenged to deal with their anxieties above the demands of the test and the complexities of the mathematics material hence the educational consequence becomes the underestimation of true ability. There is a dramatic reduction in the performance levels of learners in scenarios of high mathematics anxiety under timed and high stakes situations. This implies that an anxiety ridden learner is bound to achieve not more than 50% in mathematics tests and examinations, which might be a failure. Messer and Nash (2014) posit that mathematics achievement and proficiency in performance for mathematics anxious learners are underestimates of true ability. Therefore, mathematics anxiety and mathematical performance relationship is more likely to be determined by the level of anxiety a learner has; where high anxiety depicts low performance while low anxiety denotes high performance.

2.3.1 The Inhibition Theory

The relationship between mathematical anxiety and mathematical achievement can also be explained using the inhibition theory. The inhibition theory was proposed by Hasher and Zacks (1996) as a general processing model that assists in conceptualising performance deficits in the presence of distractors. The model was applied to highly anxious participants in the mathematical discourse. Accordingly, the inhibition theory attests that an attentional suppression mechanism functions to control the negative impact that distracters may have on task-relevant objectives (Hasher & Zacks, 1996). The attention suppression mechanisms inhibit performance as they dampen the stimulation of the task-irrelevant thoughts or representations. For instance, a learner may start having some thoughts which have nothing to do with what they are learning; this is shown by their blank faces and the look of being carried away or confessions of not hearing what the teacher just said. Therefore, in the mathematics realm, the ability of a learner is suppressed by those mechanism or distractors that inhibit recalling of mathematical problem-solving manipulation techniques.

Furthermore, the mathematics anxiety is thereby posited as characterising the attention suppressing mechanisms. The presence of intrusive thoughts evolves from the learner’s failure to inhibit attention to those thoughts (Jones, Childers & Jiang, 2012). Intrusive thoughts refer to the unwanted thoughts, impulses or mental images that prompt vital anxiety, stress and impairment within an individual’s ability to function. This may therefore prompt an outcome of poor performance on mathematics multiplication problems. For instance, when addressing multiplication word problems such as:

“Pam baked some cupcakes for her friends. She baked 24 cupcakes. Each cupcake is 75g. If she packed 6 cupcakes in each box, what is the weight of each box?”

In this regard, a learner may end up thinking about cupcakes instead of the mathematical problem as results of attention suppression mechanisms. The attention suppression mechanisms such as anxiety may inhibit the capability of mathematical knowledge to arrange the numbers for computation as follows:

$$75g \times 6 = 450g$$

Instead of thinking about how the wording in the mathematics problems can be transformed into numbers, the thoughts of cupcakes can intrude the ability to understand the mathematical problem at hand. Therefore, it suffices to state that mathematics anxiety and achievement connects on that mathematics anxiety serves as an inhibition factor; it suppresses the activation of task-related thoughts that can be applied on mathematics computation.

Several studies have found a positive correlation between mathematical anxiety and low mathematic achievement. Studies by Jones, Childers and Jiang (2012) established .92 correlation between high anxious learners in mathematics with inferior mathematical performance and performance related worries. The correlation shows a strong linear relationship between mathematics anxiety and low mathematics achievement. Against this background, one can state that mathematics anxiety negatively affects the mathematics achievement as intrusive thoughts such as sadness, hatred and dislike of the subject may inhibit computation capabilities and inhibit the mathematics relevant knowledge. Instead of retrieving task-relevant knowledge, learners may start thinking that the career they want in the future has nothing to do with mathematics (Zhang, Zhao & Kong, 2019).

2.4 Relationship between Mathematics Anxiety and Working Memory

Alloway (2016) depicts that when mathematics anxiety is high it is negatively related to the working memory capacity. According to Ashcraft and Kirk (2011), mathematics anxiety affects tentative guesses, interrupts the short-term working memory processes due to anxiousness. Learners tend to dedicate their focus to their intrusive thoughts and worries than the mathematical tasks at hand. For instance, the visual-spatial sketchpad working memory may be affected in an extent that a learner may fail to recall mental mathematics multiplications such as (3×5; 5×6). The fundamentals in dealing with fraction multiplications of $\frac{3}{5} \times \frac{5}{6}$

can be difficult to recall. Tobias (2013) posits the intrusive thought as an unwelcome involuntary thought, image, or unpleasant idea that may become an obsession, is upsetting or distressing, and can feel difficult to manage or eliminate. Learners may have intrusive thoughts like, “I am just not good at mathematics”; “I don’t need mathematics for my career”. Therefore, these entailments signify a negative relationship between mathematics anxiety and working memory, as learners lose focus that allows a working memory to grasp what is being learnt and even easily forget the fundamentals of dealing with mathematics problems taught in the class.

The prevalence of mathematics anxiety disrupts the working memory as learners incurring high anxiousness have difficulties in carrying out computing operations (Messer and Nash, 2014). In this regard, mathematics anxiety usually burdens the recalling of means to address mathematical problems due to compromised visual spatial sketchpad working memory which rapidly decreases the performance rate in mathematics for grade 5 learners. For example, 6×7 or 9×6 will be answered more slowly and less accurately than 2×3 or 4× 5 in mathematics problems. Conversely, according to Cowan (2014), learners experiencing high anxiety levels incur a decrease in mathematics performance and achievement whilst learners with low mathematics anxiety perform better. Therefore, it suffices to state that the relationship between working memory and mathematics anxiety is determined by the level of anxiety the learner has; high anxiety negatively correlates with low short-term working memory whilst low anxiety correlates with high working memory.

The Inhibition theory also attests that mathematical anxiety implicates intrusive thoughts that overburden the working memory system (Hasher & Zacks, 1996). In other words, the anxiety is sufficient to provoke task irrelevant thoughts that disrupt working memory and anxious learners may fail or find it difficult to inhibit such thoughts. Apart from compromising the recalling or retrieval of relevant information for mathematical problem-solving, the occurrence of intrusive thoughts rather culminates into performance deficits (Vukovic, 2013). Learners who accommodate intrusive thoughts end up losing focus and concentration in class; hence becoming totally ignorant to certain mathematical procedures which thereby culminates into low performance or performance deficit.

The relationship between mathematics anxiety and working memory is also unveiled through the Eysenck and Calvo (1992) model. The model unpacks that the tasks that depend on working memory resources will reveal anxiety effects on cognition. The underpinning of this prediction is that learners instead of retrieving knowledge relevant for a mathematical problem, get anxious and that affects the visual sketchpad and phonological loop working memory as they start worrying and paying attention to those worries (Toll & Van Luit, 2014). The model depicts that the ability to recall the short-term memorized mathematical knowledge or concepts is disrupted by intrusive thoughts. The content will demand a high significant involvement of working memory as a consequence of worrying about mathematical stimuli. On mathematical problems such as 4 digits by 3 digits multiplication (6741 × 231) where stages attest that there must be multiplication of the first figures by all figures below and then add the outcomes, anxiety affects the processing efficiency, which is underpinned by working memory, more often than it affects performance effectiveness.

The model by Eysenck and Calvo (1992) attests that the working memory, long-term and short term, assists the learners in retrieving the planning and decision-making processes during attempting mathematical problems (Vukovic, 2013). In this regard, the executive control system which must regulate reasoning, language comprehension; visualising and other using of resources from the central pool must be efficient to command such a unitary episodic experience (Toll & Van Luit, 2014). The Eysenck and Calvo (1992) model then attest that anxiety in learners thereby makes such executive control insufficient for demanding tasks. For instance, demanding tasks that require multi-tasking and executing several activities require sufficient working memory to unify the reasoning, language comprehension: visualising and using of resources from the central pool. In multiplication word problems such as:

Kathy is making 3 batches of pancakes for a brunch party. If each batch needs 7/12 cups of milk, how much milk does she need in total?

The application of the long-term and short-term working memory to unify the reasoning, language comprehension and visualising to break down the problem in the following manner:

$$\frac{7}{12} \times 3 = 1\frac{3}{4}$$

She needs $1\frac{3}{4}$ cups of milk in total.

In this regard, the learner should know that the numerator 7 must be multiplied by 3 and the denominator is multiplied by 1 therefore will remain as it is. The outcome $\frac{21}{12}$ will then be converted into a mixed number of $1\frac{9}{12}$**.** The visualisation of the mathematical table will inform the learner that the fraction can still be converted to its simplest form; thus, drawing from the phonological process which shares a substrate with the reading processes and increase the rapid speed of the sub vocal rehearsal process. The use of the phonological process helps the learner to combine the visualisation, coding and recall auditory explanations from the teacher.

The learner must have sufficient and efficient short-term and long-term memory to allow understanding of the language used in the mathematical problem through phonological loop (Toll & Van Luit, 2014). The visualising of the problem while applying the visual sketchpad will also allow the structuring of the math problem in its right format for computation. The epidemic buffer will thereby unify that knowledge to compute through multiplication of fractions to get the accurate answer (Toll & Van Luit, 2014). Against this background, mathematical anxiety proffers intrusive thoughts such as negative self-talk "I'll never get this right" that make the working memory underpinnings insufficient to retrieve task-relevant information such as multiplying the numerator with the whole number which is naturally given 1 as a denominator and also multiplying the denominators alone in dealing with mathematical problems. Therefore, it suffices to state that the relationship between the two concepts is causal-factor where high anxiousness makes working memory inefficient and insufficient while low mathematics anxiety makes working memory sufficient and efficient in both long and short-term.

The relationship between mathematics anxiety and working memory is unpacked by the concurrence of the inhibition theory and the Eysenck and Calvo (1992) model. In as much as the inhibition theory affirms that performance deficits are a result of a variety of distractors, Zhang, Zhao and Kong (2019)'s model depicts that the deficit of long-term and short-term working memory affects the retrieving of planning and decision-making processes when attempting mathematics problems. In that regard, the presence of mathematics anxiety culminates into a deficit of working memory ability in long and short terms.

2.5 Relationship between Working Memory and Mathematics Achievement

A significant relationship has been established between working memory and mathematics achievement. Van der Ven, Van der Maas, Straatemeier and Jansen (2013) however note that the relationship is determined by the ageing of the learner. For instance, the decrease in the relationship between visual-spatial working memory and mathematics performance as children grow older. The underlying assumption in this regard is that younger children rely more on the visual-spatial representation which prompts the utilisation of many visual-spatial strategies (Toll & Van Luit, 2014). In line with children ageing, the connection between mathematical problems and answers is verbally memorized as they recall from learning in class. The verbal memorising also draws from the novelty explanations by the teacher which also shifts the visual-spatial to verbal strategies in solving mathematical problems (Lowry, 2013). Therefore, one can argue that the relationship between working memory and mathematics achievement draws from the learner's ability to recall verbal instructions given by the teacher in the class; thus the phonological loop. For example, the teacher may recite the multiples of 9 as they are illustrated in the multiplication table and that memorized verbal teaching may be used in dealing with mental arithmetic such as (9×7; 9×6; 9×5…). The retrieval of such verbal explanations assists learners when dealing with mathematical problems where multiplication of numbers is conducted.

Moreover, the processing of mathematics knowledge through the phonological loop influences mathematics achievement (Berlacon, 2017). In learners in the fifth or sixth grades, the phonological loop is posited as a vital predictor of mathematics achievement by allowing phonological awareness and articulation speed. Lowry (2013) is of the view that the phonological loop is provision of articulation speed and accuracy in manipulating cognitive processes involved in the mathematical competences. The retrieval of multiples of 9 in a verbal manner increases the articulation speed when learners are dealing with multiplication problems. Against this background, the working memory component, the phonological loop, provides speed in articulation and awareness of mathematical problems which indicates high mathematical performance culminating to a positive mathematical achievement.

More so, working memory allows auto-retrieval once the learners visualise the mathematical problem. Lowry (2013) attests that the mathematics domain specificity explanations thereby reveal the nexus between mathematics and visual-spatial working memory. Simple multiplication problems can be solved by visualising which prompts the verbal retrieval of memorized manipulating strategies. For instance, a learner computing multiplication problems such as 3×5; 6×8; 2×9… may retrieve the accurate answers from visualising the mathematical table where multiples of each of the figures in that example is articulated. Therefore, visual-spatial working memory has a significant relationship with mathematics achievement as retrieving learned mathematics problem solving techniques such as cross multiplication, multiplication of numerators alone and common denominators alone in fraction problems and also addition after multiplication often leads to accurate answers and speedy computations.

According to Van der Ven *et al.,* (2013), the relationship between visual spatial working memory and mathematics achievement is peak on strength in the average grades such as grade 5 and 6 as explanations on mathematics topics becomes novelty. Learners will be encountering new topics in their entire academic lives hence making it new or novelty. The visualising of mathematics problems allows the modifying of instructions and activities regarding multiplication problem computations. Berlacon (2017) affirmed that working memory system accounts for learners' variability in mathematics performance, abilities and experiences which transforms from raw mathematics performance to positive mathematics outcomes after learning or being taught. Learners' variability denotes the abilities and experiences learners bring in the classroom which matters when it comes to learning. A study by Zheng, Swanson and Marcoulides (2011) indicated that the visual-spatial sketchpad significantly culminated into greater accuracy in mathematical problem solving. Therefore, it suffices to state that when working memory is high, mathematical achievement will be high and in instances of low working memory then mathematical achievement becomes low.

Furthermore, mathematical achievement is posited as low to learners with mathematical disability. Mathematics disability, according to Berlacon (2017), is when the learners reveal impairment and lower recall in all complex working memory tasks involving verbal or numerical information when compared to their peers. Mathematics computation achievement thereby depends on the executive processing of task-related information which predicts the level of visual-spatial recalling and the chronological application of multiplication principles in line with the mathematics problem. In solving a fraction problem such as $\frac{3}{4}\times\frac{2}{5}$, learners must recall that numerators are multiplied together while the denominators are also multiplied together in chronology and that the outcome $\frac{6}{20}$ can be simplified to $\frac{3}{10}$.

2.6 Relationship between Mathematics Anxiety, Working Memory and Achievement

Empirical evidence has it that mathematics anxiety strongly correlates with math performance and working memory sufficiency and efficiency. Ashcraft and Moore (2009) propound that mathematics anxiety is consistently and negatively connected to learners' achievement in complex mathematical problems as compared to simple arithmetic. For learners in grades such as 5 or 6, mathematics problems that involve carrying numbers or use of word explanations, anxiety inhibit the retrieval of short-term memory that requires prompt solutions after visualizing the problem. For instance, on mathematics that requires carrying such as:

$$\begin{pmatrix} 523 \\ \times\ 35 \end{pmatrix}$$

In the example above, 523 is first multiplied by 5 where (3 ×5 =15); the learner records 5 and carries forward the tenth to 2. The next step is (2×5 =10) +1(tenth) which was carried over from multiplying the units. The process is repeated until all three digits are multiplied by 5. The second step after placing a zero-place holder, is multiplying 523 by 3. Concurrently, any outcome that surpasses 10 will see the unit being recorded and the tenth value carried forward to the next digit. The 2 outcomes will then be added adhering to the principle of carry forward on values exceeding 10. This therefore reveals a complex interdependent relationship between mathematics anxiety, working memory and math achievement where anxious learners incur insufficient working memory which translates to low mathematics achievement.

More so, Ashcraft and Moore (2009) assert that the mechanisms that underpins the relationships between mathematics anxiety, working memory and mathematics achievement is poorly understood. In this regard, mathematics anxiety is linked to mathematics performance and working memory by allowing the intrusive thoughts that prompts sadness and dislike of the subject of complex topics (Munoz, Sliwinski, Smyth, Almeida & King, 2013). During multiplication expressed through word problems, learners in the class might start asking to visit the bathrooms more often, sleep, play with their pens or keep their hands down when teachers ask questions unlike when encountering topics such as addition and subtraction.

The interdependent relationship between mathematics anxiety, working memory and mathematics achievement is reflected by the tendency of learners to experience intrusive thoughts which correlate with mathematics achievement during various cognitive tasks (Munoz et al., 2013). The processing efficiency theory and inhibition theory depicts that worrisome thoughts interfere with the limited resources a learner's working memory system harbors hence limiting the capability to address complex math problems. This prompts fear of certain topics, for instance, multiplication word problems such as:

According to a recipe, $\frac{9}{20}$ *oz. of sugar is needed to make 6 cookies. Ashley decided to use only a third of the sugar to make it healthier. How much sugar did Ashley use?*

Drawing from the correlation between mathematics anxiety, working memory and mathematics achievement, fear that is brought by intrusive thoughts inhibit the retrieval of short-term memory and makes the mathematics knowledge in the long-term memory insufficient and inefficient hence failing to structure the math problem as follows:

$$\frac{9}{20} \times \frac{1}{3} = \frac{3}{20}$$

She used $\frac{3}{20}$ oz. of sugar.

In the above problem:

i) $9 \times 1 = 9$

ii) $20 \times 3 = 60$

iii) The outcome in form of a fraction $\frac{9}{60}$

iv) was then reduced to its simplest form hence becoming $\frac{3}{20}$

Considering the length of steps involved in dealing with such a mathematical problem, the retrieval of short memory that is applicable in dealing with the multiplication part may prompt insufficiency and inefficiency in the long term when the figures are being computed and reduced to lowest form. Therefore, the relationship between mathematics anxiety, working memory and mathematics achievement is causal linked. According to Zhang, Zhao and Kong (2019), mathematics anxiety provokes intrusive thoughts, sad, worries, low participation and interest in learning on certain multiplication topics. This therefore makes the retrieval of relevant information for the task at hand difficult and mathematics knowledge in both long and short-term memory insufficient and inefficient. This depicts that high anxiety translate into insufficient and inadequate working memory culminating into low mathematics performance or achievement.

The significant relationships have been drawn between mathematics anxiety, working memory and mathematics achievement. The inhibition theory and the processing efficiency theory correspond on establishing that when mathematics anxiety increases, an individual's working memory is compromised due to ineffective mental resource allocation and achievement deteriorates (Krawitz, 2013). In this regard, a negative association has also been found between mathematics anxiety, working memory and mathematics achievement. Nevertheless, from the relationships established, it has been noted that in order to increase mathematics performance and decrease mathematics anxiety, working memory deficits must be addressed.

The relationship between mathematics anxiety, working memory and achievement is posited as determined by the level of anxiety as the independent variable. Mammarella (2015) opines that the relationship between the three concepts indicates that highly anxious learners end up having limited or insufficient short-term working memory. This then culminates into difficulties in mathematics performance. High mathematics anxiety is related to low short-term capacity working memory and the relationship drastically affects the mathematics achievement rate (Vukovic, 2013). For instance, an anxious learner may have difficulties in storing formulae, mental mathematics and knowledge on which mathematical instruction to apply when dealing with mathematical problems. Therefore, it is safe to state that mathematical anxiety shrinks working memory which further culminates into negative mathematics achievement.

Furthermore, cognitive skills like working memory, processing speed, attention and inhibition are vital aspects in the setting of mathematical learning difficulties. These issues have been noted as mathematics anxiety with consequences associated with an impaired working memory and attention capacity that directly compromises mathematics achievement (Ramirez, 2013). In this regard, mathematics anxiety interferes with the effective and efficient operating of the goal-directed attention system as well as reducing attention control; therefore, anxiety raises an individual's attention to threat-related stimuli. Nonetheless, high mathematics anxiety compromises the working memory and mathematics achievement by limiting attention levels and capability.

More so, the relationship between the three concepts depends on the complexity of arithmetical tasks. Ramirez (2013) articulates that some mathematics anxiety is mathematics-specific which is rather associated with a reduced working memory capacity and with a slow and inaccurate handling of arithmetical problems. Owens (2014) then further propounds that the negative emotion and working memory interaction affects reasoning abilities of learners when attempting mathematical problems hence reduces performance rate. Therefore, the interaction of mathematics anxiety and working memory seriously affects mathematics achievement.

2.7 The Memory Booster Activities to Improve Working Memory Capacity

According to Berlacon (2017), mathematics achievement has been very low across many institutions. One of the ways in which mathematics achievement can be improved is through the application of memory boosting interventions. Against this background, there are many initiatives that schools or teachers can adopt to boost the memory of learners and improve their working memory capacity. Teachers should try to detect mathematics anxiety in early stages to mitigate negative attitudes towards mathematics. They can compare patterns of participation or check the concentration level of the learners on various topics. According to Begley (2007), teachers may adopt a form of therapy that utilises children's literature in which the persons incurred a similar trauma, which attracted deliberations of those instances. The teacher reviews experiences by persons in a similar situation before and use them to teach learners how to neutralize or handle such situations where mathematics anxiety is compromising working memory. Therefore, attempting to detect mathematics anxiety is a necessary intervention from reviewed literature that can serve as a solution towards improving working memory capacity.

Moreover, Gregor (2015) asserts that mathematics achievement can be possible if mathematics anxiety is reduced. There are ways of reducing mathematics anxiety. They may include alternative forms of testing such as journal writing, self-reflections, and group testing of mathematics performance patterns and trends. Begley (2014) suggests that teachers can indulge in excellent teaching practices such as interaction amongst learners, so that opportunities for active participation are provided. This can be achieved by providing timely and appropriate responses, emphasizing time on tasks, and respecting diverse talents and ways of learning when mathematics activities have been given to learners. Teachers must also encourage and create a conducive learning atmosphere which is a platform devoid of both physical intimidation and emotional hurting. This group testing intervention works to reduce mathematics anxiety and increase mathematics achievement but do nothing towards working memory capacity. Be that as it may, the intervention serves as mitigation to growing anxiety such that mathematics achievement is improved when establishing self-reflections and test groups.

Furthermore, learners' working memory can be improved by reducing cognitive load which is the effort associated with a specific topic or extraneous administered by restructuring academic presentation techniques (Gathercole, 2008). The restructuring of academic presentation may consist of explaining mathematics fundamentals in the native language of learners for easy understanding. In this regard, learners are to be encouraged to employ memory aids as strategies to boost their memory. In addition, teachers are to be well-informed on the ways to distinguish task failures due to working memory overload, indulge in learners monitoring to ascertain these failures as well as reduce the representation of learnt information (Gregor, 2015). The reviewed literature posits that working memory can be improved by administering a restructuring of academic presentation methods and implementation of ways to distinguish task failures.

2.8 Theoretical Framework: Relationship between Working Memory, Mathematics Anxiety and Mathematics Achievement

There are several theories that unpack the relationship between working memory, mathematical achievement and mathematical anxiety. Creswell (2014) articulated that theories can be employed to formulate a research question, explain, predict and understand phenomena. Kumar (2014) concurrently supported by stating that a theory can also be used to challenge and extend existing knowledge within limits of critical bounding assumptions. In essence, the study will be underpinned by the deficit theory and the two-component theory. The deficit theory focuses much on the deficiency of cognitive resources hence leaving out the underpinnings of mathematics anxiety. In this regard, the use of two theories covers the gaps in the study as their synthesis unveils the theoretical relationship between mathematics anxiety, working memory and mathematics achievement.

2.8.1 The Deficit Theory

According to Lee, Lee and Bong (2014), the deficit theory provides the reasons why learners score lower in school. The underlying assumption of the theory is that learners fail to score higher due to a lack in certain aspects, like material or resources. Accordingly, the deficit theory denotes that mathematics achievement is facilitated by the deficit of working memory enhancers which prompt mathematical anxiety (Beilock & Willingham, 2014). This therefore denotes an intrinsic correlation between a deficit in working memory and mathematical anxiety which often culminates into the foundation of poor mathematics performance by learners. Devine, Soltesz, Nobes, Goswami and Szûcs (2013) posit that cognitive resources are one of the possible deficits which could cause poor mathematics performance and mathematics anxiety. Against such a background, mathematical anxiety builds on the deficit of resources that are supposed to improve working memory. As a result, mathematics achievement is affected due to a deficit in working memory boosters that may resist anxiety. Therefore, there is a significant relationship between mathematics anxiety, working memory and mathematics achievement as a deficit of working memory may trigger negative mathematics achievement.

In addition, the deficit theory indicates that learners with low mathematical anxiety are more prone to academic success than other learners. The deficit theory also considers the teachers' low expectations on the learners' ability to handle mathematics. This is also culminated from the teacher's seeding thoughts in learners that mathematics is difficult. Simultaneously, Beilock and Willingham (2014) posit the deficit theory is not just the teacher's problem, but rather teachers might inadvertently give more attention, effective instruction, and better grades to learners who are expected to perform well in mathematics. In this case, when teachers' pay less attention to some learners' performance, the same learners' working memory is affected, prompting mathematical anxiety which culminates into low mathematics achievement.

More so, the deficit theory posits that mathematical anxiety can emerge due to a deficit of teachers' motivation to the learners (Devine et al., 2013). This deficit often influences the performance of learners in retaining what was taught and applying theorems to practical mathematical problems. Thus, the deficit theory posits the connection between working memory, mathematical anxiety and mathematical achievement. The deficit in working memory capacity directly affects the level of mathematical achievement which directly translates to mathematical anxiety.

2.8.2 The Two-Component Theory

The two-component theory of anxiety unpacks the linkage between verbal and visual-spatial working memory disruptions. Researchers, Vytal, Cornwell, Arkin and Grillon (2012) assert that the theory depicts the mathematical anxiety as two-faceted, the anxious in apprehension component and the automatic preparatory response. The anxious apprehension component deals with the central executive resources and prompts anxiety attributes such as worries in cognitive processes. The automatic preparatory response denotes the provision of prime defensive responses, automatic and moment-to-moment signalling a learner visualise the math problem. In essence, this shows the relationship between the mathematics anxiety and the working memory attributes where the two anxiety components compromise the working memory which culminates into low mathematics performance. Therefore, mathematics anxiety gains from the disruptions that faces the visual-spatial working memory and the auditory storage which translates to low mathematics achievement.

Furthermore, the anxious apprehension component and automatic preparatory component clashes with distinct neural circuits of the learner's working memory which results in a negative impact on processes that allocate such neural resources (Vytal, Cornwell, Allison & Grillon, 2013). In this reasoning, the two-component theory of anxiety attests that anxiousness set the adaptive responses vulnerable, which is the working memory, to threats such as increased heart rate, fright and potentiation of visual which are symptoms of learners ridden with mathematical anxiety. The consequence also adds to emotionally negative stimuli and negative auditory perception which derail the learners' performance in mathematics tests and examinations. In this regard, moderately difficult grade 5 mathematics multiplication problems may prompt anxiety to learners experiencing partial competition of resources leaving anxiety to control the shared cognitive processing resources. This negatively impacts on the mathematics achievement, showing a strong relationship between mathematics anxiety, working memory and mathematics achievement. In essence, high mathematics anxiety does not translate to a normalized performance.

2.9 Conclusion

This chapter reviewed literature on the relationship between working memory, mathematical anxiety and mathematical achievement. The review was conducted on borrowed views and perceptions from prevailing bodies from across the globe. The thrust was to create an all-inclusive understanding of the major constructs of the study.

The next chapter focused on the research design and methodology the study employed in establishing the relationship between the three constructs.

CHAPTER THREE: METHODOLOGY

3.1 Introduction

The previous chapter reviewed the prevailing bodies of literature on the relationship between mathematics anxiety, working memory and mathematics achievement. This chapter deliberated the research methodology and design used in conducting the study. The chapter discussed the fundamentals of research design and methodology, research paradigm, sampling techniques, data collection, data analysis, the validity and reliability as well as ethical considerations.

3.2 Research Paradigm

This study followed a positivism research paradigm as it allowed the researcher to experiment with correlations between mathematics anxiety, working memory and mathematics achievement. Also, the paradigm uses scientific means and packages which require minimum data alterations which makes the study more about experiments. Shiraz (2015) however attests that the paradigm suffers a setback of outcome unreliability if the scientific data utilized is incorrect and this often leads to the acceptance of wrong hypothesis. Nevertheless, the adoption of the positivism paradigm allowed the independence of all the impacts that arose during the research process (Creswell, 2013). The paradigm was useful for it allowed adherence to explicit instructions that utilized objective scientific and mathematical tools.

3.3 Research approach and design

The study used a quantitative approach which entails the use of correlational survey design that determined the possibility of whether the variables could be correlated.

The correlational survey design allowed the measurement and scoring of three variables: mathematics anxiety, working memory and mathematics achievement. The survey was conducted on the same group of 300 respondents given a pre-test and a post-test with memory booster activities in-between. This assisted in the identification of patterns that emerged between mathematics anxiety, working memory and mathematics achievement. More so, a quantitative research approach permitted the maintenance of objectivity as the researcher remained independent of the data due to the strategies used. The quantitative research approach assisted in the determination of the correlation between mathematics anxiety, working memory and mathematics achievement. The researcher in this regard attempted to understand the variables as separate entities and their association. More so, the quantitative research approach permitted the study to focus on facts and to allow a highly structured study that examines the status quo and therefore preserves impartiality.

3.4 Sampling

A target population of this study consisted of grade 5 mathematics learners totaling 315 in the Johannesburg West district of Gauteng province. The grade 5 mathematics learners were chosen for this study because the researcher is a primary school mathematics teacher and understands the teaching methods implemented at school at that level. The Grade 5 learners at Tshepisong circuit were chosen for this study because they are in the researcher's proximity and convenience. The number of learners per classroom range from 45 to 55 which make the convenience sample of 300. The sample was thus 300 learners and the remaining 15 were utilised in the pilot study.

3.5 Development of data collection instruments

The study used working memory and mathematics achievement tests (refer to Appendix A3), mathematics anxiety questionnaires (refer to Appendix A1) and memory booster activities (refer to Appendix A2) to collect data.

This section presents the purpose of each data collection instrument and discusses how these instruments were developed and used in this study.

3.5.1 Mathematics anxiety questionnaire

The mathematics anxiety questionnaire administered to the respondents was designed by the researcher (refer to Appendix A1). The researcher adopted the mathematics anxiety questionnaire designed by Wood et al., (2012) which was found reliable with a Cronbach alpha value of 0.71 and used on lower grade learners in Brazil. The researcher modified the instrument to suit the South African context and the setting in which it was to be used. The questionnaire requested learners to explain their feelings when attending a mathematical lesson to determine how anxious they could be. The learners were asked in the questionnaire on how often they felt anxious, what they felt when asked a mathematical question in a lesson, how they felt when told of an upcoming test, to mention a few. The instrument had 12 items which were measured using a 5-point Likert scale such as never, rarely, sometimes, often and always.

3.5.2 Working Memory / Mathematics Achievement Test

The mathematics achievement was measured by giving the learners a similar pre-test and the post-test in which the outcomes were compared (refer to Appendix A3). The questions asked were from the same topics although the level of difficulty was different in both tests. The pre-test mathematics achievement test consisted of tasks 1, 2 and 3. Task 1 assessed the learners on the memorization of number sequencing where learners were supposed to arrange the numbers in order. The six different number series were displayed on a screen. The first series had just one number (i.e., 9), the second series had two numbers (i.e., 2, and 7); the third series had three numbers (i.e., 6, 5, and 3); the forth series had four numbers (i.e., 8, 9, 2, and 4); and so on (see Appendix A). Task 2 assessed the learners' ability to recall objects. The objects were screened for 10 seconds and thereafter learners were given four multiple choice options to choose from, learners were requested to circle the letter which represented the order in which the objects appeared on the screen. Six different sequences were projected. For example:

The first sequence was  ,

The second sequence was  ,

The third sequence was , and so on (see Appendix A).

Task 3 of the test assessed multiplication of 3 by 2-digit numbers for example (334 × 23), multiplication of 3 by 3-digits such as (452 × 435) multiplication of fractions (i.e., $\frac{2}{3} \times \frac{4}{5}$), and mental arithmetic such as (11×7; 7×9; 8×8). The achievement test was developed by the researcher and questions were drawn from the Grade 5 learners' mathematics curriculum. From the pre-test, the level of difficulty increased in the post test. For example, in the pre-test, the series of numbers learners were asked to recall were single digits but the post-test requested they recall double digits, the sequencing of objects viewed in the pre-test consisted of 3 objects and was increased to 4 objects in the post test, to mention a few. The post-test was administered four weeks after the pre-test.

3.5.3 Memory booster activities

The memory booster activities were administered after the pre-test to determine their effect on learner's mathematics anxiety (refer to Appendix A2). There were questions in the achievement test that served as a memory booster activity such as number and object sequencing and multiplication tables problems such as (3×7; 5×9; 9×8) which were asked to understand how to boost learner's memory. After the pre-test, learners underwent three different sessions of memory booster activities such as revisions and discussions. The sessions were conducted for 1 hour 15 minutes each and the learners were urged to ask clarity seeking questions to gauge their understanding. The areas with the most complaints such as multiplication of fractions, computing the area of shapes and multiplication of 2 by 3 digits were retaught and ample time was spent on such topics. Furthermore, the illustrations were conducted on the chalkboard to supplement verbal explanations and assist on number sequencing problems used in pre-test and post-test. The mathematical timetable was constantly recited and practiced repeatedly as a way of boosting learners' working memory. During the memory booster activities, similar questions which tested working memory in the pre-test were given to learners as activities. However, the number sequencing was changed where series of one-digit number became two-digit numbers. Also, the screening of objects was changed in quantity where four objects displayed in the pre-test was increased to five objects. In Task B, the structure was changed where the order of problems was switched. The first problem on the paper was switched with number five (5), number two (2) switched with number eight (8), to mention a few. The variance between the results on the pre-test and post-test determined the usefulness of the memory boosters in strengthening working memory in relation to mathematics anxiety.

3.6 Data analysis and interpretation

Data was analysed using descriptive as well as inferential statistics. For descriptive statistics, the mean, standard deviation, and percentages were determined. For the inferential statistics, a paired test was compiled to compare the two sets of data, data from pre-test and post-test. The scores for each learner were not matched from pre-test and post-test but rather the achievement results average pass and the post-test results were compared. The correlation was sought using the correlation coefficient (t-test) to determine the significance of the relationship between mathematics learners' anxiety, their working memory, and their achievement.

3.7 Pilot Study

According to Salkind and Van Zyle (2014), a pilot study is a preliminary study carried out before the actual research. The piloting of a study is done to identify and refine a research question, figure out what methods are best for pursuing the main study, and estimate how much time and resources would be necessary to complete the larger version, amongst other things (Creswell, 2009). The study was piloted with 15 learners drawn from the schools under study to determine their understanding of the research instruments. The respondents who participated in the pilot study did not participate in the actual study. The researcher requested permission from the Principal of the schools where the aim and the benefits of the study were explained. The request was done in person where the researcher visited the schools. The learners that participated in the pilot study did not make the sample of the main study. The learners were asked to air their views although the results are not incorporated in this study but used only to refine the instruments. The research instrument was noted to have strong language that proved to be difficult for grade 5 learners to understand considering that English is a second language to most of the learners. Some of the assertions regarding mathematics anxiety were leading on the responses of the learners. The achievement test was piloted on the same 15 learners in the pilot study. After the pre-test, memory booster activities such as revision and in-depth explanations by the researcher to the learners were conducted, the post-test was then administered after a two-week period. In the pre-test, the highest score was 4 out of 10 with 3 learners obtaining zeros. There was improvement in the post-test results where the highest had 8 out of 10 and the lowest had 4. The following question, “Mathematics is a boring subject?” was revised to “. I feel stressed when I am about to take a multiplication test” after the pilot study where discrepancies noted in the research instrument were rectified before the actual study commenced.

3.8 Reliability and Validity

The study must ensure that the findings are authentic by guaranteeing the collected data’s reliability and validity (Creswell, 2014).

3.8.1 Reliability

According to Salkind and Van Zyl (2014), reliability occurs if the research instrument measures the same setting repeatedly attaining the same results.

- **Mathematics Anxiety Questionnaire**

The reliability of the mathematics anxiety questionnaire was measured using test-retest reliability. The mathematics anxiety questionnaire was distributed to 15 respondents on two different intervals, two weeks apart. A Cronbach's alpha of the research instrument 0.716 (see Appendix C1) was found which was greater than 0.70 which signified high reliability of the instrument.

- **Mathematics Achievement Test**

The mathematics achievement test was tested for internal consistency to determine the degree to which the multiplication problems on the instrument presented the same results. The achievement test had 10 items which was sufficient to ensure internal consistency considering the test was administered on Grade 5 learners. The researcher personally administered the achievement test in the pilot study. There were no complaints from the respondents as to the form of the test, content and instructions in the pre-test and the post-test. This was tested and retested in a pilot study where an achievement test was piloted to 15 respondents to check for consistency in the results. The Pearson correlation was measured using the SPSS statistics Version: V27 where the correlation between two scores from pre-test and post-test was depicted. The correlation coefficient was found to be 0.690 which shows a strong relationship between post-test and pre-test scores (see Appendix C2).

- **Memory Booster Activities**

A pilot study was conducted to determine the reliability of the memory booster activities. In test-retest reliability, the learners were administered memory booster activities such as learning multiplication timetables off by heart, sequencing of numbers and objects, recalling the chronological order events in a story took place, revision of similar questions on the achievement test, emphasis on topics with greater detail and audio recording during revision. The same achievement test used in the pre-test was retested in the post test after a two-week period. The results changed significantly from the pre-test results where the highest learner obtained 4 out of 10 and 3 of the 15 participants obtained 0s to the highest learner scoring 8 out of 10 and the lowest obtaining 5. The pre-test and post-test scores were matched, and the correlation coefficient was computed using the Pearson correlation coefficient. The correlation was found to be .985 which was the cut-off point of 0.95 which indicates a strong relationship (See Appendix C3).

3.8.2 Validity

Validity is the extent to which the research instrument represents the universe of items from which it is drawn (Salkind & Van Zyl, 2014). This posits the concept as the situation where the research instrument ascertains what it was intended to.

- **Mathematics Anxiety Questionnaire**

The mathematics anxiety questionnaire was measured for validity using content validity measurement. This was achieved by giving the instrument to five mathematics education specialists to determine if the research instrument ascertains what it intended. The consulted experts adjusted on the assertions to concentrate on the researched variable and to make sure the grade 5 learners understood the language considering English is a second language to most of them. The following question, “Without help I am not good at mathematics” was changed to “I need extra help in math”. Some examples of the changes in questions are illustrated in section 3.7.

- **Mathematics Achievement test**

Content validity was used to measure the validity of the mathematics achievement test. The researcher asked for review from other grade 5 teachers on the test and determine if it was feasible for grade 5 learners as per the curriculum and if its focus was on multiplication problems. The research experts advised that the language on word problems be simplified for learners to understand better (Kumar, 2014). The use of shapes was included in order to test the learners’ ability to apply formulae that include multiplying. The experts made comments which influenced changes on the research instrument until the test was focused on traits of interest. This validated the achievement test.

- **Memory booster activities**

The memory booster activities were measured using the criterion-related validity executed by using the divergent validity. The content validity was used in relation to its exterior standard on how the activities influence the abilities of learners’ performance in the achievement test. The booster activities implemented altered the performance of learners in a pilot study as the highest score changed from 4 out of 10 to 8 out of 10 and lowest obtained 5 out of 10 which was a positive achievement. The results changed significantly from the pre-test to the post-test and essentially after the conducting of memory booster activities.

3.9 Elimination of Bias

The study ensured the elimination of bias by allowing the questionnaire outcomes to be interpreted by the researcher. This ensured some consistency since the researcher was the one well-versed with the problem at hand. According to Maree (2017), the questions asked in the questionnaire were directly derived from the research questions and objectives. A chain of evidence was maintained to ensure reliability. This included a study protocol to ensure that a reader can follow the derivation of evidence from the questionnaires to the ultimate case study conclusions.

3.10 Limitations of the Study

The study used a single research approach, quantitative research, which also bears its shortcomings. Future researchers may use mixed methods to allow triangulation to provide explanations to the statistics established in this study. The research instrument was also constructed using English which was not the first language of the learners. Nevertheless, the high response rate attained in this study mitigated this limitation.

3.11 Ethical Considerations

The study abided to ethical considerations that govern researcher conduct. The researcher adhered to the following ethical principles:

3.11.1 Ensure Permission is obtained

The researcher ensured that permission was obtained from the Ethical clearance committee (Ref: 2019/11/13/64092097/60/AM) and the Tshepisong Circuit under study (Appendix D). The researcher before conducting the study sent permission request letters to three boards for permission. The Tshepisong Circuit, Gauteng department of education and the university ethical committee responded in writing affirming the proceedings of the research (refer Appendix D).

3.11.2 Ensure Informed Consent

Creswell (2014) argued that in a research study, research participants must be given an informed consent. The researcher ensured informed consent by alerting the respondents in writing before conducting the actual research. The respondents' parents were informed using written letters where the aim and purpose of the research was outlined. The parents expressed their consent by completing and signing the informed consent letters (see Appendix B1).

3.11.3 Ensure No Harm Comes to the Respondents

Kumar (2014) posited that the researcher ensured that no harm comes to the respondents. The research was conducted in the working environment the respondents operate in. This created an enabling atmosphere where participants were protected from physical harm, emotional and psychological harm.

3.11.4 Ensure Confidentiality and Anonymity

The study ensured confidentiality and anonymity principles (Leedy & Ormrod, 2014). Personal information remained confidential. Also, the researcher informed the participants that they may withdraw from the study at any point and the results will only be accessed by the researcher and or institution upon request. The researcher would keep the collected information under lock and key for a period of five years. In the same note, the presentation of data remained anonymous as names and pointers were avoided and replaced with codes.

3.11.5 Voluntary participation

The study ensured voluntary participation for the learners (Creswell, 2014). They were not coerced into participating in this study. The learners were also informed about the procedures, the potential risks and the right to withdraw without incurring any liabilities. The consent to participate was also sought.

3.12 Conclusion

This chapter deliberated on the research design and methods utilised in this study. The same chapter discussed the research design chosen, the fundamentals of the design and quantitative research approach. The thrust was to establish the relationship between mathematical anxiety, mathematical achievement and working memory. The methodology allowed the examination of realities surrounding the core research phenomenon.

The next chapter therefore discusses, interprets and presents the results of the study, owing to the stipulations prescribed by the chosen research methodology.

CHAPTER FOUR: DATA ANALYSIS

4.1 Introduction

Mathematics enables apprentices to learn how to evaluate and draw conclusions based on their knowledge. This study focused on grade 5 learners at a circuit in the Gauteng province. The study aimed to establish the relationships between working memory, mathematics anxiety and mathematics achievement as learners often struggle simply because of deficient capacity to perform multiplication problems in the primary schooling level. The topic of multiplication was chosen as it is complex and requires multiple operations to solve and poses many challenges to grade 5 learners. The analysis of the relationship between these three concepts was envisaged to enable primary school teachers to address the gap in the teaching and learning of multiplication concepts in grade 5 mathematics. The key terms in this study are further explained in the following section.

Mathematics anxiety is experienced by people or learners who develop the feeling of stress when facing mathematics related situations. Since mathematics anxiety can be experienced at any time when the learner feels stressed or anxious; when the teacher asks a question, when learners are doing their homework or during a test, that concept may be perceived as poor mathematics ability in school and in turn can even affect adulthood.

The working memory keeps track of short-term information that requires learners to choose the correct formula, apply the steps in the correct sequence and attempt to produce the correct answer when computing multiplication problems. The question is how can learners improve their working memory? Working memory enables learners to work with information that short-term memory stores. This concept is used all the time in the learning process for solving mathematics problems such as multiplication, fractions, and shapes in their minds (often referred to as mental mathematics). Mental mathematics helps to strengthen or improve working memory.

Mathematics achievement is the proficiency (know-how) shown by learners in the subject of mathematics. The mathematics achievement is a score on the achievement test in mathematics.

Given the continuity challenging effects of mathematics anxiety, it was important to understand how mathematics anxiety affected mathematics achievement. A sample size comprising of 300 grade 5 learners was randomly selected from a larger sample from schools in the Johannesburg West District of South Africa. The researcher developed a three-aspect research tool, task 1, task 2, and task 3 that was administered to the learners on two different occasions. Firstly, the grade 5 learners were given a working memory and achievement test on the basis of pre-test and post-test where three tasks were considered. Three tasks were designed as enclosed in the appendix A containing:

- Task 1: Required the learners to memorize the largest amount of numbers in the correct sequence.
- Task 2: Required the learners to recall the correct order of 3 displayed objects among a series of given options.
- Task 3: Required the learners to compute different types of multiplication calculations.

Those tasks represented the score on the learner's achievement to assess the working memory and the mathematics achievement where determination was made whether working memory plays an important role in the anxiety of the learner. Secondly, the researcher used a questionnaire to investigate the mathematics anxiety for pre-test and post-test. Each learner participated in answering all the tests and questionnaires enclosed in the appendix A.

The analysis of this work is divided into two parts:

Part I: entails the analysis of the single assessment based on

(1) Section 1: Working memory and mathematics achievement on the basis of the pre-test and post-test.
(2) Section 2: The mathematics anxiety on the basis of the pre-test and post-test.

The frequency (frequency percentages) and the descriptive statistics (the mean and the standard deviation) were used to analyze the results.

Part II: The testing of the hypotheses in order to establish the relationship between the working memory and mathematics achievement test on the basis of the mathematics anxiety. The inferential statistics (paired t-test, Pearson's correlation coefficient (*r*), correlation coefficient (*t-stat*) were used to analyze the data.

4.2. Single Evaluation on Working Memory and Mathematics Achievement

The working memory tasks were given to the respondents before memory boosters and similar tasks were administered after incorporating the memory booster activities. The achievement test was given to ascertain the scores of the learners with working memory before administering of memory boosters and their performance after administration of memory boosters. The pre-test and post-test were used to understand grade 5 learners' mastery of mathematics specifically in the topic of multiplication. The assessment utilized the learning activities to engage the learners and to determine their knowledge, application, and skills in solving various multiplication problems. In this evaluation, learners took a pre-test to determine their baseline knowledge in multiplication. The pre-test was given to the learners at the beginning of the learning process to determine their initial understanding when given specific instructions that will lead a learner to complete a multiplication task. Learners who could demonstrate mastery in the pre-test were those who had a certain understanding in solving multiplication problems. The post-test provided comprehensive data of the learners as it was conducted just after completion of the teaching of the multiplication topic and evaluated what knowledge or skills had been acquired. Through the post-test, both the teacher and learners reflected on the learner's mastery of the task and the results were used for diagnostic purposes and informed the teacher whether further learning activities needed to be undertaken by the learners. The assessment was based on a three-task test (Task 1 and Task 2 focused on working memory and Task 3 on mathematics achievement) on working memory and mathematics achievement.

4.2.1. Section 1: Working Memory and Mathematics Achievement Test; pre-test and post-test analysis

The section presents frequency tables which reflect learners 'achievement, in terms of the scores, that represented the working memory based on Task 1 in the working memory and mathematics achievement test.

4.2.1.1. Task 1: Keeping memory of the largest amount of numbers in the correct sequence on the basis of the pre-test

The grade 5 learners were instructed to recall 1-6 single digit numbers in the correct sequence in a given timeframe. The achievement of learners was assessed by measuring the ability to recall a correct sequence after an instruction was given. The random numbers were put in brackets from 1 number to 6 numbers and the learners were asked to recall their arrangement. For instance, numbers were displayed as (6, 5, 3) and learners were asked to recall the displayed numbers in their order. The results on keeping memory of 1-6 single digit numbers are displayed in Tables 4.1.

Table 4.1: Pre-test: Keeping memory of the largest amount of numbers in the correct sequence: **1-6 single digit number displayed**

Number(s) displayed	**Sequence**	**Frequency**	**Frequency percentage**
1-Number displayed {9}	Correct	300	100
2-Numbers displayed {2,7}	Correct	300	100
3-Numbers displayed {6,5,3}	Incorrect	32	10.7
	Correct	268	89.3
	Total	**300**	**100**
4-Numbers displayed {8,9,2,4}	Incorrect	68	22.7
	Correct	232	77.3

	Total	**300**	**100**
5-Numbers displayed {7,1,6,2,5}	Incorrect	148	49.3
	Correct	152	50.7
	Total	**300**	**100**
6-Numbers displayed {3,8,4,9,0,6}	Incorrect	250	83.3
	Correct	50	16.7
	Total	**300**	**100**

1. *Pre-test: Memory of the largest amount of numbers in the correct sequence from a display of one 1-digit number {9}.*

Table 4.1 indicates that 100% of the respondents were able to keep the sequence of the number displayed in mind while identifying the number screened. This implies that the learners have high working memory and high mathematics achievement in terms of working on visualization skills.

2. *Pre-test: Memory of the largest amount of numbers in the correct sequence from a display of two 1-digit numbers presented {2,7}.*

The results in Table 4.1 show that 100% of the respondents answered correctly on identifying the order the numbers screened. That was an affirmative achievement that learners had retained small pieces of information in the short-term memory stores to work with in solving mathematics problems.

3. *Pre-test: Memory of the largest amount of numbers in the correct sequence from a display of three 1-digit numbers {6, 5, 3}.*

The results in Table 4.1 indicate a high score of performance in the working memory of learners' as 89.3% answered correctly and only 10.7% answered incorrectly. This implied a high working memory on the recalling of a three 1-digit number sequence.

4. *Pre-test: Memory of the largest amount of numbers in the correct sequence from a series of four 1-digit numbers {8, 9, 2, 4}.*

The results in Table 4.1 show that 77.3% of the learners correctly answered the sequence of four 1-digit number, while 22.7% answered it incorrectly. The results suggest a decline in learners' working memory compared to the previous questions.

5. *Pre-test: Memory of the largest amount of numbers in the correct sequence from a display of five 1-digit numbers {7, 1, 6, 2, 5}.*

The results in Table 4.1 show that a little over a half of all respondents (50.7%) surveyed answered correctly whilst 49.3% were unable to remember the series of numbers comprising of the dataset. The results suggest that working memory becomes low when the complexity of mathematics problems increases.

6. *Pre-test: Memory of the largest amount of numbers in the correct sequence from a display of six 1-digit numbers {3, 8, 4, 9, 0, 6}.*

Table 4.1 shows that out of 300 learners 83.3% failed to memorize the numbers in the correct sequence, but 50 learners (16.7%) were able to recall the six numbers in the correct sequence. This implies that more complex mathematics problems translate to significantly low working memory, as shown by how learners failed to recall the six numbers in the correct sequence.

In summary, the results of Task 1 based on the pre-test indicated that learners were able to hold numbers from a small data set in their minds simply because the system in the brain had allowed them to process the information. This is supported by the views by Prebler and Hasselhorn (2013) who argued that the short-term memory denotes the ability to recall digits, letters, words and non-words in mathematical problem solving without interfering information and competing. Considered the increase of numbers displayed, learners had demonstrated a progressive decrease of some level of working memory.

The learners were provided with memory boosters such as playing cards, working on visualization skills by creating mental images of multiplication problems, finding ways to connect new information with what the learner already knows and using multisensory teaching. The mathematical timetable was constantly recited and practiced repeatedly as another way of boosting learners' working memory. The memory booster activities were provided after the pre-test, prior to the post-test. Section 4.2.1.2 presents the results and discussion on the memory of the largest amount of numbers in the correct sequence based on the post-test.

4.2.1.2 Task 1: Memory of the largest amount of numbers in the correct sequence on the basis of post-test

The post-test was designed by the researcher to measure grade 5 learners' working memory capacity. Results are presented in Table 4.2 below. The post-test commenced with a single 2-digit number unlike the pre-test. The level of difficulty was increased given that memory boosters were administered prior to the post-test.

Table 4.2: Post-test: Keeping memory of the largest amount of numbers in the correct sequence: **1-6 two-digit numbers displayed**

Number(s) displayed	Sequence	Frequency	Frequency percentage
1-Number displayed {13}	Correct	300	100
2-Numbers displayed {25,46}	Correct	300	100
3-Numbers displayed {68,81,11}	Correct	300	100
4-Numbers displayed {36,50,03,99}	Incorrect	30	10.0
	Correct	270	90.0
	Total	**300**	**100**
5-Numbers displayed {45,27,73,52,18}	Incorrect	60	20.0
	Correct	240	80.0
	Total	**300**	**100**
6-Numbers displayed {28,65,40,69,31,07}	Incorrect	76	25.3
	Correct	224	74.7
	Total	**300**	**100**

1. *Post-test: Memory of the largest amount of numbers in the correct sequence from a display of a single 2-digit number {13}.*

The results in Table 4.2 show that 100% of the learners gave the correct answer. The results were to be expected as all learners had correctly recalled a one number sequence in the pre-test.

2. *Post-test memory of the largest amount of numbers in the correct sequence from a display of two 2-digit numbers {25,46}.*

The results in Table 4.2 reveal that 100% of the participants responded correctly by listing the sequence of two numbers from a displayed series. The results affirmed that learners were able to keep small data sets in their minds whilst engaging in other tasks.

3. *Post-test: Memory of the largest amount of numbers in the correct sequence from a display of three 2-digit numbers {68, 81,11}.*

The results in Table 4.2 indicate that 100% of the learners obtained the correct answer. This suggests an improvement as compared to the pre-test. It was evident that the working memory boosters administered had improved the learners' working memory, allowing them to retain larger amounts of information.

4. *Post-test: Memory of the largest amount of numbers in the correct sequence from a display of four 2-digit numbers.*

The results in Table 4.2 show that the majority of the participant (90%) answered accurately whilst 10% of the respondents answered inaccurately. The results suggest that although there was a vast improvement from the pre-test, some learners were still challenged in keeping memory of the largest amount of numbers in the correct sequence from a display of four 2-digit numbers.

5. *Post-test: Memory of the largest amount of numbers in the correct sequence from a display of five 2-digit numbers {45, 27, 73, 52, 18}.*

The results in Table 4.2 show that out of 300 learners, 240 (80%) answered correctly in the test and 60 of the respondents (20%) answered incorrectly. The results show that even after administration of memory boosters, some learners still demonstrated a low working memory capacity and failed to recall all five numbers in the correct sequence.

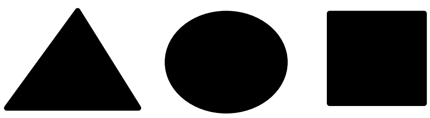
6. *Post-test: Memory of the largest amount of numbers in the correct sequence from a display of six 2-digit numbers {28, 65, 40, 69, 31, 07}.*

The results in Table 4.2 show that most of the participants (74.7%) answered correctly and 25.3% answered incorrectly in that particular task. This implies that the growing complexity of mathematics problems translates to working memory growing weaker, although there was a great improvement in the results of the post-test as compared to the pre-test.

In summary, an improvement was observed where working memory gave learners the confidence to attempt more problems and thus leave fewer questions unanswered. The trend of correctly answering increased in the post-test, especially on larger amounts of number sequences, as compared to the pre-test, which implies that memory boosters significantly influence learners' working memory. These results confirm the importance of booster activities and showed that most grade 5 learners had a poor to average working memory in the pre-test which allowed them to recall small pieces of information but struggled to retain large pieces of information necessary in recalling lengthier sequences of numbers. According to Lowry (2013), on working memory of the learners, the phonological loop's provision of articulation speed and accuracy is vital towards mathematics achievement and the improvement in these segments requires application of boosters or strategies. The implication was that the average performance of learners in that task improved significantly after the memory boosters were administered, therefore concurring with the notion that working memory and mathematics achievement can be improved through the application of memory boosting interventions.

4.2.2. Section 2: Working Memory and Mathematics Achievement Test; Ordering of Sequences pre-test and post-test analysis

This section aimed to investigate whether learners were able to memorize the correct order of objects displayed in a given timeframe. In task 2 of the working memory and mathematics achievement test, three or four 2-D shapes were displayed on the screen and learners had to remember the order in which those objects appeared. Learners were expected to pick the correct sequence from four multiple choice options by choosing the correct letter.

For example: 

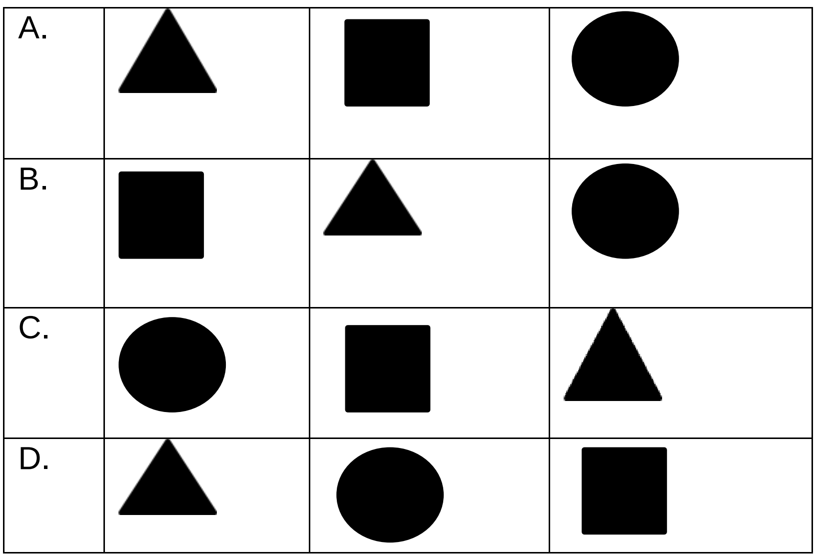


Table 4.3 below presents the frequency percentages on the basis of pre-test.

4.2.2.1. Task 2: Pre-test: Keeping memory of the order of a sequence of objects

Table 4.3: Frequency percentages on keeping memory *of the sequence of three 2-D shapes* in task 2 of the pre-test

Three 2-D shapes	**Sequence**	**Frequency**	**Frequency percentage**
	Incorrect	24	8.0
	Correct	276	92.0
	Total	**300**	**100.0**
	Incorrect	24	8.0
	Correct	276	92.0
	Total	**300**	**100.0**
	Incorrect	28	9.3
	Correct	272	90.7
	Total	**300**	**100.0**
	Incorrect	36	12.0
	Correct	264	88.0

	**Total**	**300**	**100.0**
	Incorrect	70	23.3
	Correct	230	76.7
	Total	**300**	**100.0**

1. *Pre-test: Memory of sequence 1 from the displayed series of 3 objects*

The results in Table 4.3 indicate that out of 300 participants, 276 (92%) responded correctly and only 12 learners (8%) responded incorrectly. The results suggest a high visualization working memory capacity in grade 5 learners as many of them mastered the task on their first trial.

2. *Pre-test: Memory of sequence 2 from the displayed series of 3 objects*

Table 4.3 shows that the majority of the learners (92%) responded correctly whilst 8% inaccurately reported the order of the sequence. As with the previous question, most of the learners showed a high working memory as they were able to apply the necessary visualization skills required and in turn give the correct answer.

3. *Pre-test: Memory of sequence 3 from the displayed series of 3 objects*

Table 4.3 shows that a large number of learners (90.7%) answered correctly whereas 9.3% incorrectly recalled the order the third sequence. The results resonate with Van der Ven *et al.,* (2013) who noted that visualization strategies were used as a tool to inform teachers in lesson planning and presentation as it entailed that learners were more likely to retain and recall pieces of information given as pictures or objects as opposed to numbers or digits.

4. *Pre-test: Memory of sequence 4 from the displayed series of 3 objects*

Table 4.3 shows that out of 300 learners, 88% were correct in their responses as requested but 12% of them could not recall the order. This shows that the growing complexity of the test had a bearing on the learners' working memory.

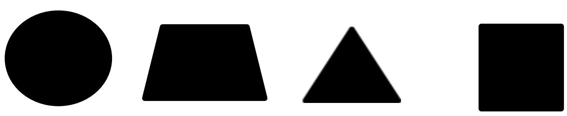
5. *Pre-test: Memory of sequence 5 from the displayed series of 3 objects*

The results in Table 4.3 indicate that 76.7% of the learners gave the correct answers while 23.3% incorrectly recalled the order of the sequence of objects. The results show a decrease in performance which can be attributed to increasing difficulty of the test or factors such as diminishing concentration spans in learners. Generally, it can be seen from the results presented in Table 4.3 how learners showed exceptional achievement and high working memory in visualization skills. The same perspective was established by Toll and Van Luit (2014) who attested to younger children relying more on the visual-spatial representation which prompts the utilisation of many visual-spatial strategies, which culminates to high mathematics achievement and working memory. That has affirmed the belief that younger learners or learners in primary school learn best through multi-sensory teaching.

In summarizing learners' performance in task 2 in memorizing the order of the sequence of 3 objects on the basis of the pre-test, most of the participants (over 75%) gave the impression of skillful learners in that particular task as they were able to master the task without any interventions. The results lead the researcher to believe that learners had above average working memory in terms of visualization skills. The results of this study are supported by the study of Van der Ven *et al.,* (2013) who established that there is a significant relationship between visual spatial working memory and mathematics achievement; thus, affirming the significance of visualisation skills. This corresponds to the results in the study by Zheng, Swanson and Marcoulides (2011) who indicated that the visual-spatial sketchpad significantly culminated into greater accuracy in mathematical problem solving and improvement of the learners' working memory.

Task 2: Post-test: Keeping memory of the order of a sequence of objects

The post-test was administered after the learners were exposed to a few sessions of memory booster activities. The post-test served as a necessary diagnostic tool to measure whether the memory booster activities administered had any effect on the learners' working memory. The post-test was similar to the pre-test; the difference being that learners were now expected to choose from a series of four 2-D shapes instead of three. The increase from 3 objects in the pre-test to 4 objects in the post-test was based on the fact that learners engaged in memory booster activities prior to the test, were familiar with the activity as they had encountered it in the pre-test and had scored relatively high in the pre-test.

Example: 

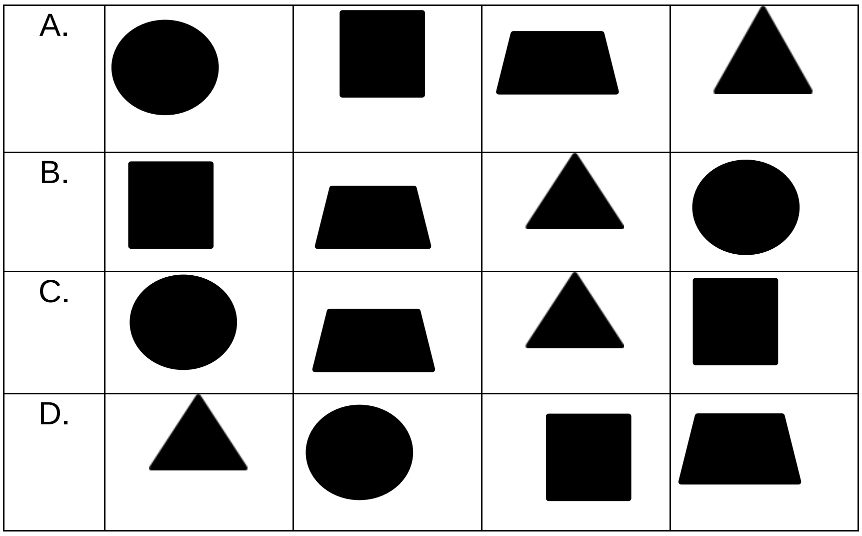


Table 4.4 below presents the frequency percentages on the basis of post-test.

Table 4.4: Frequency percentages on keeping memory *of the sequence of four 2-D shapes* in task 2 of the post-test

Four 2-D shapes	Sequence	Frequency	Frequency Percentage
	Incorrect	4	1.3
	Correct	296	98.7
	Total	**300**	**100.0**
	Incorrect	8	2.7
	Correct	292	97.3
	Total	**300**	**100.0**

Sequence 3 	Incorrect	2	0.7
	Correct	298	99.3
	Total	**300**	**100.0**
Sequence 4 	Incorrect	0	0.00
	Correct	300	100.0
	Total	**300**	**100.0**
Sequence 5 	Incorrect	2	0.7
	Correct	298	99.3
	Total	**300**	**100.0**

1. *Post-test: Memory of sequence 1 from the displayed series of 4 objects.*

The results in Table 4.4 show that 98.7% of the learners answered correctly to sequence 1 of 4 objects while 1.3% failed to give the correct response. The results suggest that the memory boosters were significant towards improving learners working memory as a 6.7% improvement from the pre-test was evident.

2. *Post-test: Memory of sequence 2 from the displayed series of 4 objects*

Table 4.4 shows that 97.3% of all respondents gave the correct outcome to sequence 2 of 4 objects displayed and only 2,7% answered incorrectly. The results are an indication of high working memory.

3. *Post-test: Memory of sequence 3 from the displayed series of 4 objects*

Out of 300 learners, 298 (99.3%) gave the correct answer to the order of sequence 3 from the 4 objects displayed, whilst only 2 learners (0.7%) answered incorrectly in that particular question. The results, depicted above in Table 4.4, suggested a clear indication of the improvement in working memory after memory boosters had been administered, as more learners were able to retain and recall larger pieces of information after engaging in memory booster activities.

4. *Post-test: Memory of sequence 4 from the displayed series of 4 objects*

The results in Table 4.4 show that all (100%) of the learners accurately indicated the order of sequence 4 from the 4 objects displayed. The results reflected how learners had an above average working memory in terms of visualization skills since they were able to store, recall and correctly identify a series of 4 objects in the correct order.

5. *Post-test: Memory of sequence 5 from a series of 4 objects displayed.*

Table 4.4 shows that 99.3% of the learners answered correctly to sequence 5 from a series of 4 objects displayed, whilst only 0.7% responded incorrectly. The results implied that there was an improvement in learners' working memory after memory booster administration. That was the assurance that those grade 5 learners surveyed had good visualization skills since they were able to store and recall pictures in their minds.

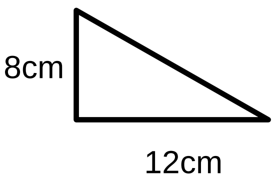
A summary of the post-test task 2, the learners performed particularly well in that task; the performance in the pre-test was good and even more exceptional in the post-test. An improvement of about 11% was noted in the average of the pre and post-test; that affirmed the notion that memory boosters can increase working memory and in turn increase mathematics achievement. The same perspective was upheld by Berlacon (2017) who affirmed that working memory system accounts for learners' variability in mathematics performance, abilities and experiences which transforms from raw mathematics performance to positive mathematics outcomes after learning or being taught.

SECTION 3: Working Memory and Achievement Test: Multiplication calculations pre-test and post-test analysis

In this section, the focus is on the results in task 3 of the working memory and mathematics achievement test, the researcher wanted to investigate learner achievement in solving multiplication problems using a pre-test and post-test. Task 3 consisted of separate instructional tasks regarding the learning of multiplication in grade 5. The present section was concerned with the effect of the pre-test and post-test feedback. The teacher gave the instruction before each task was carried out. The use of cellphones and calculators were prohibited. The frequency percentages for analysis are employed in Table 4.5 below.

4.2.3.1. Calculations on the basis of the pre-test

Table 4.5: Frequency percentages on multiplication problems in task 3 of the pre-test

Pre-test on multiplication calculations	**Sequence**	**Frequency**	**Frequency percentage**
Multiplication: 2-digits by 2-digits 11× 75	Incorrect	90	30.0
	Correct	210	70.0
	Total	**300**	**100.0**
Multiplication: 3-digits by 2-digits 334 × 23	Incorrect	246	82.0
	Correct	54	18.0
	Total	**300**	**100.0**
Multiplication: fraction by a whole number $\frac{1}{4} \times 12$	Incorrect	160	53.3
	Correct	140	46.7
	Total	**300**	**100.0**
Multiplication: fraction by fraction $\frac{2}{3} \times \frac{4}{5}$	Incorrect	158	46.0
	Correct	162	54.0
	Total	**300**	**100.0**
Calculation: Area of triangle 	Incorrect	274	91.3
	Correct	26	8.7
	Total	**300**	**100.0**

Calculation: Area of rectangle  3cm 5cm	Incorrect	26	8.7
	Correct	274	91.3
	Total	**300**	**100.0**

1. *Pre-test: Task 3- Multiplication of a 2-digit number by another 2-digit number.*

Learners were instructed to solve the following multiplication problem: 11× 75

by breaking down

10 × 70 =700

10 × 5 = 50

1 × 70 = 70

1 × 5 = 5

825

or using columns

Th	H	T	U
		^{1}1	1
	×	7	5
		5	5
	7	7	0
	8	**2**	**5**

Table 4.5 shows that 70% of the learners responded correctly, whilst 30% presented incorrect answers. The results show that multiplying a 2-digit number by another 2-

digit number was not much of a challenge for grade 5 learners as many of them furnished the correct response. This finding was not surprising as the topic had been covered intensely in previous grades.

2. *Pre-test: Multiplication of a 3-digit number by a 2-digit number.*

Participants were requested to solve the following problem: 334 × 23

by breaking down

300 × 20 = $^{1}6\ ^{1}000$

300 × 3 = 900

30 × 20 = 600

30 × 3 = 90

4 × 20 = 80

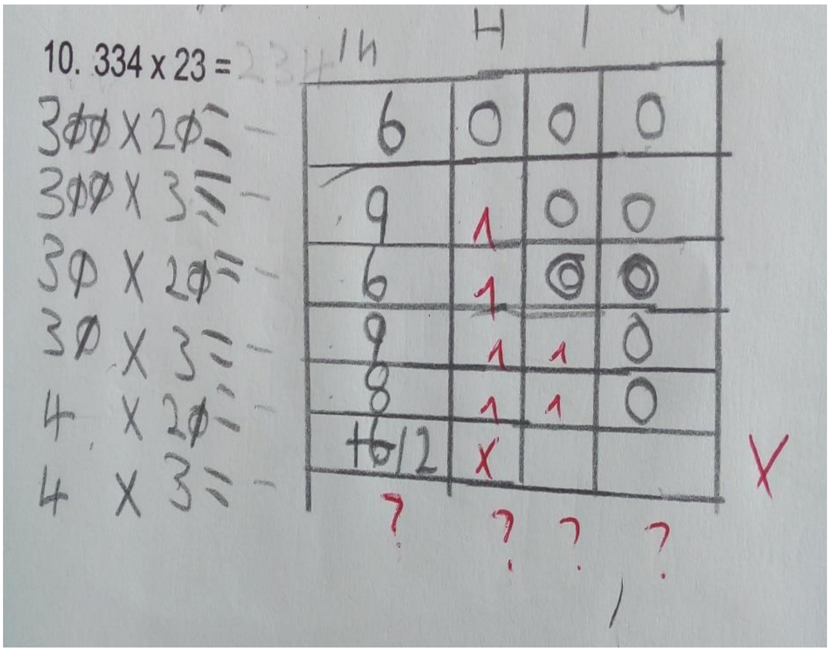
4 × 3 = 12

7 682

or using columns

Th	H	T	U
	$^{1}3$	$^{1}3$	4
×		2	3
1	0	0	2
6	6	8	0
7	**6**	**8**	**2**

The results in Table 4.5 show that 82% of the learners incorrectly answered to the multiplication of a 3-digit number by a 2-digit number while 18% of the learners gave correct solutions. The results suggest that most of the learners struggle or are unable to multiply 2 digit by 3-digit numbers. The working of the learners is illustrated in the attachment below:



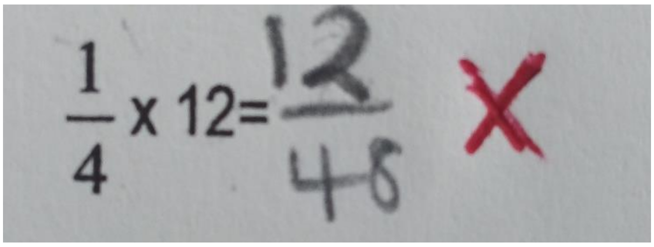
This implied that learners needed to be taught how to compute 2 by 3-digit multiplications, or extensive and/or focussed teaching was needed in this topic, or intervention strategies were required.

3. *Pre-test: Multiplication of a fraction by a whole number.*

The following multiplication problem was given to the learners: $\frac{1}{4} \times 12$

$$\frac{1}{4} \times \frac{12}{1} = \frac{1X12}{4X1} = \frac{12}{4} = 3$$

Out of 300 learners, 53.3% failed to answer the multiplication of a fraction by a whole number correctly whereas 46.7% answered correctly, as shown in Table 4.5 above. The results suggest that more than half of the grade 5 learners surveyed did not know or understand how to multiply a fraction by a whole number. The attempts by the learners are shown below:



This indicated that learners needed the support of the teacher as this problem proved to be too complex and required several mathematics skills, such as converting a whole number to a fraction before multiplying.

4. *Pre-test: Multiplication of a fraction by another fraction.*

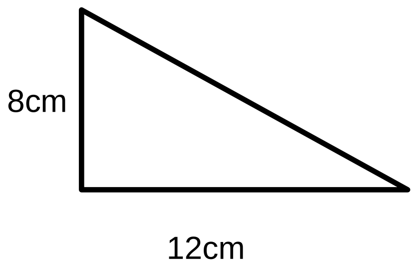
Learners were instructed to solve the following problem: $\frac{2}{3} \times \frac{4}{5}$

$\frac{2}{3} \times \frac{4}{5} = \frac{2 \text{ X } 4}{3 \text{ X } 5} = \frac{8}{15}$

Table 4.5 shows that 54% of the learners correctly answered to the multiplication of a fraction by another fraction but 46% answered incorrectly. This implied that the multiplication of a fraction by another fraction was challenging to learners hence the need for an intervention in the form of support.

5. *Pre-test Calculations: Geometry of triangle.*

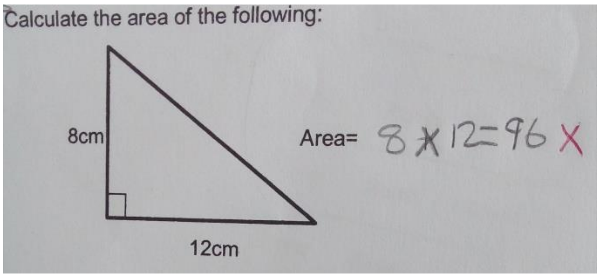
The participants were requested to calculate the area of the following triangle:



Area = $\frac{1}{2}$base × height

Area = $\frac{1}{2} \times 12 \times 8 = \frac{1 \text{ X } 12 \text{ X } 8}{2} = \frac{96}{2} = 48\text{cm}^2$

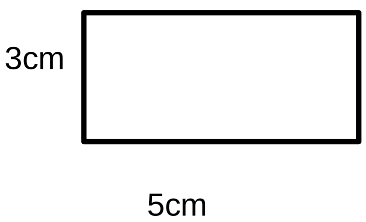
The results in Table 4.5 show that 91.3% of the learners experienced difficulties whilst calculating the area of a triangle as only 8.7% managed to complete the task successfully. The results suggest that most learners did not have the ability or tools required to perform geometry calculations on a triangle. As shown below, the learners failed to work out the area of a triangle.



That might be because learners were exposed to new words or terminology, were unfamiliar with or could not correctly recall or apply the relevant formulae. The results imply that learners needed the teacher to assist or teach them how to memorize formulae in dealing with calculating the area of this particular shape.

6. *Pre-test Calculations: Geometry of a rectangle.*

Learners were requested to calculate the area of the following rectangle*:*



Area= Length × Breadth

Area= 5×3 =15cm²

The results in Table 4.5 show that 91.3% of the learners correctly answered the question on calculating the area of the rectangle, while only 8.7% answered the question incorrectly. Since the question only involved a one-step calculation of two 1-digit numbers, learners did a direct recall of knowledge stored in their short-term memory by using their timetables to solve the problem. This implied that the learners were better in calculating areas of rectangles.

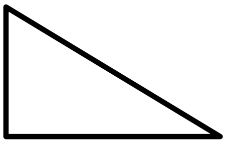
In summary, learners were confident in dealing with simple arithmetic multiplication that required a simple recall from their short-term memory as with multiplying single digits and 2-digit numbers by 2-digit numbers, but experienced difficulties when dealing with more complex calculations such as multiplying fractions, 3 by 2-digit multiplications and multiplication of more than two numbers at a time (as with calculating the area of a triangle). The inability of the learners to use the information and tools stored in their short-term memory to break down and complete more complex tasks was an indication of the learners' low working memory capacity.

4.2.3.2. Calculations on the basis of the post-test

To measure the mathematics achievement of the grade 5 learners, the researcher had chosen various activities on multiplication topics covered during the learning process and presented them in the form of a test. The post test administered was similar to the pre-test. The frequency percentages were used to analyze the data as indicated in Table 4.6 below.

Table 4.6: Frequency percentages on multiplication problems in task 3 of the post-test

Post-test on multiplication calculations	Sequence	Frequency	Frequency percentage
Multiplication: 2-digits by 2-digits 19× 85	Incorrect	0	0.0
	Correct	300	100.0
	Total	**300**	**100.0**
Multiplication: 3-digits by 2-digits 324 × 13	Incorrect	142	47.3
	Correct	158	52.7
	Total	**300**	**100.0**
Multiplication: fraction by a whole number $\frac{1}{4} \times 16$	Incorrect	80	26.7
	Correct	220	73.3
	Total	**300**	**100.0**
Multiplication: fraction by fraction $\frac{3}{5} \times \frac{5}{6}$	Incorrect	58	19.3
	Correct	242	80.7
	Total	**300**	**100.0**
Calculation: Area of triangle	Incorrect	182	60.7
	Correct	118	39.3

8cm  9cm	**Total**	**300**	**100.0**
Calculation: Area of rectangle  3cm 7cm	Incorrect	0	0.0
	Correct	300	100.0
	Total	**300**	**100.0**

1. *Post-test: Multiplication of two 2-digit numbers.*

Learners were instructed to solve the following multiplication problem: 19 × 85

19 × 85 = (10 + 9) × (80 + 5)

10 × 80 = 800

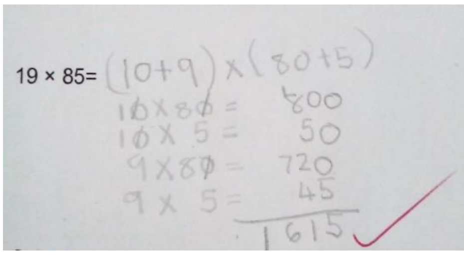
10 × 5 = 50

9 × 80 = 720

9 × 5 = 45

1 615

Table 4.6 shows that all the learners (100%) were able to produce the correct answer when multiplying two 2-digit numbers. That represented a 30% improvement in achievement from the pre-test. The improvement in mathematics achievement is shown by the correct working out or attempting of 2-digit multiplication as shown below:



The results show that the intervention or support of memory booster activities was essential in improving the achievement in calculating two 2-digit number multiplications. From the results above, it was clear that the application of memory booster activities had had a positive outcome in learner performance.

2. *Post-test: Multiplication of a 3-digit number by a 2-digit number.*

Learners were requested to solve the following: 324 ×13

324 × 13 = (300 + 20 + 4) × (10 + 3)

300 × 10 = 3 000

300 × 3 = 900

20 × 10 = 200

20 × 3 = 60

4 × 10 = 40

4 × 3 = 12

4 212

The results in Table 4.6 revealed that 52.7% of the learners correctly multiplied a 3-digit number by a 2-digit number whereas 47.3% could not. The results show that although memory boosters were administered, many learners still struggled with 3 by 2-digit number multiplications as the process involved multiple complex steps. Nonetheless, that was a large improvement in the learners' achievement as only 18% of the total respondents had correctly answered the question in the pre-test, before learners' working memory was strengthen by the administration of memory booster activities.

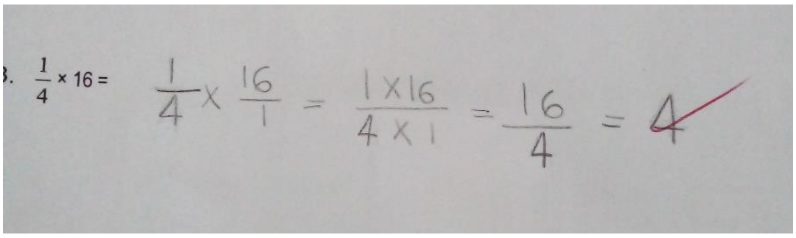
3. *Post-test: Multiplication of a fraction by a whole number.*

The following multiplication problem was given to learners: $\frac{1}{4} \times 16$

$\frac{1}{4} \times 16$

$\frac{1}{4} \times \frac{16}{1} = \frac{16}{4} = 4$

Table 4.6 indicates that 73.3% of the learners answered correctly to the problem on multiplication of a fraction by a whole number, whilst 26.7% gave the incorrect answer. The results show that the memory booster intervention was essential, given the 20% improvement in multiplication of fractions. The multiplication of fractions was attempted correctly as shown below:



The increase in mathematics achievement scores further proved how the improvement of working memory equipped learners with the skills required to keep track of short-term information (formulae, procedures, or steps), to recall it, and to use it to solve mathematics problems.

4. Post-test: Multiplication of a fraction by a fraction.

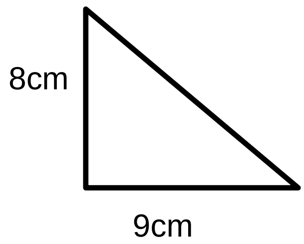
Learners were asked to solve the following problem: $\frac{3}{5} \times \frac{5}{6}$

$\frac{3}{5} \times \frac{5}{6} = \frac{3 \times 5}{5 \times 6} = \frac{15}{30} = \frac{1}{2}$

Table 4.6 above demonstrates that 80.7% of the learners were able to multiply a fraction by another fraction, whilst 19.3% could not. The results suggest that the majority of learners understood the calculation. The achievement improved by 26% as a direct result of memory booster activities, these results agreed with the literature that suggested that high working memory improves mathematics achievement.

5. *Post-test: Geometry of a triangle.*

Learners were requested to calculate the area of the following triangle:

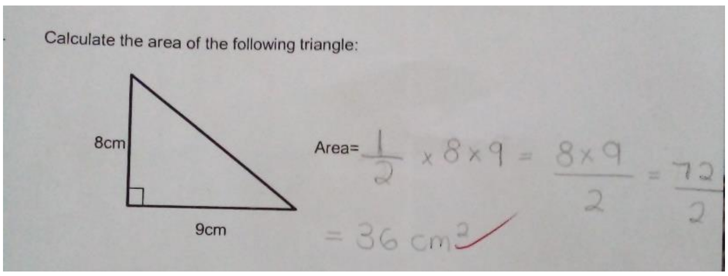


Area = $\frac{1}{2} \times 9 \times 8$

Area = $\frac{1 \times 9 \times 8}{2} = \frac{72}{2}$

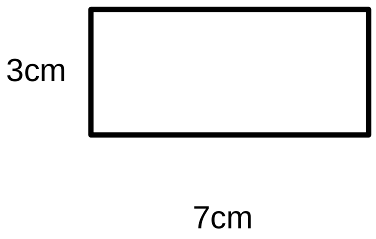
Area = 36 cm^2

The results in Table 4.6 indicate that 60.7% of the learners incorrectly answered the problem on calculating the area of a triangle, whilst only 39.3% calculated it correctly. The results suggest that most of the learners still struggled to calculate the area of a triangle, however there was still a notable improvement between the pre-test and post-test. The 30.6% improvement in correct responses can be accredited to the administration of working memory boosters. The correct working of the area of a triangle is shown below:



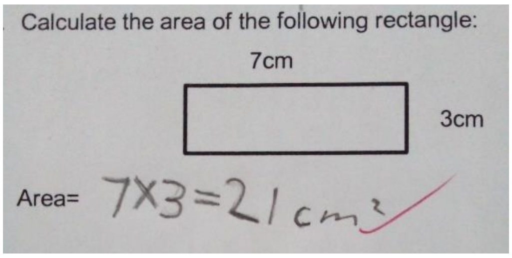
6. Post-test: Geometry of a rectangle.

Learners were asked to calculate the area of the following rectangle:



Area = 7cm × 3cm = 21 cm^2

The results in Table 4.6 show that all (100%) of the learners correctly calculated the area of a rectangle. The results suggest that all the learners understood how to calculate the area of a rectangle. That depicted an 8.7% improvement in the learners' average mathematics achievement in calculating the area of a rectangle. The calculation of a rectangle was done correctly as shown below:



In summary, the post-test of task 3 confirmed that learners were able to maintain a bit of information in the mind and use it to solve a variety of multiplication problems. That indicated that the learners' working memory was thereby improved by the memory boosters as the outcome of the achievement tests increased in the positive note. However, there were significant percentages of learners who got it wrong even after booster activities which may imply the complexity of multiplication in mathematics.

Against that background, it was noted that when working memory was low, for instance in calculating area of triangles and fractions, mathematics achievement became low, and when working memory was improved through application of various memory boosters, high mathematics achievements were obtained. In this reasoning, Berlacon (2017) propounded that when the learners reveal impairment and lower recall in all complex working memory tasks involving verbal or numerical information when compared to peers, application of booster activities may alleviate anxiousness and both short-term and long-term intrusions.

4.3 Mathematics Anxiety

In this section, the researcher examined the experience of mathematics anxiety in grade 5 learners in a circuit in the Gauteng province. It was important to understand how mathematics anxiety affected mathematics achievement since mathematics anxiety had been associated with the reduction of working memory capacity (Berlacon, 2017). Owens et al., (2014) reported that high levels of anxiety have negatively affected mathematics reasoning in individuals with relatively small spatial spans. Mathematics anxiety was examined through a questionnaire completed by each learner who participated in the research project. The assessment was based on 12 questions upon which the learners were asked to choose one answer per statement based on the five proposed options such as never, rarely, sometimes, often, and always. Table 4.7 and 4.8 depicts frequencies, frequency percentages and the descriptive statistics (mean and standard deviation).

4.3.1. The frequency of learners' experience of mathematics anxiety in the pre-test

The frequency of mathematics anxiety was assessed in the pre-test as a basis for determining how it relates to working memory and mathematics achievement. In the pre-test, booster activities were not administered yet, hence sufficed to ascertain the frequency by which learners were experiencing mathematics anxiety.

Table 4.7: Frequency percentages and mean of learners' experience of mathematics anxiety in the pre-test

Statements in Mathematics anxiety questionnaire- Pre-Test	Frequencies and frequency percentages (%)					Mean	Standard deviation	Remark
	Never	Rarely	Some-times	Often	Always			
1. When I do multiplication, I feel nervous	2 (0.7%)	-	18 (6.0%)	52 (17.3%)	228 (76.0%)	4.68	.648	Always anxious
2. I worry that other learners might understand multiplication problems better than me	8 (2.7%)	8 (2.7%)	42 (14.0%)	76 (25.3%)	166 (55.3%)	4.28	.984	Often anxious
3. I feel stressed when I am about to take a multiplication test	2 (0.7%)	6 (2.0%)	28 (9.3%)	68 (22.7%)	196 (65.3%)	4.50	.801	Always anxious
4. I get "butterflies" in my stomach when multiplication is mentioned	42 (14.0%)	18 (6.0%)	76 (25.3%)	80 (26.7%)	84 (28.0%)	3.49	1.335	Sometimes anxious
5. Being called on to answer a multiplication question scares me	10 (3.3%)	8 (2.7%)	48 (16.0%)	80 (26.7%)	154 (51.3%)	4.20	1.023	Often anxious
6. I feel frustrated when working on multiplication problems	10 (3.3%)	8 (2.7%)	60 (20.0%)	78 (26.0%)	144 (48.0%)	4.13	1.038	Often anxious
7. I have trouble sleeping the night before a multiplication test	-	-	18 (6.0%)	112 (37.3%)	170 (56.7%)	4.51	.610	Always anxious
8. I avoid my multiplication homework	26 (8.7%)	70 (23.3%)	120 (40.0%)	64 (21.3%)	20 (6.7%)	3.37	1.543	Sometimes anxious
9. I need extra help in solving multiplication problems	-	14 (4.7%)	98 (32.7%)	104 (34.7%)	84 (28.0%)	3.57	1.212	Often anxious
10. When I need help in multiplication, I ask for it	2 (0.7%)	58 (19.3%)	134 (44.7%)	70 (23.3%)	36 (12.0%)	3.30	1.208	Sometimes anxious
11. After getting a multiplication test back, I don't want others to see my marks	6 (2.0%)	44 (14.7%)	164 (54.7%)	44 (14.7%)	42 (14.0%)	3.90	1.022	Often anxious

12. I have said "I hate multiplication" this year	4 (1.3%)	44 (14.7%)	182 (60.7%)	50 (16.7%)	20 (6.7%)	3.91	.922	Often anxious

1. *Statement: When I do multiplication, I feel nervous*

As shown in Table 4.7, learners always feel nervous when they do multiplication (mean = 4.68; standard deviation = 0.648). That is, 76% of the learners agreed that when they do multiplication, they always feel nervous, 17.3% said they often feel nervous, 6% of the learners said only sometimes and 7% of the respondents never feel nervous. That result clearly showed that many grade 5 learners who participated in the study had feelings of tension and worry towards the topic of multiplication. These intrusive thoughts negatively affected learners working memory prompting low mathematics achievement in the pre-test.

2. *The statement: I worry that other learners might understand multiplication problems better than me*

According to Table 4.7, learners always worried that other learners might understand multiplication problems better than them (mean = 4.28; standard deviation = 0.948). That is, 55.3% of the learners were worried that other learners might understand multiplication problems better than them, 25.3% said without a doubt that this happens often, 14% of the participants experienced those feelings sometimes and 2.7% either never or rarely worry that other learners understood multiplication activities better than them. This implies that anxiety makes learners afraid of others becoming better than them in terms of working memory and mathematics achievement.

3. *The statement: I feel stressed when I am about to take a multiplication test*

The results in Table 4.7 show that learners always feel stressed when they were about to take a multiplication test (mean = 4.50; standard deviation = 0.801). That is, 65.3% of the learners said that they always feel stressed when they were about to take a multiplication test, 22.7% feel stressed often, 9.3% sometimes feel stressed and 7% of the respondents were not fazed by taking a multiplication test. That result clearly showed that many grade 5 learners who participated in the study were stressed in situations that involved solving multiplication problems, which may thereby compromise working memory and negatively affect mathematics achievement.

4. *The statement: I get "butterflies" in my stomach when multiplication is mentioned*

As indicated in Table 4.7, learners always get "butterflies" in their stomach when multiplication was mentioned (mean = 3.49; standard deviation = 1.33). That is, 28% of the learners always experienced "butterflies" in their stomach when multiplication was mentioned, 26.7% often had "butterflies", 25.3% developed "butterflies" sometimes, 14% never and 6% of the respondents rarely had "butterflies" in the stomach when multiplication was mentioned. The results suggest that learners may have intrusive thoughts about multiplication which interrupt the working memory and might inhibit them from completing multiplication tasks effectively. This translated to low test scores in the mathematics achievement pre-test.

5. *The statement: Being called on to answer a multiplication question scares me*

The results in Table 4.7 reveal that learners always felt scared when they were called on to answer a multiplication question (mean = 4.20; standard deviation = 1.023). That is, out of the 300 respondents, 51.3% felt that "Being called on to answer a multiplication question scares me” always, 26.7% responded often, 16% sometimes, 3.3% never experienced such anxiety, whilst 2.7% of the participants rarely became scared. This suggests that most of the learners are scared to be called upon to answer a multiplication question which may reflect low working memory and poor mathematics achievement.

6. *The statement: I feel frustrated when working on multiplication problems*

Table 4.7 reveals that learners always felt frustrated when working on multiplication problems (mean = 4.13; standard deviation = 1.038). That is, 48% of the learners always became frustrated when working on multiplication problems, 26% often experience frustration when working on multiplication activities, 20% experience frustrations sometimes, 2.7% rarely sense frustrations and 3.3% had never been frustrated whilst working on multiplication problems. The results suggest that the majority of the learners are frustrated when calculating multiplication and such discomfort compromises the working memory and mathematics achievement.

7. *The statement: I have trouble sleeping the night before a multiplication test*

The results in Table 4.7 reveal that learners always had trouble sleeping the night before a multiplication test (mean = 4.51; standard deviation = 0.610). That is, out of the 300 learners surveyed, 56.7% always had trouble when sleeping the night before a multiplication test, 37.3% often and 6% sometimes feel anxiety the night before a multiplication test. The results suggest that learners worry about multiplication even before engaging in the tasks, those preconceptions lead to additional stress and worry whilst actually undertaking the task.

8. *The statement: I avoid my multiplication homework*

As shown in Table 4.7, learners sometimes avoid multiplication homework (mean = 3.37; standard deviation = 1.543). That is, 40% of the learners sometimes avoid multiplication homework, 23.3% said that happens rarely, 21.3% of the learners often stay away from multiplication homework, 8.7% never keep away and 6.7% of the respondents always avert multiplication homework. The results suggest that some learners are intimidated by multiplication problems and might avoid or not attempt to solve them, which attests to the low performance in both working memory and mathematics achievement in the pre-tests.

9. *The statement: I need extra help in solving multiplication problems*

Table 4.7 shows that learners often needed extra help in solving multiplication problems (mean = 3.57; standard deviation = 1.212). That is, 34.7% of the learners often needed extra help in solving multiplication problems, 32.7% believed they sometimes needed extra help in solving multiplication problems, 28% always wanted help and 4.7% rarely called for help in answering multiplication problems. The results implies that learners need help in solving multiplication problems which resonates with the improvement in working memory and mathematics achievement shown from pre-test to post-test.

10. *The statement: When I need help in multiplication, I ask for it*

Table 4.7 shows that learners sometimes ask for help in multiplication when they need it (mean = 3.30; standard deviation = 1.208). That is, 44.7% of the learners believed sometimes when they needed help in multiplication, they solicit it, 23.3% were often certain that when they needed help in multiplication, they demanded it, 19.3% rarely asked for it and 12% of the learners always requested help when they needed it. The results suggest that in most cases the majority of learners require help in multiplication problems which might be due to low working memory which translates to low mathematics achievement as shown in the pre-test results. That showed the struggles that learners encounter as a result of anxiety and how that often translated to learners lacking the confidence to complete multiplication activities independently.

11. *The statement: After getting a multiplication test back, I do not want others to see my marks*

The results in Table 4.7 show that learners sometimes did not want others to see the results obtained from multiplication tests (mean = 3.90, and standard deviation = 1.022). That is, 54.7% of the learners sometimes did not want others to see the results obtained from multiplication tests, 14.7% of learners often or rarely had the same feelings and 14% of the participants never wanted others to see their marks. The results suggest that some learners were afraid to show others their results due to low mathematics achievement in multiplication.

12. *The statement: I have said "I hate multiplication" this year*

Table 4.7 shows that learners sometimes believed that they hated multiplication (mean = 3.91; standard deviation = 0 .922). That is, 60.7% of the learners sometimes believed that they detested multiplication, 16.7% of the participants often disliked multiplication, and 14.7% of the learners rarely despised multiplication this year and 6.7% of the grade 5 learners totally hated multiplication and had expressed that on many occasions. The results suggest that many learners hate multiplication which may be due to low working memory and low mathematics achievement. This resonates with the low mathematics achievement noted in the pre-test on multiplication problems.

In summary, the grade 5 learners surveyed frequently experienced mathematics anxiety, that was evident as they had reported feelings of stress, worry and fear when dealing with multiplication problems, those feelings at times prompted them to avoid multiplication problems, be ashamed to ask for help or feared showing others their test results. Mathematics anxiety hindered learners' achievement as it often gave the perception that learners were failures. In concurrence, Kargar, Tarmizi and Bayat (2010) posited that the increasing anxiety culminates to depression, tenseness, sad and low self-esteem towards mathematics which culminates into low mathematical performance. Therefore, many of the learners surveyed expressed fear, as evidenced in statements that they were afraid to be called on to solve multiplication problems, they got "butterflies" in their stomach when multiplication was mentioned, they could not solve multiplication problems on their own and felt, more often than not, that they needed the help of others.

4.3.2 The frequency of learners' experience of mathematics anxiety in the post-test

The frequency of mathematics anxiety was assessed in the post-test to determine how it related to working memory and mathematics achievement after the application of memory booster activities. The results in Table 4.8 were elicited from the post-test on the mathematics anxiety questionnaire.

Table 4.8: Frequency percentages and means of learners' experience of mathematics anxiety in the post-test

Statements in Mathematics anxiety questionnaire- Post Test	Frequencies and frequency percentages (%)					Mean	Standard deviation	Remark
	Never	Rarely	Some-times	Often	Always			

1. When I do multiplication, I feel nervous	14 (4.7%)	30 (10.0%)	76 (25.3%)	90 (30.0%)	90 (30.0%)	3.71	1.138	Often anxious
2. I worry that other learners might understand multiplication problems better than me	10 (3.3%)	32 (10.7%)	100 (33.3%)	78 (26.0%)	80 (26.7%)	3.62	1.091	Sometimes anxious
3. I feel stressed when I am about to take a multiplication test	6 (2.0%)	28 (9.3%)	140 (46.7%)	72 (24.0%)	54 (18.0%)	3.47	.960	Sometimes anxious
4. I get "butterflies" in my stomach when multiplication is mentioned	4 (1.3%)	60 (20.0%)	128 (42.7%)	98 (32.7%)	10 (3.3%)	3.17	.831	Sometimes anxious
5. Being called on to answer a multiplication question scares me	8 (2.7%)	48 (16.0%)	118 (39.3%)	94 (31.3%)	32 (10.7%)	3.31	.956	Sometimes anxious
6. I feel frustrated when working on multiplication problems	24 (8.0%)	60 (20.0%)	100 (33.3%)	92 (30.7%)	24 (8.0%)	3.11	1.069	Sometimes anxious
7. I have trouble sleeping the night before a multiplication test	2 (0.7%)	22 (7.3%)	122 (40.7%)	108 (36.0%)	46 (15.3%)	3.58	.861	Sometimes anxious
8. I avoid my multiplication homework	26 (8.7%)	70 (23.3%)	120 (40.0%)	64 (21.3%)	20 (6.7%)	2.94	1.031	Sometimes anxious
9. I need extra help in solving multiplication problems	-	14 (4.7%)	98 (32.7%)	104 (34.7%)	84 (28.0%)	3.86	.883	Often anxious
10. When I need help in multiplication, I ask for it	2 (0.7%)	58 (19.3%)	134 (44.7%)	70 (23.3%)	36 (12.0%)	3.27	.932	Sometimes anxious
11. After getting a multiplication test back, I don't want others to see my marks	6 (2.0%)	44 (14.7%)	164 (54.7%)	44 (14.7%)	42 (14.0%)	3.24	.939	Sometimes anxious
12. I have said "I hate multiplication" this year	4 (1.3%)	44 (14.7%)	182 (60.7%)	50 (16.7%)	20 (6.7%)	3.13	.788	Sometimes anxious

1. *When I do multiplication, I feel nervous*

Table 4.8 shows a significant decrease from the learners who always feel nervous when doing multiplication (mean = 3.71; standard deviation = 1.138). That is, 30% of the learners always feel nervous, 30% said they often feel nervous, 25.3% of the learners said only sometimes and 4.7% of the respondents never feel nervous. There was a 46% decrease in learners who always feel nervous when doing mathematics. The results suggests that the booster activities were essential in reducing mathematics anxiety.

1. *The statement: I worry that other learners might understand multiplication problems better than me*

According to Table 4.8, learners always worried that other learners might understand multiplication problems better than them (mean = 3.62; standard deviation = 1.091). That is, 25.7% of learners were worried that other learners might understand multiplication problems better than them, 26% said with no doubt that this happens often, 33.3% of the participants experienced those feelings sometimes and 10.7% either never or rarely worry that other learners understood multiplication activities better than them. The number of learners who affirmed always worrying in the pre-test decreased by 29% which implies that the interventions were necessary towards reducing anxiety, given that most of the learners sometimes worried shows that the boosting of working memory may alleviate the mathematics anxiety of learners.

2. *The statement: I feel stressed when I am about to take a multiplication test*

As indicated in Table 4.8 show a significant reduction from the 65.3% of learners who always felt stressed when they were about to take a multiplication test (mean = 3.47; standard deviation = 0.960). That is, 18% of the learners said that they always feel stressed when they were about to take a multiplication test, 24% feel stressed often, 46.7% sometimes feel stressed and 9.3% of the respondents were not fazed by taking a multiplication test. The results show a significant difference from the pre-tests where the rate of learners who always feel stressed decreased by 47.3%. The results suggest the increment of working memory moves the learners from always feeling stressed to sometimes feeling stressed. This echoes Gregor (2015)'s assertion that mathematics achievement can be possible if mathematics anxiety is reduced. This therefore indicates that memory boosters can reduce mathematics anxiety and in turn improve mathematics achievement.

3. *The statement: I get "butterflies" in my stomach when multiplication is mentioned*

As presented in Table 4.8, learners sometimes get "butterflies" in their stomach when multiplication was mentioned (mean = 3.17; standard deviation = 0.831). That is, 42.7% of the learners sometimes experienced "butterflies" in their stomach when multiplication was mentioned, 32.7% often had "butterflies", 20% never develop "butterflies", 3.3% always had "butterflies" in the stomach when multiplication was mentioned. There was a significant change from the pre-test results where learners always had butterflies when doing mathematics to most of them sometimes having butterflies. In the study by Gathercole (2008) it was established that learners' working memory can be improved by reducing cognitive load which is the effort associated with a specific topic. The results thereby suggest that before memory boosters learners were experiencing butterflies in their stomachs and after the boosters, there was evidence of working memory improvement which also reduced mathematics anxiety.

4. *The statement: Being called on to answer a multiplication question scares me*

The results in Table 4.8 reveal that learners sometimes felt scared when they were called on to answer a multiplication question (mean = 3.31; standard deviation = 0.956). The results show a 40% reduction from the learners who felt that "Being called on to answer a multiplication question scares me" always, 5% increase on those who responded often, 39.3 % sometimes, 2.7% never experienced such anxiety, whilst 16% of the participants rarely became scared. The results suggest that learners were less scared when called to answer a multiplication question in the post-test, which implies a significance of memory boosters towards reduction of mathematics anxiety. In the study by Berlacon (2017), the significance of working memory boosters were established as they led learners to get rid of fear of mathematics problems.

5. *The statement: I feel frustrated when working on multiplication problems*

Table 4.8 reveals that learners sometimes felt frustrated when working on multiplication problems (mean = 3.11; standard deviation = 1.069). That is, 30.7% often feel frustrated, 20% rarely experience frustration when working on multiplication activities, 8% never experience frustrations and 8% have always been frustrated whilst working on multiplication problems. The results show a significant improvement of learners from the pre-test which suggests that the booster activities reduced the frustrations experienced by learners when working on multiplication problems. Gregor (2015) also noted that the reduction of anxiety through memory boosters mitigate frustrations and other signs of anxiety.

6. *The statement: I have trouble sleeping the night before a multiplication test*

The results in Table 4.8 reveal that learners sometimes had trouble sleeping the night before a multiplication test (mean = 3.58; standard deviation = .861). This shows an improvement from the pre-test, where 56.7% of learners always had trouble sleeping the night before a multiplication test, had decreased to 15.3%. Most of the learners are sometimes anxious (40.7%), 36% often and 15.3% always feel anxiety the night before a multiplication test. The results suggest that learners were sometimes anxious the night before multiplication tests. Lee, Lee and Bong (2014) also found out that anxiety prompts fear which compromises the working memory. This also implied that the memory boosters alleviated anxiety through improving the working memory of learners.

7. The statement: I avoid my multiplication homework

The results in Table 4.8 reveal that learners sometimes avoid multiplication homework (mean = 2.94; standard deviation = 1.031). That is, 40% of the learners sometimes avoid multiplication homework, 23.3% said that happens rarely, 21.3% of the learners often stay away from multiplication homework, 8,7% never keep away and 6.7% of the respondents always avert multiplication homework. The results suggested that regardless of implementing the memory boosters, learners still sometimes avoided multiplication problems. This was also noted in the study by Beilock and Willingham (2014), the deficit in mathematics preparation can still cause anxiousness which makes the learners avoid mathematics problem.

8. The statement: I need extra help in solving multiplication problems

Table 4.8 shows that learners often needed extra help in solving multiplication problems (mean = 3.86; standard deviation =.883). That is, 34.7% of the learners often needed extra help in solving multiplication problems, 32.7% are sometimes in need of help when attempting multiplication problems and 28% always wanted help. The results in the post-test resonate with the pre-test. This suggested that to solve multiplication problems, learners often felt they still required interventions, support, or help from teachers even after the application of memory booster activities.

9. The statement: When I need help in multiplication, I ask for it

Table 4.8 shows that learners sometimes ask for help in multiplication when they need it (mean = 3.27; standard deviation = .932). That is, 44.7% of the learners believed that when they needed help in multiplication, they sometimes requested it, and 23.3% often asked for it. There was no difference from the results in the pre-test. The results thereby suggest that in most cases the majority of learners required help in solving multiplication problems regardless of memory booster application. Vytal, Cornwell, Allison and Grillon (2013) also established that learners require assistance when dealing with mathematics problems if they are to achieve higher mathematics achievement.

10. *The statement: After getting a multiplication test back, I don't want others to see my marks*

The results in Table 4.8 show that learners sometimes didn't want others to see the results obtained from multiplication tests (mean = 3.24, and standard deviation = .939). The learners sometimes felt anxious about what other learners would think of them regarding their mathematics achievement. The fear and anxiety might be due to poor mathematics achievement (Devine et al., 2013). This suggested that learners might still be anxious even after the multiplication test.

11. *The statement: I have said "I hate multiplication" this year*

Table 4.8 shows that learners sometimes believed that they hated multiplication (mean = 3.13; standard deviation = .788). The post-test and pre-test results were similar in attesting that 60.7 % of the learners have uttered, "I hate multiplication" this year. The hating of multiplication may be due to low working memory which culminated to high mathematics anxiety. This suggest that mathematics anxiety may lead to learners hating mathematics and this may occur regardless of having implemented the memory booster activities.

In summary, most of the grade 5 learners surveyed sometimes experienced mathematics anxiety that was evident on the reduction of learners who always reflected signs of anxiety such as stress, worry and fear when dealing with multiplication problems. Kargar, Tarmizi and Bayat (2010) posited that the increasing anxiety culminates to depression, tenseness, sad and low self-esteem towards mathematics which culminates into low mathematical performance. In this regard, the memory boosters alleviated the mathematics anxiety that often gave the perception that learners were failures. The same perspective was shared by (Berlacon,2017) who argued that memory boosters work to reduce mathematics anxiety and increase mathematics achievement but do nothing towards working memory capacity. Therefore, many of the learners surveyed sometimes expressed fear after the provision of memory booster activities as reflected in the decrease of learners who always asked for help, were afraid to be called on to solve multiplication problems, and felt, more often than not, that they needed the help of others.

4.4 PART II: Evaluation of the Relationship between Working Memory and Mathematics Achievement on the basis of Mathematics anxiety.

This section summarizes the approaches, methods and procedures followed by the researcher to determine the relationships between mathematics anxiety, working memory and mathematics achievement. The quantitative design allowed us to collect the required information from 300 grade 5 learners who were randomly selected to participate in the objectives of the study. The researcher holds the information regarding mathematics activities and more specifically the feelings of learners towards the topic of multiplication in the subject of mathematics. The understanding of that problem was based on the data collected on the basis of a pre-test and post-test. In this work, the researcher was a partaker and an observer in the collection of data. That said, this study aimed to empirically ascertain the relationship between mathematics anxiety, working memory and mathematics achievement in grade 5 learners. The statistical paired sample t-test approach was used in the analysis.

The assessment aimed to determine whether there were relationships between the variables of interests as the study was centered on the test of hypotheses. The hypothesis testing was a process of making inferences from a sample of whether or not a statement about the population appeared to be true. In other words, hypothesis testing empowered the researcher on how they could make decisions. For hypothesis testing, the null hypothesis denoted H_0 and the alternative hypothesis denoted H_1 were formulated. The null hypothesis (H_0) is usually stated on what the study is intending to accept whereas the alternative hypothesis (H_1) is the negation of the null hypothesis. That said, H_1 was what the study wanted to prove. A statistical test called test statistic and p-value were calculated for accepting or rejecting the null hypothesis. For instance, when p-value was smaller than 0.05 level of significance, we rejected the null hypothesis at the level of significance. The level of significance enabled the researcher to decide on whether the test was statistically significant or not.

4.4.1. Paired Samples T-Test: Working Memory and Mathematics Achievement

The paired sample t-test was used to test the means of the two measurements using the activities such as Task 1, Task 2, Task 3, and the score of the anxiety of the mathematics achievement test taken from the same population (learners). The measurement had to be considered in different times, such as on the basis of pre-test and post-test. The aim of this section was to determine if there was statistical evidence in the mean difference between the working memory and mathematics achievement. In this study, the following hypotheses were used for the analysis.

H_0: There is no relationship between mathematics anxiety, working memory and mathematics achievement when solving multiplication problems in Grade 5

H_1: There is a relationship between mathematics anxiety, working memory and mathematics achievement when solving multiplication problems in Grade 5

In using the paired samples T-test, the following outputs were provided through SPSS software version 28. The results from the paired samples statistics gave the univariate descriptive statistics (Table 4.9) for each Task:

- The mean represents the average difference between the two statements
- The standard deviation of the difference scores
- The statistic t-test
- The p-value and

The correlation coefficient t-test for the two-tailed test (Tables 4.9, 4.10, 4.11) for each task examined.

1.4.1.1. ***The Paired Sample T-test: Task 1***

Table 4.9: The Paired Sample T-test: Task 1

		Paired Differences			
		Mean	Std. Deviation	t	P-value
Pair 3	Task 1: Pre-test-Keeping memory of the largest amount of numbers in the correct sequence with 3-Numbers - Task 1: Post-test-Keeping memory of the largest amount of numbers in the correct sequence with 3-Numbers	-.107	.310	-4.218	.000

Pair 4	Task 1: Pre-test-Keeping memory of the largest amount of numbers in the correct sequence with 4-Numbers - Task 1: Post-test-Keeping memory of the largest amount of numbers in the correct sequence with 4-Numbers	-.127	.353	-4.392	.000
Pair 5	Task 1: Pre-test-Keeping memory of the largest amount of numbers in the correct sequence with 5-Numbers - Task 1: Post-test-Keeping memory of the largest amount of numbers in the correct sequence with 5-Numbers	-.293	.608	-5.908	.000
Pair 6	Task 1: Pre-test-Keeping memory of the largest amount of numbers in the correct sequence with 6-Numbers - Task 1: Post-test-Keeping memory of the largest amount of numbers in the correct sequence with 6-Numbers	-.580	.571	-12.446	.000

The results from the testing of the hypotheses Task 1 when analyzing two statements denoted by Pair 3 to 6, indicate that there was statistical evidence (p-value = 0.001 less than 0.05) that the pairs population means were different. That indicated that there was statistically significance difference between an assessment to memorize a series of numbers on the basis of pre-test and post-test. The results suggest that the memory boosters' interventions were essential in improving working memory and alleviating mathematics anxiety. Although some learners did very well in the pre-test, the memory boosters improved the learners' working memory and performance which makes it suffice to state that boosters alleviate the mathematics anxiety.

It was important to consider how strongly the two statements were related with one another. Understanding the relationship between the two variables was helpful and informative simply because the value of one variable was used to predict the value of the other: mathematics anxiety as an independent variable and mathematics achievement as a dependent variable. The coefficient of correlation (r) was used to measure the direction and the strength of the linear relationship between the two variables.

This section determined whether there was a difference between pre-test and post-test variables for the same subject such as task1, task 2 or task 3. This work demonstrated whether there was a difference between the pre-test and post-test for task 1. Using the paired samples t-test for task 1, the following three Tables 4.9 (a to c) were obtained or calculated:

1) Table 4.9a: provides the mean, the sample size, the standard deviation, the standard error for the pre-test and post-test. For instance, in Table 4.9a, in pair #3 the first raw for testing the pre-test and post-test being the variables displayed with a mean = 1.00, the sample size n = 300, the standard deviation = 0.000 and standard error of the mean = 0.000.
2) Table 4.9b: provides the paired sample correlation. If the standard error of the mean difference from Table 4.9a (column 5) is zero, then the calculation of the correlation between the two variables examined cannot be generated, therefore these variables were eliminated in the calculations. That is, contribution is almost zero. Table 4.9a has been reduced from six paired test to four paired test. Table 4.9b presents the sample size, correlation value and the p-value. To determine whether the difference between the population mean was statistically significant, a significance level of p-value to 0.05 was used in this work. When p-value < 0.05, we say that the difference between the means is statistically significant, and the decision was to reject the null hypothesis H_0.

   For instance, in Table 4.9b, the p-value = 0.000 for pair #3 which was less than 0.05. We can conclude that there was significance difference between task 1: pre-test memorize the largest number with 3-digits & task 1: post-test memorize the largest number with 3-digits. This result correlates with previous results.

3) Table 4.9c: provides the paired sample test for the paired differences. This Table comprised the mean, standard deviation, the standard error of the mean, the 95% confidence interval of the difference, the t-test, the degrees of freedom and the p-value. The confidence interval for the population mean difference indicates at 95% of what one can expect to access for practical significance level. For instance, in Table 4.9c, for pair 3: the population mean = -1.07 that is, we can be at 95% confident that the population mean difference is between -1.57 and – 0.057. On the other hand, the p-value indicates whether the difference is statistically significant. In Table 4.9c for pair #3, t-value = -4.218 and the p-value = 0.000. The result indicates that the null hypothesis H_0: the population mean for task 1: pre-test memorize the largest number with 3-digits and task 1: post-test memorize the largest number with 3-digits was equal to 0. Since the p-value = 0.000wasless than 0.05 the significance level therefore the decision was to reject the null hypothesis ho. We can conclude that there a difference in the two variables examined.

Table 4.9a: Paired Samples Statistics for Task 1

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Task 1: Pre-test-memorize the largest number with 1-Number	1.00[a]	300	.000	.000
	Task 1: Post-test-memorize the largest number with 1-Number	1.00[a]	300	.000	.000
Pair 2	Task 1: Pre-test-memorize the largest number with 2-Numbers	1.00[a]	300	.000	.000
	Task 1: Post-test-memorize the largest number with 2-Numbers	1.00[a]	300	.000	.000
Pair 3	Task 1: Pre-test-memorize the largest number with 3-Numbers	.89	300	.310	.025
	Task 1: Post-test-memorize the largest number with 3-Numbers	1.00	300	.000	.000

Pair 4	Task 1: Pre-test-memorize the largest number with 4-Numbers	.77	300	.420	.034
	Task 1: Post-test-memorize the largest number with 4-Numbers	.90	300	.301	.025
Pair 5	Task 1: Pre-test-memorize the largest number with 5-Numbers	.51	300	.502	.041
	Task 1: Pre-test-memorize the largest number with 5-Numbers	.80	300	.401	.033
Pair 6	Task 1: Pre-test-memorize the largest number with 6-Numbers	.17	300	.374	.031
	Task 1: Post-test-memorize the largest number with 6-Numbers	.75	300	.436	.036
a. The correlation and t cannot be computed because the standard error of the difference is 0.					

Table 4.9b: Paired Samples Correlations for Task 1

		N	Correlation	Sig.
Pair 3	Task 1: Pre-test-memorize the largest number with 3-Numbers & Task 1: Post-test-memorize the largest number with 3-Numbers	300	.461.	.000.
Pair 4	Task 1: Pre-test-memorize the largest number with 4-Numbers & Task 1: Post-test-memorize the largest number with 4-Numbers	300	.563	.000
Pair 5	Task 1: Pre-test-memorize the largest number with 5-Numbers & Task 1: Pre-test-memorize the largest number with 5-Numbers	300	.107	.194
Pair 6	Task 1: Pre-test-memorize the largest number with 6-Numbers & Task 1: Post-test-memorize the largest number with 6-Numbers	300	.014	.868

Table 4.9c: Paired Samples Test for Task 1

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference: Lower	Upper			
Pair 3	Task 1: Pre-test-Memorize the largest number with 3-Numbers - Task 1: Post-test-memorize the largest number with 3-Numbers	-.107	.310	.025	-.157	-.057	-4.218	299	.000

Pair 4	Task 1: Pre-test-Memorize the largest number with 4-Numbers - Task 1: Post-test-Memorize the largest number with 4-Numbers	-.127	.353	.029	-.184	-.070	-4.392	299	.000
Pair 5	Task 1: Pre-test-Memorize the largest number with 5-Numbers - Task 1: Post-test-memories the largest number with 5-Numbers	-.293	.608	.050	-.391	-.195	-5.908	299	.000
Pair 6	Task 1: Pre-test-Memorize the largest number with 6-Numbers - Task 1: Post-test-Memorize the largest number with 6-Numbers	-.580	.571	.047	-.672	-.488	-12.446	299	.000

The results show that for Test 1 pair 3 had a coefficient correlation r = 0.467, that indicated a weak correlation but because p-value = 0.001 less than 0.05 level of significance, it was concluded that the relationship was statistically significant. That is, In Task 1 pair 3: Keeping memory of the largest amount of numbers in the correct sequence of 3 digits on the basis of the pre-test was weak compared to Keeping memory of the largest amount of numbers in the correct sequence of 4 digits on the basis of post-test. That was because the pre-test was given prior to administering memory boosters and the information collected was mostly for diagnostic purposes. The coefficient correlation for pair 4wasr = 0.563: moderate relationship but statistically significant.

4.4.1.2 The Paired Sample T-test: Task 2

Table 4.10a: Paired Samples Statistics for Task 2

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Task 2: Pre-test-Keeping memory of the order sequence 1	.92	300	.272	.022
	Task 2: Post-test-Keeping memory of the order sequence 1	.99	300	.115	.009
Pair 2	Task 2: Pre-test-Keeping memory of the order sequence 2	.92	300	.272	.022
	Task 2: Post-test-Keeping memory of the order sequence 2	.97	300	.162	.013
Pair 3	Task 2: Pre-test-Keeping memory of the order sequence 3	.91	300	.292	.024
	Task 2: Post-test-Keeping memory of the order sequence 3	.99	300	.082	.007
Pair 4	Task 2: Pre-test-Keeping memory of the order sequence 4	.88	300	.326	.027
	Task 2: Post-test-Keeping memory of the order sequence 4	1.00	300	.000	.000
Pair 5	Task 2: Pre-test-Keeping memory of the order sequence 5	.77	300	.424	.035
	Task 2: Post-test-Keeping memory of the order sequence 5	.99	300	.082	.007

Table 4.10b : Paired Samples Correlations for Task 2

		N	Correlation	Sig.
Pair 1	Task 2: Pre-test-Keeping memory of the order sequence 1 & Task 2: Post-test-Keeping memory of the order sequence 1	300	-.034	.677
Pair 2	Task 2: Pre-test-Keeping memory of the order sequence 2 & Task 2: Post-test-Keeping memory of the order sequence 2	300	-.049	.553
Pair 3	Task 2: Pre-test-Keeping memory of the order sequence 3 & Task 2: Post-test-Keeping memory of the order sequence 3	300	-.026	.750

Pair 4	Task 2: Pre-test-Keeping memory of the order sequence 4 & Task 2: Post-test-Keeping memory of the order sequence 4	300	.	.
Pair 5	Task 2: Pre-test-Keeping memory of the order sequence 5 & Task 2: Post-test-Keeping memory of the order sequence 5	300	.148	.070

Table 4.10c: Paired Samples Test for Task 2

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Pair 1	Task 2: Pre-test-Memorize the order sequence 1-Task 2: Post-test-Memorize the order sequence 1	-.067	.299	.024	-.115	-.018	-2.729	299	.007
Pair 2	Task 2: Pre-test-Memorize the order sequence 2 - Task 2: Post-test-Memorize the order sequence 2	-.053	.323	.026	-.105	-.001	-2.020	299	.045
Pair 3	Task 2: Pre-test-Memorize the order sequence 3 - Task 2: Post-test-Memorize the order sequence 3	-.087	.305	.025	-.136	-.037	-3.479	299	.001

Pair 4	Task 2: Pre-test-Memorize the order sequence 4 - Task 2: Post-test-Memorize the order sequence 4	-.120	.326	.027	-.173	-.067	-4.508	299	.000
Pair 5	Task 2: Pre-test-Memorize the order sequence 5 - Task 2: Post-test-Memorize the order sequence 5	-.227	.420	.034	-.294	-.159	-6.609	299	.000

The results reveal that from Table 4.10a, 4.10b and 4.10c for Task 2 presented as pair 1 to 5 statements had a coefficient correlation r which was very low, that indicated a very weak correlation but with a p-value greater than 0.05 level of significance, it was concluded that the relationship was not statistically significant. That is, In Task 2 for instance, pair 1: r= - 0.034, that was a poor negative relationship for that statement. To Keeping memory of the order of a sequence of objects on the basis of the pre-test was very weak compared to memorizing the sequence of objects on the basis of the post-test. That was because pre-test was given as a measure of outcome of interest followed by the post test that appeared not to differ. The working memory of visualization skills should be encouraged for active achievement.

4.4.1.3 *The Paired Sample T-test: Task 3*

Table 4.11a: Paired Samples Statistics for Task 3

		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	Task 3: Pre-test-Calculations 2-digits by 2-digits	.70	300	.460	.038

	Task 3: Post-test-Calculations 2-digits by 2-digits	1.00	300	.000	.000
Pair 2	Task 3: Pre-test-Calculations 3-digits by 2-digits	.18	300	.385	.031
	Task 3: Post-test-Calculations 3-digits by 2-digits	.53	300	.501	.041
Pair 3	Task 3: Pre-test-Calculations Fraction by Fraction	.54	300	.500	.041
	Task 3: Post-test-Calculations Fraction by Fraction	.81	300	.396	.032
Pair 4	Task 3: Pre-test-Calculations Fraction by Whole Number	.47	300	.501	.041
	Task 3: Post-test-Calculations Fraction by Whole Number	.73	300	.444	.036
Pair 5	Task 3: Pre-test-Calculations Geometry-Triangle	.09	300	.282	.023
	Task 3: Post-test-Calculations Geometry Triangle	.39	300	.490	.040
Pair 6	Task 3: Pre-test-Calculations Geometry-Rectangle	.91	300	.282	.023
	Task 3: Pre-test-Calculations Geometry Rectangle	1.00	300	.000	.000

Table 4.11b: Paired Samples Correlations for Task 3

		N	Correlation	Sig.
Pair 1	Task 3: Pre-test-Calculations 2-digits by 2-digits & Task 3: Post-test-Calculations 2-digits by 2-digits	300	.504.	.000.
Pair 2	Task 3: Pre-test-Calculations 3-digits by 2-digits & Task 3: Post-test-Calculations 3-digits by 2-digits	300	.444	.000

Pair 3	Task 3: Pre-test-Calculations Fraction by Fraction & Task 3: Post-test-Calculations Fraction by Fraction	300	.530	.000
Pair 4	Task 3: Pre-test-Calculations Fraction by Whole Number & Task 3: Post-test-Calculations Fraction by Whole Number	300	.564	.000
Pair 5	Task 3: Pre-test-Calculations Geometry-Triangle & Task 3: Post-test-Calculations Geometry Triangle	300	.383	.000
Pair 6	Task 3: Pre-test-Calculations Geometry-Rectangle & Task 3: Post-test-Calculations Geometry Rectangle	300	.321.	.000

Table 4.11c: Paired Samples Test for Task 3

		Paired Differences					t	df	Sig. (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower	Upper			
Pair 1	Task 3: Pre-test-Calculations 2 by 2-digit number Task 3: Post-test-Calculations 2 by 2-digit number	-.300	.460	.038	-.374	-.226	-7.991	299	.000
Pair 2	Task 3: Pre-test-Calculations 3 by 2-digit number Task 3: Post-test-Calculations 3 by 2-digit number	-.347	.478	.039	-.424	-.270	-8.892	299	.000

Pair 3	Task 3: Pre-test-Calculations Fraction by Fraction Task 3: Post-test-Calculations Fraction by Fraction	-.267	.444	.036	-.338	-.195	-7.361	299	.000
Pair 4	Task 3: Pre-test-Calculations Fraction by a whole number Task 3: Post-test-Calculations Fraction by a whole number	-.267	.444	.036	-.338	-.195	-7.361	299	.000
Pair 5	Task 3: Pre-test-Calculations Geometry-Triangle Task 3: Post-test-Calculations Geometry-Triangle	-.307	.463	.038	-.381	-.232	-8.118	299	.000
Pair 6	Task 3: Pre-test-Calculations Geometry-Rectangle Task 3: Post-test-Calculations Geometry Rectangle	-.087	.282	.023	-.132	-.041	-3.760	299	.000

The results provided by Tables 4.11a, 4.11b and 4.11c for Task 3 presented as pair 1 to 6 statements had a coefficient correlation r moderate, that indicated a good correlation but with a p-value less than 0.05 level of significance, it was concluded that the relationship was statistically significant. That is, In Task 3 for instance, pair 4: r =

0.564 was a positive relationship between the two variables. The multiplication of a fraction by a whole number on the basis of the pre-test was good (moderate) compared to that of the post-test. That was because the working memory kept track of the short-term information in the pre-test activity, but the anxiety to score well in the post test in order to prove what they had learned negatively affected learners. Mammarella (2015) supported the results by stating that working memory keeps short-term information before interventions are implemented in terms of memory boosters.

4.4.2 Paired Sample T-test: Mathematics Anxiety

In this section, the researcher wanted to investigate whether there was a relationship between mathematics anxiety and mathematics achievement as there was a perception that mathematics anxiety was associated with reduced working memory capacity. The hypotheses are:

H_0: Mathematics anxiety does not affect mathematics achievement.

H_1: Mathematics anxiety does affect mathematics achievement.

Table 4.12 provided the results for the mathematics anxiety which prohibited the ability to perform multiplication tasks effectively.

Table 4.12: One-Sample Test for Mathematics Anxiety

	Test Value = 0					
					95% Confidence Interval of the Difference	
	t	df	P-value	Mean Difference	Lower	Upper
When I do multiplication, I feel nervous	88.401	299	.000	4.680	4.58	4.78

I worry that other learners might understand multiplication problems better than me	53.277	299	.000	4.280	4.12	4.44
I feel stressed when I am about to take a multiplication test	68.841	299	.000	4.500	4.37	4.63
I get "butterflies" in my stomach when multiplication is mentioned	31.992	299	.000	3.487	3.27	3.70
Being called on to answer a multiplication question scares me	50.272	299	.000	4.200	4.03	4.37
I feel frustrated when working on multiplication problems	48.683	299	.000	4.127	3.96	4.29
I have trouble sleeping the night before a multiplication test	90.443	299	.000	4.507	4.41	4.61
I avoid my multiplication homework	26.719	299	.000	3.367	3.12	3.62
I need extra help in solving multiplication problems	36.045	299	.000	3.567	3.37	3.76
When I need help in multiplication, I ask for it	33.452	299	.000	3.300	3.11	3.49
After getting a multiplication test back, I don't want others to see my marks	46.756	299	.000	3.900	3.74	4.06
I have said "I hate multiplication" this year	51.888	299	.000	3.907	3.76	4.06

The results reveal that mathematics anxiety affects the mathematics achievement since the p-value equals to 0.000, which was less than 0.05 in the level of significance for all the tests on Table 4.12. For illustrative purposes, let us consider the statement "when I do multiplication, I feel nervous", that gave the univariate statistics such as the test statistic t = 88.401, the p-value = 0.000 and the 95% confidence interval was (4.58; 4.78). The experience observed through the analysis showed that learners had a feeling of stress when they were facing multiplication activities and therefore their mathematics anxiety negatively influenced mathematics achievement. The results of the study showed that there was a significant negative relationship between mathematics anxiety and mathematics achievement on the basis of multiplication activities. This resonates with previous studies by Cowan (2014) which shows a (-0.8) correlation between the two concepts depicting a strong degree of negative correlation between mathematics anxiety and achievement.

4.5 Answers to research questions

The results of the data analysis presented above were used to address the research questions posed in this study.

4.5.1 Research question one

The first research question was:

- What is the relationship between mathematics learners' anxiety, their working memory and their achievement with respect to solving multiplication problems in Grade 5?

The results were that the mathematics learners' anxiety, their working memory and their achievement with respect to solving multiplication problems in Grade 5 are related as determined by measuring the relationship between working memory vs achievement, working memory vs mathematics anxiety and mathematics anxiety vs mathematics achievement as shown in Section 4.4.1 and 4.4.2. The relationship was reflected in comparing the pre-test and post-test results, and anxiety was determined through a survey questionnaire addressed by the learners. In the pre-test, the learners were found as always having low working memory when the complexity or difficulty of mathematics problems increased. The compromising of working memory was found as allowing the learner to experience mathematics anxiety which thereby affected the mathematics achievement. Further, the results from the post-test showed the relationship between the three variables where memory boosters improved working memory and reduced mathematics anxiety, as shown by the improvement in performance of learners demonstrated in Table 4.7 and 4.8. Therefore, the results indicated that the working memory is the regulator of the relationship between the three variables by which low working memory culminates into high mathematics anxiety and poor mathematics achievement.

4.5.2 Research question two

The second research question was:

- How do memory booster activities improve learners' working memory capacity with respect to solving multiplication problems in Grade 5?

The results of the analysis on the role of memory booster activities in improving learners' working memory capacity with respect to solving multiplication problems in Grade 5 were reflected in the results of the post-test Task 3. To determine the role of memory boosters, a comparison was noted from the pre-test and post-test results. The majority of learners affirmed to always feel anxious as shown in Table 4.7 and the pre-tests learners' performance was poor as they failed to recall the way to solve problems such as finding the area of triangles and calculations of fraction multiplications. The post-test conducted after the memory boosters showed a significant improvement in tasks 1, 2 and 3. There was a notable decrease from learners who always experienced anxiety, to experiencing such anxious feelings sometimes and in some instances often. It lies in that significant change in results that memory boosters can be attested as substantial towards improving working memory capacity with respect to solving multiplication problems in Grade 5. The memory boosters improve the working memory which give learners the capacity to repel mathematics anxiety and thereby improve mathematics achievement.

4.5.3 Research question three

The third research question was:

- What is the relationship between learners' memory booster activities and their working memory capacity with respect to solving multiplication problems in Grade 5?

The results on the analysis of the relationship between learners' memory booster activities and their working memory capacity with respect to solving multiplication problems in Grade 5. The memory booster activities have a significant relationship with the working memory capacity as shown in Section 2. The pre-test results showed low working memory capacity of the learners as accorded by the low performance in the tasks. The results in tasks improved significantly in the post test after the memory booster activities were implemented on learners. The shift in improvement on the results from tasks shows a relationship between memory booster activities and the working memory capacity as reflected in Section 4.2.2. This suggests that memory booster activities are vital towards improving working memory capacity with respect to solving multiplication problems in Grade 5.

4.5.4 Research question four

The fourth research question was:

- What is the effect of incorporating memory booster activities towards the learners' working memory capacity with respect to solving multiplication problems in Grade 5?

The effect of incorporating memory booster activities towards the learners' working memory capacity with respect to solving multiplication problems in Grade 5 was reflected in the results (section 4.2.3.2). The incorporation of memory booster activities carries a positive effect on the learners working memory capacity. The pre-test results in task 1 and 2 showed that when the mathematics problems became complex or difficult, the learners' working memory capacity decreased. The shift to positive performance by learners after incorporating memory boosters, shows a positive effect towards working memory capacity with respect to solving more complex multiplication problems in Grade 5.

4.6 Conclusion

The chapter unpacked the single evaluation on working memory, evaluation of tasks regarding the working memory and mathematics achievement tests. The mathematics anxiety was also tested as well as an evaluation of the relationship between the working memory and mathematics achievement based on mathematics anxiety. The study established that the working memory capacity determined the experiencing of mathematics anxiety and mathematics achievement. In that regard, a higher working memory capacity decreased mathematics anxiety and in turn increased mathematics achievement. The next chapter also focused on the conclusions and recommendations of the study.

CHAPTER FIVE: CONCLUSIONS AND RECOMMENDATIONS

5.1 Introduction

The preceding chapter presented, analysed, and interpreted the results of the study. This chapter thereby provides summaries of the chapters inclusive of the methodology and literature review. The chapter also deliberates the reflections on the limitations of the study, areas of further research and the conclusions. The thrust was to demonstrate the adequacy response in dealing with the research problem, aims and objectives of the study.

5.2 Summary of Research Results

The results are summarised below in accordance with the research objectives:

5.2.1 The relationship between mathematics learners' anxiety, their working memory, and their achievement with respect to solving multiplication problems in Grade 5

The results revealed that there was a significant relationship between mathematics anxiety, working memory and mathematics achievement. On the data collected during both the pre-test and post-test, it was found that learners struggled with mathematics due to the lack of or weak ability in performing multiplication activities (See Table 4.7). In the tests, the learners showed high frequencies of mathematics anxiety, as they had reported feelings of stress, worry and fear when dealing with multiplication problems, those feelings at times prompted them to avoid multiplication problems (See Table 4.7). It was noted that mathematics anxiety affected mathematics achievement since mathematics anxiety was associated with the reduction of working memory capacity. Consistent to the reviewed literature, the relationship between mathematics anxiety, working memory and mathematics achievement is causal linked; mathematics anxiety causes low working memory which also causes low mathematics achievement.

More so, the results highlighted that grade 5 learners usually experience mathematics anxiety when dealing with multiplication problems, those feelings at times prompted them to avoid multiplication problems, be ashamed to ask for help or feared showing others their test results (See section 4.3 in Chapter 4). In this regard, mathematics anxiety hindered learners' achievement as it often gave the perception that learners were failures. This concurs with the results in the literature review that increasing anxiety culminates to depression, tenseness, sad and low self-esteem towards mathematics which culminates into low mathematical performance. Against such a background, there was a significant relationship between mathematics anxiety, working memory and mathematics achievement.

However, the literature further revealed that mathematics anxiety slows down performance and degrades accuracy in solving multiplication problems (Gregor, 2015). In the study, the researcher focused on how it affected the working memory capacity as a determinant of mathematics achievement. The distinction was therefore on that the literature revealed the effect of mathematics anxiety on processing accuracy while the study noted mathematics anxiety as affecting information retrieval in real time addressing of mathematics problems. Regardless of such a small deviation on working memory areas affected, the outcome was that mathematics anxiety affected working memory which also decreases mathematics achievement.

5.2.2 Memory booster activities improve learners' working memory capacity with respect to solving multiplication problems in Grade 5

According to the research results, the memory booster activities are necessary for improving the working memory capacity of grade 5 learners. The significance of the memory booster activities was determined in the pre-test and post-test where learners' average performance improved significantly after the memory boosters were administered. This concurred with the notion in the reviewed literature that working memory and mathematics achievement can be improved through the application of memory boosting interventions.

Furthermore, the results highlighted that the visualization memory booster strategies were more significant in improving the working memory of learners (See section 3 in chapter 4). Consistent with the results in the reviewed literature, the visual-spatial sketchpad significantly culminated into greater accuracy in mathematical problem solving and improvement of the learners' working memory (Berlacon, 2017). It was found that the application of visualisation skills improved the learners' working memory which allowed learners to maintain a bit of information in the mind and use it to solve a variety of multiplication problems.

5.2.3 The relationship between learners' memory booster activities and their working memory capacity with respect to solving multiplication problems in Grade 5

The results of the study established the relationship between learners' memory booster activities and their working memory capacity with respect to solving multiplication problems in Grade 5. In the tasks and tests, the visualization strategies were used as a tool to inform teachers in lesson planning and presentation, as it entailed that those learners were more likely to retain and recall pieces of information given as pictures or objects as opposed to numbers or digits. The results lead the researcher to believe that learners had an above average working memory in terms of visualization skills. This therefore shows a significant relationship between learners' memory booster activities and their working memory capacity.

In addition, it was established in the results that memory booster activities administered assisted participants to recall larger pieces of information. This was consistent with the elicited views in the literature review that memory booster activities if administered on learners, may allow them to reduce work overload in their memory which reduces mathematics anxiety (Tobias, 2013). The outcome was enhanced mathematics achievement; given that the results indicated that the working memory of visualization skills should be encouraged for active achievement.

5.2.4 The effect of incorporating memory booster activities towards the learners' working memory capacity with respect to solving multiplication problems in Grade 5

According to the results, the incorporation of memory booster activities has a significant effect on the learners' working memory capacity. The memory booster activities served a dual purpose of decreasing anxiety and improving the cognitive processes in Grade 5 learners when solving multiplication problems. In the tests, the learners demonstrated a progressive increase of some level of working memory as reflected by the mathematics achievement. It was noted that the incorporation of memory booster activities shifted the working memory capacity of learners who kept track of the short-term information in the pre-test activity, and the scoring well in the post test showed that incorporating memory booster activities mitigated anxiety that negatively affected learners.

However, the literature revealed that the working memory mechanisms are rooted on processing reading comprehension, memory retrieval and real time processing hence considering the possibility of mathematics anxiety influencing working memory span and capacity (Berlacon, 2017). In the study, the researcher only focused on working memory capacity and not the uncertainty of whether learners had genuinely learned and stored the information as opposed to cramming it for reproduction, given that time frame after administration of memory boosters was not considered as significant. Nevertheless, on synthesis, the results and the literature both revealed that mathematics anxiety affects working memory although the researcher focused on working memory capacity only.

5.3 Limitations of the Study

The first limitation of the study was the time constraints in conducting the study. The movements in data collection in the circuit was constrained by COVID-19 restrictions which had to be adhered to in South Africa. The measures proposed for curbing the spreading of coronavirus were adhered to such as mask-up and sanitisation and social distancing. Secondly, the study was limited by a dearth of literature regarding the relationship between mathematics anxiety, working memory and mathematics achievement.

The other limitation was that the study used a single research approach, quantitative research, which also bears its shortcomings. The research instrument was also constructed using English which was not the first or native language spoken by the learners. Nevertheless, the high response rate of participants attained mitigated this limitation.

5.4 Conclusion

Based on the results, it can be concluded that mathematics anxiety, working memory and mathematics achievement are strongly correlated. The relationship between mathematics anxiety, working memory and mathematics achievement is causal linked; mathematics anxiety causes low working memory which also causes low mathematics achievement. Thus, mathematics anxiety affects mathematics achievement since mathematics anxiety is associated with the reduction of working memory capacity. Against such a background, when memory boosters are implemented on the learners, they decrease anxiety and improve learners' cognitive processes when solving multiplication problems. It is therefore significant for interventions such as instructional strategies to be utilized to alleviate mathematics anxiety and ensure high working memory. The reduction of anxiety will translate into high working memory and increased mathematics achievement by learners.

5.5 Recommendations

The study established that mathematics anxiety compromises working memory which further affects the mathematics achievement. Based on the results, the recommendations are presented below:

5.5.1 Recommendations to Mathematics Teachers

- Mathematics teachers must implement instructional strategies that are affirmed for reducing mathematics anxiety in learners.

- Mathematics teachers must use manipulatives to elucidate specific topics that prompt anxiety, fear and stress in learners, seek help from their colleagues and also explore further in the history of mathematics.
- An intervention program could be developed to address learners with high levels of mathematics anxiety. The program would build the confidence in learner's mathematical ability and help reduce their negative attitudes towards mathematics.

5.5.2 Recommendations to DBE

- Mathematics teachers must be engaged in various workshops on how to deliver content to learners in a way that increases working memory capacity but does not prompt mathematics anxiety. The workshops must be empowering for the teachers to improve their teaching skills and competence and to deepen their knowledge so that they implement measures to facilitate learners' high mathematics achievement.
- Mathematics teachers should be trained on how to develop mathematics lesson plans and activities rather than depending on textbooks and DBE workbooks. This will allow teachers to understand the needs of the learners they teach and the type of memory booster activities they require to increase their working memory capacity.
- Assist teachers on how to unpack the curriculum to ensure effective classroom implementation. The effective teaching skills will remove the fears and inferiorities in learners which give room to mathematics anxiety.
- The curriculum designers should allow teachers to decide what to do based on their own context as far as teaching mathematics is concerned. This will help

the teacher to widespread their allocation of time in mathematics topics which prove challenging to learners. The allocation of ample time on difficult topics increases the working memory capacity of learners which reduces mathematics anxiety in learners.

5.5.3 Recommendations for Future Research

The following recommendations for future research were made against the results of the study:

- Future studies may be conducted using mixed methods which allows triangulation where data can also be collected using surveys and interviews. The study may be conducted on a large sample.
- Future research may be conducted through a comparative approach on differing classes such as grade 5 and grade 6 in various districts or provinces.
- Future studies may also be conducted on developing a framework by which guidelines may be provided for mathematics teachers on how they can manage mathematics anxiety and identify suitable memory boosters for each section and level of mathematics teaching.
- Future researchers may use mixed methods to allow triangulation or qualitative research approach to provide explanations to the statistics established in this study.

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APPENDICES

Appendix A: Research Instruments

Appendix A1: Mathematics Anxiety Questionnaire

Instructions: Indicate how often each statement describes you by circling **only one** of the five terms next to the statement.

Nickname: _________________________ Class: Grade 5 __________

1.	I feel nervous, when solving multiplication problems.	Never	Rarely	Sometimes	Often	Always
2.	I worry that other learners might understand multiplication problems better than me.	Never	Rarely	Sometimes	Often	Always
3.	I feel stressed when I'm about to take a multiplication test.	Never	Rarely	Sometimes	Often	Always
4.	I get "butterflies" in my stomach when multiplication is mentioned.	Never	Rarely	Sometimes	Often	Always
5.	Being called on to answer a multiplication question scares me.	Never	Rarely	Sometimes	Often	Always
6.	I feel frustrated when working on multiplication problems.	Never	Rarely	Sometimes	Often	Always
7.	I have trouble sleeping the night before a multiplication test.	Never	Rarely	Sometimes	Often	Always
8.	I avoid my multiplication homework.	Never	Rarely	Sometimes	Often	Always
9.	I need extra help in solving multiplication problems.	Never	Rarely	Sometimes	Often	Always
10.	When I need help in multiplication, I ask for it.	Never	Rarely	Sometimes	Often	Always
11.	After getting a multiplication test back, I don't want others to see my marks.	Never	Rarely	Sometimes	Often	Always
12.	I've said "I hate multiplication" this year.	Never	Rarely	Sometimes	Often	Always

Appendix A2: Working Memory and Mathematics Achievement Pre-Test

Pseudo name / A K A: ___________________________________

Class: Grade 5 _______

Instruction to the learners

- This test consists of **3 tasks**. Section A: Task 1 and 2, Section B : Task 3
- All the tasks should be completed in the spaces provided.
- Your teacher will read the instruction for each task before you start.
- Remember each task has a time limit, so you need to complete the task as quickly as you can.
- The use of cellphones and calculators is not allowed.
- Take a deep breath and most importantly, try to have fun!

SECTION A :TASK 1

Objectives: Memorize the largest amount of numbers without making a mistake.

Time allowed: 10 seconds per round.

INSTRUCTIONS :

A set of numbers will appear on the screen. The first series will be of just one number, increasing each time. The next series will have 2 numbers, then 3 etc. Pay attention to each set of numbers as you will have to reproduce each set. You will have 5 seconds to memorize each set. (21)

1) _______.
2) _______, _______.
3) _______, _______, ________.
4) _______, _______, ________, ________.
5) _______, _______, ________, ________, _______.
6) _______, _______, ________, ________, _______, _______

SECTION A: TASK 2

Objective: Memorize the **order** of 3 objects, select the correct series in the given timeframe.

Time allowed: 10 seconds per round.

INSTRUCTIONS :

You will see 3 objects on the screen and you must remember the order in which these objects appeared. After 10 seconds, the objects will disappear and four sets of objects will appear. You will have to identify the order by using an **x** or circling the correct letter. (5)

Sequence 1	A	B	C	D
Sequence 2	A	B	C	D
Sequence 3	A	B	C	D
Sequence 4	A	B	C	D
Sequence 5	A	B	C	D

SECTION B: TASK 3

INSTRUCTIONS: Calculate the following as quickly as possible. You have 20 minutes to complete this part of the task.

1. 452

   × 435

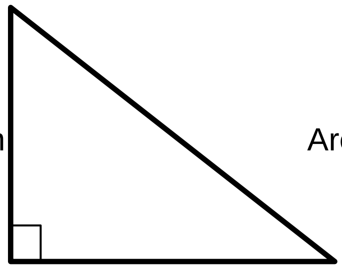
2. $\frac{2}{3} \times \frac{4}{5} =$

3. $\frac{1}{4} \times 12 =$

4. $\frac{3}{5} \times \frac{5}{6} =$

5. Calculate the area of the following:

8cm



Area=

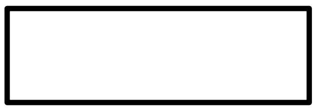
12cm

6. 7×9=

7. 8×8=

8. Calculate the area of the following:

5cm



3cm

Area=

9. 11 × 75 =

10. 334 × 23 =

¬¬ END ¬¬¬¬¬¬¬¬¬¬¬¬¬¬¬¬¬¬¬¬¬¬¬¬¬¬¬¬¬¬¬¬¬¬¬¬¬¬

Appendix A3: Working Memory and Mathematics Achievement Post-Test

Pseudo name / A K A: ____________________________________

Class: Grade 5 _______

Instruction to the learners

- This test consists of **3 tasks**. Section A: Task 1 and 2, Section B : Task 3

- All the tasks should be completed in the spaces provided.
- Your teacher will read the instruction for each task before you start.
- Remember each task has a time limit, so you need to complete the task as quickly as you can.
- The use of cellphones and calculators is not allowed.
- Take a deep breath and most importantly, try to have fun!

<u>SECTION A :TASK 1</u>

Objectives: memorize the largest amount of numbers without making a mistake.

Time allowed: 10 seconds per round.

<u>INSTRUCTIONS :</u>

A set of numbers will appear on the screen. The first series will be of just one number, increasing each time. The next series will have 2 numbers, then 3 etc. Pay attention to each set of numbers as you will have to reproduce each set. You will have 5 seconds to memorize each set. (21)

1) _______.
2) _______, _______.
3) _______, _______, ________.
4) _______, _______, ________, ________.
5) _______, _______, ________, ________, _______.
6) _______, _______, ________, ________, _______, _______.

SECTION A: TASK 2

Objective: memorize the **order** of 3 objects, select the correct series in the given timeframe.

Time allowed: 10 seconds per round.

INSTRUCTIONS :

You will see 3 objects on the screen and you must remember the order in which these objects appeared. After 10 seconds, the objects will disappear and four sets of objects will appear. You will have to identify the order by using an **x** or circling the correct letter. (5)

Sequence 1	A	B	C	D
Sequence 2	A	B	C	D
Sequence 3	A	B	C	D
Sequence 4	A	B	C	D
Sequence 5	A	B	C	D

SECTION B: TASK 3

INSTRUCTIONS: Calculate the following as quickly as possible. You have 20 minutes to complete this part of the task.

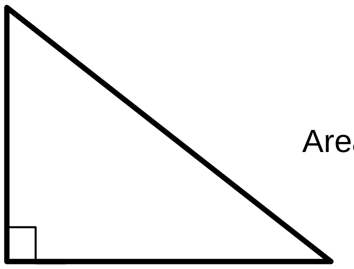
1. 352 × 255 =

2. $\frac{2}{3} \times \frac{4}{5} =$

3. $\frac{1}{4} \times 16 =$

4. $\frac{3}{5} \times \frac{5}{6} =$

5. Calculate the area of the following:



6. 7 × 9=
7. 19 × 85
8. Calculate the area of the following:

Area=

9. 11 × 75 =

10. 324 × 13 =

¬¬¬ END ¬¬¬

Appendix B: Permission Request Letters

Appendix B1: Informed Consent

Dear Parent/ Guardian,

My name is **Maria Tebogo Mnguni**, a student at University of South Africa under the supervision of Ms EG Makwakwa and Prof ZMM Jojo, conducting research regarding the ***Relationship between Anxiety, Working Memory and Achievement in Mathematics in Grade 5 Learners: A case study of Tshepisong schools.***

The research will be conducted on the Grade 5 learners. I am writing to request your permission to let your child participate in the research. The research will be of positive impact to the child as there will be implementation of memory booster activities which might help him/her in the mathematics discourse. The research will adopt the following principles:

- Participation of this project is completely voluntary.
- All information provided through your participation in this study will be kept confidential.
- You as well as the learner will not be identified in the thesis or any report of this research.
- The data collected on this study will be kept for a period of 5 years in a secure location.

The study requests the presentation of the parent's permission to the universities ethical committee before research can commence. Your permission will be indicated by signing the space below:

……………………………………………………….. ………………………………….

Parent/ Guardian Name **Signature**

Thank you in advance for your co-operation and letting your child participate in my research.

Yours Sincerely,

Maria Tebogo Mnguni

Tel: (+27)84 445 668

Email: tebogotebs@gmail.com

Appendix B2: Request for permission to conduct research at the school

"An Assessment of the Relationship between Anxiety, Working Memory and Achievement in Mathematics in Grade 5 Learners"

October 2019

<u>The Principal and the School Governing Body</u>

Dear Sir/Madam,

I, Miss Maria Tebogo Mnguni, am doing research with Ms EG Makwakwa and Prof ZMM JoJo at the University of South Africa's Faculty of Education.

Presently I have a relationship with the institution as a student. I am currently engaging in an experimental Masters Research Project with the following specific details:

- The study aims to assess the Relationship between Anxiety, Working Memory and Achievement in Mathematics in Grade 5 Learners at Tshepisong schools.
- The study will entail the collection of information from participants through survey questionnaires.
- There are almost no potential risks unless in case of unanticipated events outside the control of the researcher.
- Research participants are allowed to withdraw at any time should they feel their rights or security might be compromised.
- The school will be provided with feedback through research reports and journal articles of the study.
- The school has been selected to participate in the study due to its proximity to the researcher.

According to the UNISA Research Ethics Policy the following should be noted;

All participation will be on a voluntary basis, with the participant's prior consent and right to exit the process at any time without any recourse;

All information gathered will remain as the property of the researcher and UNISA and will only be used for this research project;

The data will be securely maintained by myself for a period of 5 years after which it will be destroyed;

The researcher will ensure confidentiality and anonymity of the respondents and your organisation;

There will be no payment, gifts, rewards or any other incentives to the participants.

Please note that I would require permission to conduct my research at your organisation to submit on my application for Ethical Clearance prior to conducting the research. I will forward you a copy of the certificate when obtained.

You are also free to engage with me:

Tebogo Maria Mnguni

Cell: (+27) 84 442 5668

Email: tebogotebs@gmail.co.za

Or my supervisors

Ms EG Makwakwa (Supervisor)

Tel: (+27) 12 429 4575

Email: makwaeg@unisa.ac.za

Prof ZMM Jojo (Co-supervisor)
Tel: (+27) 12 429 6627
Email: jojozmm@unisa.ac.za

With appreciation

Maria Tebogo Mnguni

Appendix C: Test of Normality

Appendix C1: Tests of Normality

Tests of Normality – Pre-Test : Task 1

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Task 1: Pre-test-Memorize the largest number with 3-Numbers	.528	300	.000	.355	300	.000
Task 1: Pre-test-Memorize the largest number with 4-Numbers	.479	300	.000	.517	300	.000
Task 1: Pre-test-Memorize the largest number with 5-Numbers	.344	300	.000	.636	300	.000
Task 1: Pre-test-Memorize the largest number with 6-Numbers	.505	300	.000	.449	300	.000

a. Lilliefors Significance Correction

Tests of Normality – Pre-Test : Task 2

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Task 2: Pre-test-Memorize the order sequence 1	.536	300	.000	.300	300	.000
Task 2: Pre-test-Memorize the order sequence 2	.536	300	.000	.300	300	.000
Task 2: Pre-test-Memorize the order sequence 3	.532	300	.000	.329	300	.000
Task 2: Pre-test-Memorize the order sequence 4	.524	300	.000	.379	300	.000
Task 2: Pre-test-Memorize the order sequence 5	.475	300	.000	.523	300	.000

a. Lilliefors Significance Correction

Tests of Normality – Pre-Test : Task 3

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Task 3: Pre-test-Calculations 2 by 2- digit number	.443	300	.000	.575	300	.000
Task 3: Pre-test-Calculations 3 by 2-digit number	.500	300	.000	.466	300	.000
Task 3: Pre-test-Calculations Fraction by Fraction	.361	300	.000	.634	300	.000
Task 3: Pre-test-Calculations Fraction by a whole number	.358	300	.000	.635	300	.000
Task 3: Pre-test-Calculations Geometry-Triangle	.534	300	.000	.315	300	.000
Task 3: Pre-test-Calculations Geometry-Rectangle	.534	300	.000	.315	300	.000

a. Lilliefors Significance Correction

Tests of Normality – Post-Test : Task 1

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Task 1: Post-test-Memorize the largest number with 4-Numbers	.530	300	.000	.342	300	.000
Task 1: Pre-test-Memorize the largest number with 5-Numbers	.491	300	.000	.490	300	.000
Task 1: Post-test-Memorize the largest number with 6-Numbers	.466	300	.000	.541	300	.000

a. Lilliefors Significance Correction

Tests of Normality – Post-Test : Task 2

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Task 2: Post-test-Memorize the order sequence 1	.533	300	.000	.091	300	.000
Task 2: Post-test-Memorize the order sequence 2	.539	300	.000	.148	300	.000

Task 2: Post-test-Memorize the order sequence 3	.526	300	.000	.055	300	.000
Task 2: Post-test-Memorize the order sequence 4	.526	300	.000	.055	300	.000
Task 2: Post-test-Memorize the order sequence 5	.526	300	.000	.055	300	.000

a. Lilliefors Significance Correction

Tests of Normality – Post-Test : Task 3

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
Task 3: Post-test-Calculations 3 by 2-digit number	.354	300	.000	.635	300	.000
Task 3: Post-test-Calculations Fraction by Fraction	.494	300	.000	.482	300	.000
Task 3: Post-test-Calculations Fraction by a whole number	.459	300	.000	.552	300	.000
Task 3: Post-test-Calculations Geometry-Triangle	.396	300	.000	.620	300	.000

a. Lilliefors Significance Correction

Tests of Normality – Mathematics Anxiety

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
When I do multiplication, I feel nervous	.449	300	.000	.548	300	.000
I worry that other learners might understand multiplication problems better than me	.321	300	.000	.734	300	.000
I feel stressed when I am about to take a multiplication test	.387	300	.000	.664	300	.000
I get "butterflies" in my stomach when multiplication is mentioned	.196	300	.000	.862	300	.000

Being called on to answer a multiplication question scares me	.296	300	.000	.759	300	.000
I feel frustrated when working on multiplication problems	.280	300	.000	.784	300	.000
I have trouble sleeping the night before a multiplication test	.357	300	.000	.710	300	.000
I avoid my multiplication homework	.206	300	.000	.831	300	.000
I need extra help in solving multiplication problems	.206	300	.000	.878	300	.000
When I need help in multiplication, I ask for it	.222	300	.000	.878	300	.000
After getting a multiplication test back, I don't want others to see my marks	.233	300	.000	.839	300	.000
I have said "I hate multiplication" this year	.231	300	.000	.830	300	.000
When I do multiplication, I feel nervous	.202	300	.000	.875	300	.000
I worry that other learners might understand multiplication problems better than me	.188	300	.000	.886	300	.000
I feel stressed when I am about to take a multiplication test	.267	300	.000	.873	300	.000
I get "butterflies" in my stomach when multiplication is mentioned	.220	300	.000	.874	300	.000
Being called on to answer a multiplication question scares me	.208	300	.000	.902	300	.000
I feel frustrated when working on multiplication problems	.185	300	.000	.910	300	.000
I have trouble sleeping the night before a multiplication test	.236	300	.000	.875	300	.000

I avoid my multiplication homework	.203	300	.000	.912	300	.000
I need extra help in solving multiplication problems	.208	300	.000	.854	300	.000
When I need help in multiplication, I ask for it	.259	300	.000	.879	300	.000
After getting a multiplication test back, I don't want others to see my marks	.314	300	.000	.847	300	.000
I have said "I hate multiplication" this year	.330	300	.000	.824	300	.000

a. Lilliefors Significance Correction

Appendix C2: Reliability: Mathematics achievement test

Pre-Test

Reliability Statistics

Cronbach's Alpha	N of Items
.690	18

Post-Test

Reliability Statistics

Cronbach's Alpha	N of Items
.619	18

Appendix C3: Math Anxiety Questionnaire

Reliability Statistics

Cronbach's Alpha	N of Items
.716	24

Appendix D: Ethical Clearance Letter

UNISA university of south africa

UNISA COLLEGE OF EDUCATION ETHICS REVIEW COMMITTEE

Date: 2019/11/13

Dear Miss MT Mnguni

Decision: Approved on condition that all the recommendations below are effected on or before 22 November 2019

Ref: **2019/11/13/64092097/60/AM**
Name: Miss MT Mnguni
Student No.: 64092097

Researcher(s): Name: Miss MT Mnguni
E-mail address: 64092097@mylife.unisa.ac.za
Telephone: 084 442 5668

Supervisor(s): Name: Ms EG Makwakwa
E-mail address: makwaeg@unisa.ac.za
Telephone: 012 429 6627

Name: Prof ZM Jojo
E-mail address: jojozmm@unisa.ac.za
Telephone: 012 429 6627

Title of research:

The relationship between anxiety, working memory and achievement in mathematics in grade 5 learners: A case of Tshepisong schools

Qualification: MEd Mathematics Education

Research Ethics Committee Recommendations:

3.2 Status of field work.

Is this not a retrospective application?

3.3 Risk category indicated.

- With learners involved, the categorisation may not be 2.

Justification for category given.

- o Should be completed.

3.4 Conflict of interest.

- Not addressing conflict of interest risks

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3.5 How should this study be characterised.

3.6 Research Background.

- Noting aims and objectives of the study, you may need to revisit the research sub-question which are amenable to providing only Yes/No answers.

3.7 Research design and methodology.

- o Where will you get the 300 learners from? Please elaborate on your population and sample
- o Please write N/A for the collection instruments not applicable to your study.

3.8 Data collection process.

- Having gone through appendix C, you need to indicate clearly how the learners will be exposed to the screen you are referring to in the description of your data collection process. What devise will be connected to the screen?

4.1 Risks involved.

- A study on anxiety may expose the vulnerability of some learners. Please indicate how you mitigate against this

Yours sincerely,

Name of the Chair: Prof AT Motlhabane

E-mail: motlhat@unisa.ac.za

Tel: (012) 429-2840

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Appendix E: Editor's Certificate

LANGUAGE INSTITUTE

Editing Confirmation

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Registration number: 131 804 NPO

02/01/2022

Report on dissertation by: Maria Tebogo Mnguni

Dissertation title: The Relationship between Anxiety, Working Memory and Achievement in Mathematics in Grade 5 Learners: A case study of Tshepisong schools

This serves to confirm that the above document (excluding Table of Contents, List of Figures, and Reference list) was edited substantively by members of the KZN Language Institute's professional English language editing team. The document was returned to the author with numerous tracked changes and comments intended to correct errors and to clarify meaning. It was the author's responsibility to attend to these changes.

Please note that the final, corrected version of the document was not proofread by an editor from the KZN Language Institute.

Ms G. Coertze *MSocSc (Culture, Communication and Media Studies)*
Outsourced Editing Manager

Ms J. Kerchhoff *BEd (Hons), MA (Applied Language Studies), CELTA*
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KZN Language Institute – Transforming Words

Appendix F: Turnitin Certificate

turnitin

Digital Receipt

This receipt acknowledges that Turnitin received your paper. Below you will find the receipt information regarding your submission.

The first page of your submissions is displayed below.

Submission author:	Mt Mnguni
Assignment title:	Revision 3
Submission title:	Final Thesis
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File size:	514.46K
Page count:	170
Word count:	37,802
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Submission date:	20-Jan-2022 05:49PM (UTC+0200)
Submission ID:	1744801013