

**THE INFLUENCE OF USING A SCIENTIFIC CALCULATOR IN
LEARNING FRACTIONS: A CASE STUDY OF ONE SCHOOL IN
GAUTENG PROVINCE.**

by

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submitted in accordance with the requirements
for the degree of

MASTER OF EDUCATION - WITH SPECIALISATION IN MATHEMATICS EDUCATION

at the

University of South Africa

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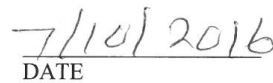
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MA Education

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7. Enter the title of thesis. If thesis is written in a language other than English, please specify which language and Translate title into English. Language of text: English

Title:

**THE INFLUENCE OF USING A SCIENTIFIC CALCULATOR IN LEARNING
FRACTIONS: A CASE STUDY OF ONE SCHOOL IN GAUTENG PROVINCE**

8. Subject category of thesis.

0280

Summary

The main purpose of the research was to investigate the influence of scientific calculators on Grade 8 South African learner's understanding of fractions in learning mathematics. Quasi-experimental quantitative research methods were used.

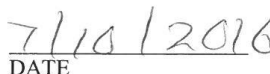
A sampling frame was selected using non probability sampling technique. A total of 15 learners in each group were randomly selected for an experimental and control group for the study. Both groups were taught fraction concepts by different teachers for the same duration and at the same time. The experimental group used a calculator as a learning aid while the control group used the traditional paper pencil method. Two tasks (post-test and assignment) were administered to both groups and a questionnaire to the experimental group.

The results indicated that the scientific calculator has a positive influence in learner's conceptual understanding of fractions in mathematics as reflected in their performance.

Keywords: scientific calculator, fraction, learning, performance, learners, conceptual understanding



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Dedication

In memory of my late grandmother Sabina Mutsvangwa and my uncle L.V. Mutsvangwa.

Acknowledgements

I would like to express my sincere gratitude and appreciation to the following for their contribution towards the successful completion of this dissertation:

- Dr M.M Phoshoko my supervisor for his patience, valuable advice, support and guidance throughout the duration of the study.
- University of South Africa for providing me with a bursary to fund this dissertation.
- The Gauteng Department of Education for giving me the opportunity to carry out this study using one of its schools.
- The principal, deputy principal and school governing body of school used for allowing me to use their school to carry out this study.
- 2014 Grade 8 learners of the school who were involved in the investigation for being co-operative and well-disciplined for the whole duration of the investigation and their parents for allowing me to use their children in the investigation.
- The mathematics teachers of the school used for teaching the learners during the investigation.
- My children Alice, Tanatswanashe and Kupakwashe for their emotional support and encouragement when I was stressed and wanted to give up.
- My aunt Dr B Mutsvangwa Mahamba for being such an inspiration towards my studies.
- God the Almighty for giving me the strength and endurance to go on despite all the challenges.

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List of Acronyms

The following abbreviations will be used in the script

CAPS	-Curriculum Assessment Policy Statement
GDE	-Gauteng Department of Education
NCS	-National Curriculum Statement
NCTM	-National Council of Teachers in Mathematics
SGB	-School Governing Board
UNISA	-University of South Africa
PDST	-Professional Development Service for Teachers

Chapter 1: Introduction or Background of the investigation

1.1 Introduction

The National Council of Teachers in Mathematics, (National Council of Teachers in Mathematics, 2000), The Department of Basic Education (DBE), National Curriculum Statement (DBE, 2011), (Hembree & Dessart, 1986), (Pomerantz, 1997) and (Ellington, 2006) as professional bodies and researchers in the teaching and learning of mathematics, have encouraged the use of a non-programmable calculator in the teaching and learning of mathematics. Although there is been widespread research in support of a calculator as a learning aid, its effective implementation in the classroom is very limited. The National Council of Teachers of Mathematics (NCTM, 2000:22) technology principle states that "Technology is essential in teaching and learning Mathematics. It influences the mathematics that is taught and enhances students learning".

South Africa's National Curriculum Statement (NCS), (DBE, 2011:8) on Mathematics (Grade 7-9), states: "Mathematics is a human activity that involves observing, representing and investigating patterns and quantitative relationships in physical and social phenomena and between mathematical objects themselves. It helps to develop mental processes that enhance logical and critical thinking, accuracy and problem-solving that will contribute in decision making".

South African mathematics teaching aims at developing the following in learners (DBE, 2011):

- the necessary confidence to deal with any mathematical situation without being hindered by a fear of mathematics;
- an appreciation for the beauty and elegance of mathematics;
- a spirit of curiosity and a love for mathematics;
- a recognition that mathematics is a creative part of human activity;
- deep conceptual understandings in order to make sense of mathematics;
- the application of mathematics to physical, social, and mathematical problems; and
- further study in mathematics.

Hembree and Dessart (1986) conducted a meta-analysis research to investigate the effectiveness of a calculator in mathematics and drew the following conclusions:

- the calculator provides a learner with the opportunity to observe and investigate

patterns;

- there are no definite harmful effects in using a calculator at an early age, and if the calculator is used as a teaching and learning aid it will enhance the learning of mathematics;
- the use of a calculator enables students to spend more time solving problems conceptually; and
- since real mathematics means knowing a variety of strategies to solve problems and having the ability to apply them, the calculator enables students to think more abstractly allowing children to solve problems of solutions that are within theoretical but not computational grasp.

Hembree and Dessart's (1986) findings reveal that the use of a calculator helps the teacher to achieve the aims of teaching and learning mathematics set by the National Curriculum Statement on Mathematics: Grade 7-9 (DBE, 2011).

This research is aimed at investigating the influence a scientific calculator has on teaching and learning fractions at Grade 8 level. The problems that students encounter when dealing with fractions is well recognised in literature by many researchers, such as (Steffe & Olive, 1991), (Carpenter, Hiebert, & Moster, 1981), (Davdov & Tsvetkovich, 1991), (Newstead & Murray, 1998), and (Housemann, 1981) in (Hiebert, Carpenter, Fennema, Fuson, Human, Murray, Olivier and Wearne, 1997). These researchers identified the following problems in the teaching and learning of fractions:

- the vague way in which fractions are obtainable; and
- the predisposition to present algorithms for the procedures on fractions before learners have understood the concepts.

As a mathematics teacher for years through practice and observation, I concur with the results from the discussed researchers, that the method of teaching of fractions contributes a lot towards a learner mastering of the fraction concept. Students as far as Grade 10 still do not understand a simple concept like the common denominator, its purpose and when to use it. It has occurred to me, that this comes to learners as a mere routine, and one tends to wonder whether the merits of developing a common denominator has been fully explained before application. It is from such questions that the definition of learning needs to be addressed according to research and theories of education.

Constructivism as a theory is concerned with how individuals learn and places the individual as the active person in the process of thinking, learning, and coming to know. (Ornstein & Hunkins, 2004) point out that a learner cannot passively accept information by

mimicking the wording or conclusions of others, but rather the learner must engage himself or herself in internalising and reshaping or transforming information via active considerations.

According to socio-constructivism, knowledge is the dynamic product of the work of individuals operating in communities, not a solid body of immutable facts and procedures independent of mathematics. From this perspective, mathematics learning is considered more as a matter of meaning-making and of constructing one's own knowledge, rather than memorising mathematical results and absorbing facts from the teacher's mind or the textbook (Jones, 1997).

However, based on constructivism and social constructivism in mathematics education, it is important to note that successful learning of mathematical concepts and skills is a function of the approaches and strategies that teachers use in their teaching. The manner in which mathematics is taught is, to a large extent, influenced by the perceptions that teachers have regarding the subject, their methodology, and what they believe to be good teaching practices. Understanding fractions is vital in other mathematical concepts, such as trigonometry and algebraic fractions, and in these mathematical concepts a calculator will not provide the final answer.

Thus, through this study, the researcher hopes to be able to give an informed recommendation to Grade 8 mathematics teachers and curriculum developers regarding the influence of a calculator in the teaching and learning of fractions in Grade 8 learners in South Africa.

The researcher chose Grade 8 because this marks the beginning of high school. Teachers' approaches to mathematics learning at this stage is vital, since they will instil a better attitude towards the subject in high school and may improve their learners' achievement in mathematics in the years to come.

1.2 Statement of the Problem

The researcher's experience in teaching fractions and the importance of this concept in future concepts require teachers to be careful when teaching fractions. The results established by research regarding the use of a calculator in mathematics education by (Hembree & Dessart, 1986), (Suydam, 1997), (Ellington, 2006) and (Mbugua, Muthoni & Okere, 2011) encourage

the use of a calculator. However, a calculator provides an answer in questions that involve fractions without necessarily knowing the method. Learners doing fractions from the latter will never be able to apply the fraction concept later on in mathematics. Therefore, this encourages one to question whether the use of calculators in learning fractions will hinder the learners' learning of the fraction concept or not. Therefore, my research question is:

Is there a difference in the learners' conceptual understanding and performance during calculator-aided instruction or during non-calculator-aided instruction in the learning of fractions at Grade 8 levels?

1.3 Aims and Objectives of the Study

The main purpose of the research is to investigate whether or not the use of a calculator in teaching and learning improves learners' conceptual understanding and performance through the way learners answer problems in fractions and their performance during a calculator-aided instruction. The study is aimed at achieving the following objectives:

- to enable the curriculum developers and the curriculum implementers make an informed decision regarding the use of a calculator in the classroom.
- to provide the mathematics teacher with an understanding of the advantages and disadvantages of using a calculator in teaching fractions, as well as learners' misconceptions in the learning of fractions.
- to enable mathematics teachers and the parents distinguish between facts and myths regarding the use of calculators.
- to enable the teacher to use the calculator appropriately in the classroom.

1.3.1 Hypothesis

(a) There is no significant difference in conceptual understanding and performance of fractions in a calculator aided instruction and a non-calculator aided instruction.

Or

(b) There is a significant difference in learners' conceptual understanding and performance of fractions in calculator-aided instruction and non-calculator-aided instruction.

1.4 Research Design and Methodology

This research follows a quantitative research approach, a quasi-experimental research design and social constructivism as the research paradigm. The quantitative research approach emphasises objectivity in measuring and describing phenomena. Experimental, as a sub-classification of quantitative approach, includes an intervention for participants. The researcher intervenes with a procedure that determines what the subjects will experience. Quasi-experimental research design approximates a true experimental type and involves a random assignment of subjects so that each subject used will have equal chances of participating in each group (McMillan & Schumacher, 2010).

In this research two groups of learners (control and experimental) were taught fraction concepts using different approaches, by different teachers, but during the same time. In the control group the fraction concepts were taught and assessed using a strictly traditional paper and pencil method, no calculator was used. However, in the experimental group the same concepts were taught and assessed in exactly the same way as the control group, but this group was permitted to use a calculator as a learning aid. In the experimental group learners were taught all the necessary steps in applying a fraction concept, but they were allowed to use calculators to do all necessary calculations, and the use of a lowest common denominator was not stressed.

1.4.1 Demarcation of the Study

The target population was all Grade 8 learners at a high school in Johannesburg East District in Gauteng, South Africa. The school had a total of 120 Grade 8 learners. Since the researcher is a teacher at that school it was convenient for her to use the school due to its close proximity which alleviated transport and time constraints, thereby reducing the cost of carrying out the research. A sample of 30 learners was used in conducting the investigation.

1.4.2 Sampling

Purposeful sampling was used to select the sampling frame from which the sample was obtained. A diagnostic test on fractions was given to all Grade 8 learners. All learners who scored below 40% were selected as the sampling frame. Samples of 30 learners, and two extra

learners in case of dropouts, were randomly selected from the sampling frame to be either in the experimental or control group. Each group consisted of 15 learners and one extra in case of dropouts.

1.5 Literature Review

The literature review included the research on the role of calculators dating back as late as 1976 and 1980 through a study by Suydam in 1987 consisting of 75 studies from 1960 through 1970. Although Suydam's research concluded that the learners who used a calculator performed better than the learners who did not. Contrary to Suydam's conclusion, 50% of the learners used in the research showed that there was no difference between the learners who used a calculator and those who did not a calculator. However, (Suydam, 1987) made a valid point towards the teaching of fractions by stating that the use of a calculator enables the teaching of concepts like estimation, long division and decimals to be taught before fractions than if learners do not have a calculator. This forms an important foundation for the grasping of the fraction concept.

The research on the role of calculators includes the research by (Humbree & Dessart, 1986) that concluded that, apart from improving learners' aptitudes the calculator develops students' conceptual thinking as well as helping them to achieve mathematical abilities and self-confidence. This was supported by (Maxwell *et al.*, 2004), (NCTM, 2000) under the technology principle, Ellington's meta-analysis research of 2006, (Mbugua, Muthoni & Okere, 2011) as well as (Ochanda & Indoshi, 2011), these researchers concluded that the merits of the use a calculator in teaching and learning clearly outweighed the demerits of using a calculator.

Not all researchers could conclude that the calculator was better than the traditional paper pencil for instance, (McNamara 1995), she concluded that the use of a calculator neither do good or bad for school children. This implies that none of the studies could show that a calculator was indeed harmful to learners' learning in the classroom.

Research by (Pomerantz, 1997) and (Risser, 2011) on the other hand, points out that the effective use of a calculator in the classroom regardless of the positive reports from research, is hindered by the people's attitude towards the calculator rather than on the merits or the demerits of the calculator which (Pomerantz, 1997) labels as myths instead of facts.

However, as a teacher with so much experience in teaching mathematics, I cannot ignore the negative impact inappropriate use of a calculator has on the teaching and learning of fractions especially in conceptual understanding. On the other hand, what (Pomerantz, 1997) refers to as myths cannot not be ruled, but it is the responsibility of the teacher to not turn myths into facts. For example in this problem ($\frac{2}{3} + \frac{3}{5}$) a calculator can enable a learner to get the answer to this question without gaining conceptual understanding and, unfortunately if the teacher does not guard against this, this will defeat the whole purpose of learning and later-on education.

Research in education is aimed at enhancing learning, (McMillan & Schumacher, 2010). In order to address this reason, my literature review also looked at the definition of learning, its three critical components from (Mayer, 2002) in a comprehensive study by (Ambrose, Bridges, DiPetro, Lovett & Norman 2010) and the principles of learning and its implications on the teacher. The learning principle according to National Council of teachers of Mathematics (2000) also forms part the literature reviews to inform the study on what mathematics learning wishes to achieve in a learner.

Since learning lies heavily on effective teaching, (NCTM, 2000), the NCTM teaching principle forms part of the literature review for this study. Theories of teaching and learning in mathematics education from the theories of constructivism as well as the definition of mathematics from South African Education Curriculum (CAPS), (DBE, 2011) and its objective could not be ignored as this informed the study on the concepts suitable for the South African Grade 8 mathematics learner.

A research on the fraction concept is also analysed, its definition and the fundamental facts about fractions. The previous studies conducted in the teaching and learning of fraction in South Africa by (Lukhele, Murray, & Olivier,1999) on teaching and learning of fractions formed part of the literature review to establish the challenges associated with the teaching and learning of fractions in South Africa.

The role of the calculator, the definition of learning focusing mainly on mathematics education; the fraction concept and misconceptions in learning fractions as well as the previous studies on the teaching and learning of fractions formed part of the literature review in order to shade light on what was already done on the study and what still needs to be done on the study. These topics were done in order to reflect the challenges in the implementation of the previous findings, in order to address the research problem at hand.

1.6 Instrumentation

Data were collected through three tasks, namely a post-test, an assignment, and a questionnaire.

Tasks. A diagnostic **test** was administered to all Grade 8 learners in the school under examination condition in order to sample the learners for the study. This was followed by post-test and an **assignment** on fractions after intervention on two different days. The results of the two groups were compared. Each task had a duration of two hours. The test was written under examination conditions and learners were not allowed to consult their textbooks or notebooks. An assignment was given to learners after the intervention, but this was administered in class under the teacher's supervision, and learners were not allowed to discuss with each other but could consult their textbooks. Questions were all structured in the same way, and learners were expected to show all necessary workings out. The questions tested their knowledge of all fraction concepts, word problems, and algebraic fractions. All the three tasks were marked using a memorandum relevant to the task.

Questionnaire. A questionnaire was administered to the experimental group to establish learners' perceptions and attitudes towards the use of a calculator in learning fractions in relation to traditional paper and pencil. Responses were ranked on a five-point Likert scale. All 15 questions were closed questions where learners were supposed to indicate whether they agreed or disagreed with the statements given.

1.6.1 Pilot testing

A pilot testing was performed on the questionnaire before administering the questionnaire to the learners being used in the investigation. This was done in order to establish whether or not the questions were going to be clear to the learners being used in the investigation. The pilot test was administered on the grade 8 learners who were not part of the sampled learners.

1.6.2 Moderation

The assignment and both tests were validated by the school's head of the mathematics department, the school's Grade 8 teachers, and the district's mathematics subject specialist to ensure that the tests and assignment met the requirements of the curriculum assessment

guidelines and that the content was suitable for Grade 8 levels.

1.7 Data Presentation and Analysis

The learners' test and assignment results were recorded and presented in frequency tables. A pie chart, a box and whisker plot were used to compare learners' performances in the test, and a frequency polygon was used to compare learners' results in the assignment. Learner's responses to the questionnaire were compiled as a percentage, and a compound bar chart was drawn to clearly show the responses. The statistical software package used to analyse the data was *Stata VII*. A Pearson's chi-square test was used to test for associations between categorical variables. A rank-sum test was used to compare overall scores between the two groups. Man-Whitney test was conducted to compare the overall results of the post-test results per group. The results were presented in a tabular format. The interpretation was performed at 95% confidence limit. A test for internal consistency was performed through the use of Cronbach's alpha, with a cut-off point of 0.7.

1.8 Clarification of Terms

- **Fraction** is defined a fraction as “a way of representing divisions of a whole into parts. It has a form $\frac{\text{numerator}}{\text{denominator}}$ where the numerator is the number of parts chosen and denominator is the total number of parts”. The Department of Computer Science at George Mason University, USA.
- **Scientific Calculator** is a tool not only to perform mathematical computations, but it is also a tool for learning mathematics (Boon, 2009).
- **Learners** refers to children attending both primary and secondary school (Grades R-12). In this research, it simply refers to children in Grade 8 at the school the research was being conducted at and any child of school-going age (DBE, 2011).
- **Learning** in this research refers to a process that leads to change and it occurs as a result of experience and increases the potential for improved performance and future learning (Mayer, 2002).
- **Performance** is what can be observed and measured during instruction or training, (Soderstrom & Bjork, 2015). In this research learners' performance was used to measure conceptual understanding.
- **Conceptual Understanding and Conceptual knowledge** means comprehension of

mathematical concepts, operations, and relations in such a way that it allows a student to apply and possibly adapt some acquired mathematical ideas to new situations. Balka, Hull and Miles (2011). Herbert, (1986) in (Hierbert & Gouws, 2009) points out that conceptual knowledge is knowledge that is rich in knowledge, a network in which the linking relationships are as prominent as the discreet pieces of information. In this research the definition of conceptual understanding refers to a deep knowledge in the fraction concept that enables a learner to apply and adapt the knowledge to new situations and learners' performance will be used to measure conceptual understanding or conceptual knowledge. Conceptual Knowledge and conceptual understanding means the same in this research.

- **Attitude** can be defined as a set of beliefs developed in a due course of time in a given social cultural setting. Positive attitudes facilitate learning. If a learner is reluctant to learn he or she does not have a positive attitude, he or she does not produce any result. (Verma, 2005).
- **Mathematics Anxiety** is defined as a feeling of tension and nervousness that interferes with the manipulation of mathematical problems in a wide variety of ordinary life and academic situations (Richardson & Suinn in Thijsse, 2002).
- **Intrinsic motivation** is characterized as that motivation which comes from within the individual. It inspires action even when there is no perceived external stimulus or reward. While **extrinsic motivation**, in contrast, provides incentive to engage in action which may not be inherently pleasing or engaging, but which may offer benefits in terms of perceived potential outcomes (Stirling, 2014). Intrinsic motivation is referred as motivation in this research.
- **Confidence** is a mental attitude of trusting in or relying on; firm trust, reliance, faith assured expectation, assurance arising from reliance on oneself, circumstances, *et cetera*.

(Norman & Hyland, 2003).

1.9 Layout of the Study

Chapter 1: Introduction/background of the investigation.

Chapter 2: Information on reviewed existing literature.

Chapter 3: Research design and methodology of the study.

Chapter 4: Deals with data presentation, analysis, and interpretations of results of the data.

Chapter 5: Summary, conclusions, and recommendations.

1.10 Conclusion

Research and mathematics education advocates the use of a calculator as a learning aid in mathematics. Unfortunately, many teachers despise the use of calculators in the classroom because they believe that calculators hinder the learner's understanding of the fraction concept, thereby hindering learners in applying the concept to situations in the future. The need to justify the authenticity of the teacher's claims on fractions motivated this study. The next chapter will look at the literature review on fractions, theories of learning, mathematics education both internationally and locally, and the influence of the calculator in mathematics education.

Chapter 2: Literature Review

2.1 Introduction

This chapter seeks to present the literature review on the influence of technology in the teaching and learning of mathematics, with the major focus on the advantages and disadvantages of a scientific calculator; and to investigate the myths associated with the use of a scientific calculator. This chapter also discusses the principles of learning, theories of mathematics teaching and learning, the mathematics definition and the aims of mathematics in South Africa and internationally. This chapter focuses on the nature of a fraction, the teaching and learning of fractions, learners' misconceptions regarding fractions, and mistakes that teachers make when teaching the fraction concept resulting in learners struggling to understand the concept.

This chapter will also look at mathematics anxiety its definition and causes. Mathematics anxiety affects learners' confidence and results in poor performance, therefore addressing it in relation to use of a calculator might result in credible recommendations. Apart from mathematics anxiety, a brief discussion on theories in mathematics education is discussed as part of the literature review, because an effective teaching aid (calculator) needs to be in line with the expectations of mathematics education. Since the research is aimed at providing the curriculum developers and curriculum implementers with information to make an informed decision with regards to the use of a calculator in the classroom. Theories of constructivism will be discussed since constructivism approach to teaching and learning is vital in mathematics education, (Major, 2010). Particular emphasis will be placed on social constructivism since this is the approach that the study embraced when teaching fractions during the research study, and is also embraced by the principle of learning, (NCTM, 2000).

The appropriate use of a calculator is an important factor to bear in mind when trying to establish whether or not a calculator is effective in the teaching of fractions. Thus, the aims and objectives of South African mathematics education will be discussed in this chapter to inform the researcher of such aims and objectives, and to verify whether or not the use of calculator supports these aims and objectives. Performance is not only measured by marks, but by achieving the goals and objectives of South African mathematics education. An

understanding of the NCTM and CAPS aims and objectives of mathematics education are vital in this research because the researcher intends to produce learners who will be competent in mathematics both locally and internationally.

In Chapter 1 of the study rationale, teachers expressed concern as to whether or not learning with a calculator equips learners with the necessary concepts to apply later on in mathematics. In order to answer this question, a brief explanation of misconceptions already established in teaching fractions will be discussed, and a distinction of relational and instrumental understanding will be attempted because failure to adopt relational understanding will result in learners not gaining conceptual understanding.

2.2 Teaching and Learning

The NCTM (2010) points out that the improvement in learners' performance implies that learning and effective teaching has taken place, and effective learning is a result of effective teaching, which is observed through learners' performance, NCTM. It is for this reason that a brief discussion will take place regarding what learning entails, and what constitutes effective teaching in mathematics education.

2.2.1 What is learning?

According to Mayer (2002) in (Ambrose, *et al.*, 2010) define learning as an important change procedure. It takes place as a result of practice, and increases the potential for better performance in forthcoming learning. As stated in Chapter 1, the major aim of this research is to investigate whether there is a significant difference in the learners' performance in calculator-aided instruction and non-calculator-aided instruction. The researcher agrees with Ambrose's definition that learning is a procedure, and if achieved it increases performance. Increasing performance is a process that involves several procedures to achieve it. It is for this reason that the critical components of Ambrose, *et al.*, 's definition to learning, its principles, and its implications on the teacher will be discussed, since they will form the basis of deciding whether or not the calculator was effective. (Ambrose, *et al.*, 2010).

Ambrose's definition consists of three critical components (Mayer, in Ambrose *et al.*, 2010):

- Learning is a procedure not a result. Since this procedure occurs in the mind, inferences can only be made that it occurred from students' products and performances.
- Learning involves alteration and unfolds in due course in the understanding, philosophy, behaviours, or attitudes, and has a permanent impact on how students reflect and perform.
- Learning directly results in how students react to their conscious and non-conscious past and current experiences; it is something they accomplish themselves instead of what is completed for them.

These critical points reinforce the assertion that learners' accomplishments, as evidenced by better performance entail effective learning. It further links performance and learning via learners' understanding, philosophy, behaviours, and attitudes. This research will evaluate the effectiveness of a calculator in the light of the above critical components. Furthermore, this research seeks to evaluate how the calculator effectively influences learners' learning from a learners' perspective—a critical component of Ambrose, *et al.*, define learning as what learners accomplish themselves instead of what is completed for them.

Ambrose, *et al.*, (2010) identified seven principles of learning, and these principles enable teachers to do the following:

- to recognise teaching approaches and strategies that support student learning;
- to adopt teaching approaches and strategies that effectively foster students' learning in a given context; and
- to use and carry them out in other concepts.

The results of this research are aimed at improving mathematics education in South Africa via the recommendations it will provide to those who develop and implement the curriculum in South Africa. In light of this goal, embracing the principles of learning with the intention of the above-mentioned points, it will allow the research to make well-informed recommendations.

Ambrose *et al.*, (2010) identified seven learning principles that influence learners' learning. These are:

- students' prior knowledge can help or hinder learning;
- how students organise knowledge influences how they learn and apply what they know;
- students' motivation determines, directs, and sustains what they do to learn;
- to develop mastery, students must acquire component skills, practise integrating them, and know when to apply what they have learned;

- goal-directed practice coupled with targeted feedback enhances the quality of students' learning;
- students' current level of development interacts with the social, emotional, and intellectual climate of the course to impact learning; and
- to become self-directed learners, students must learn to monitor and adjust their approaches to learning.

To fully evaluate the effectiveness of the calculator in learners' performance these principles will be embraced because they present a basis to successful learning, which forms part of the objectives of learning.

Learners' prior knowledge will be taken into consideration in order to design learning material that will be used during the intervention. How students organise their work will be observed to measure learners' confidence in their work. Acquiring component skills and knowing when to use them will enable learners to gain conceptual understanding, and using the calculator to check whether their answers are correct will help the learners to confirm their answers and this gives the learners a chance of redoing the problem without the teacher. The ability of the learners to confirm their solutions on the calculator enables the learners to interact with the questions on their own and correct it or express it in the same format to prove the two answers are correct, through this interaction with the calculator the learners will master the concept. The ability of the calculator to act as a tool that enables learners to monitor their work will motivate the learners, directs and sustains what they learn when doing mathematics. Furthermore, the calculator interacts with the learners emotional and intellectual climate as stated by Ambrose *et al.*, (2010).

2.2.2 Learning According to the National Council of Teachers of Mathematics (2000):

The NCTM learning principle

The NCTM (2000) learning principle points out that students must learn mathematics with understanding, and actively build a new knowledge while building on prior knowledge. This requires understanding and being able to apply measures, concepts, and processes. This notion is vital in this research since it helps the researcher to measure learners' conceptual understanding.

The NCTM (2000), states that learning with understanding supports mathematics' aim of creating independent learners, and that students' learning is expanded and improved if they are

in charge of their learning by defining their goals and monitoring their development.

According to the NCTM (2000), school mathematics programmes will enhance students' innate desire to understand what they are asked to learn, and boost learners' understanding by actively engaging students in tasks and experiences intended to intensify and connect their knowledge. Additionally, it asserts that appropriate classroom communication enables students to propose and share mathematical ideas and conjectures throughout the year.

Since this researcher's main aim is to investigate whether or not there is a significant difference in conceptual understanding if a learner uses a calculator or not. In other words this implies that the research, seeks to address whether the calculator hinders learners' conceptual understanding or not. An in-depth understanding of the NCTM (2000), a body that informs mathematics education both locally and internationally provides an established basis of what mathematics education hopes to achieve in a learner.

Furthermore, the researcher's application of mathematics understanding from the NCTM's perspective enables the researcher to investigate a calculator's effectiveness through analysing learners' answers to questions, and attitudes towards the use of a calculator, and their performance after an intervention. The researcher's assumption is that a learner's ability to perform better in tests after intervention is an indication that the learner can work independently while the learners' ability to answer algebraic questions better will confirm a better conceptual understanding, and lastly the researcher's ability to draw such conclusions is an indication that the calculator does not hinder conceptual understanding given instead it enhances it.

The notion pointed out by the (NCTM, 2000) that students must learn mathematics with understanding, clearly shows that understanding is a major goal for mathematics education. In support of NCTM, (2000) notion of teaching mathematics for understanding, (Simon, 2006:359) stated: "Recent discourse in mathematics education has coalesced around the importance of focusing on and fostering students' mathematical understanding. This agreement among mathematics educators has led to a commitment to generate new learning goals for students that are less skewed in favour of skill and facts learning and more focused on student thinking".

It can be concluded from this discussion that understanding forms an integral part in this research as it does in the NCTM (2000) principles of learning. However, in adopting a

learning aid such as a calculator, it is important to ensure the tool enhances understanding instead of adversely affecting it. Understanding in mathematics education is differentiated into instrumental and relational understanding. A discussion of these types of understanding clearly informs the research question as to whether the calculator enhanced conceptual understanding or hinders it, since conceptual understanding is grounded in these forms of understanding, this will enable the researcher to provide an informed recommendation on the research question raised in Chapter 1.

2.2.3 Relational Understanding versus Instrumental Understanding

Skemp (1976) and Xin (2009) identified the advantages of “*instrumental understanding* (knowing how) over *relational understanding* (knowing both how and why)” as follows: instrumental understanding is easier to understand; it is more immediate and more evident; and it is faster in getting to the correct answer. (Skemp, 1976) points out that instrumental understanding is like getting a verbal instruction to go to a place one has never been, which means one has to rely heavily on one’s memory of the given instruction to get there. While relational understanding is like being given a map to get to the same place. Therefore, the difference is in instrumental understanding, as illustrated above, one has to rely on memory to get to this new place, while in relational understanding one figures out how to get to a place with the aid of a map for directions, and thus one is most likely not to forget.

Skemp (1976) pointed out that due to its nature, instrumental understanding results in memorisation of rules and algorithms which are likely to be forgotten or misinterpreted, whilst relational understanding involves taking responsibility for one’s own learning by generalising and forming one’s own algorithms, which is not conducive to forgetting. However, this implies that in terms of mathematics education, relational understanding of mathematics has the following advantages over instrumental understanding of mathematics: relational understanding is (a) more compliant to new tasks; (b) easier to memorise than instrumental understanding; (c) useful as a goal; and (d) pure in quality. (Skemp, 1976).

Skemp (1976), points out that most teachers regularly make use of rhymes to facilitate students’ comprehension of mathematical properties, and this results in learners gaining instrumental understanding. As opposed to instrumental understanding, relational understanding is aimed at making the student aware of the very reason behind every mathematical action (or manipulation), for example solving x in the equation $3x-2 = 4$, a

teacher employing instrumental understanding would tell the learner to shift the 2 from the left side of the equation to the right side and then change the sign from negative to positive. The learner in this situation is taught that when a number skips the equal sign it changes from addition to subtraction, from subtraction to addition, division changes to multiplication, and multiplication changes to division. Although there is nothing fundamentally wrong with this approach, this approach to mathematical understanding has created many misconceptions and resulted in confusion, because students do not understand why this regulation governs this mathematical action. Contrary to this procedural regulation, a teacher aims at relational understanding that stresses the operations of equation properties, like adding or subtracting the same number on both sides of an equation, and balances the equation. This results in the students applying relational understanding, adding 2 to both sides as follows: $3x - 2 + 2 = 4 + 2$, resulting in $2x = 6$ (Xin, 2009). In this way the learner understands the rationale behind the mathematical action and this allows him or her to apply with the acquired knowledge.

A teacher who adopts instrumental understanding therefore produces procedural knowledge, whereas the teacher who adopts relational understanding produces conceptual knowledge (Xin, 2009). Hiebert and Lefevre (1986:3-4) in (Xin, 2009) define conceptual knowledge as “knowledge that is rich in relationships ... a network in which the linking relationships are as prominent as the discrete pieces of information”. (Xin,2009) points out that it is for this reason that effective classroom teaching for mathematical understanding regards connection as a key aspect of understanding.

The preceding discussion lays out the major advantages of aiming for relational understanding rather than instrumental understanding in education. If the calculator enables learners to achieve relational understanding, then it implies that it does not hinder learners’ conceptual understanding.

2.3 Teaching

The effectiveness of teaching should be guided by certain principles, and hence the need to look at the NCTM (2000) teaching principle, which guides teaching both locally and internationally. The NCTM’s (2000) teaching principles lay out what is considered successful teaching in mathematics; meeting these principles results in improved learners’ performance. An analysis of teaching and learning with the aid of a calculator with one

group and without a calculator in another group, the ability by the learner to successfully show all steps to a fraction question as well as the ability by the learner to successfully solve an algebraic fraction in either one of the two groups implies the learner has gained conceptual understanding. Furthermore, the ability of one group to obtain better marks than the other group, implies that the calculator either enhances or does not enhance learners learning of fractions. A poor performance means that these principles were not met, and hence teaching would was not effective.

2.3.1 The National Council of Teachers of Mathematics' Teaching Principles

The NCTM (2000), points out that understanding what the students know, what they need to learn, testing them, and then providing support for them to learn well is pivotal to effective mathematics teaching. The knowledge the teachers make available to students enables them to learn mathematics. This implies that the teaching the learners encounter in schools shapes the students' understanding of mathematics, their ability to use it to solve problems, and their confidence in, and disposition towards mathematics, (NCTM, 2000).

The NCTM (2000), points out that successful teaching of mathematics involves knowing and understanding mathematics and students as learners, and the educational strategies that are involved in successful learning. It states that successful mathematics teaching requires a demanding and encouraging classroom learning environment. According to (NCTM, 2000:14).

“Teachers establish and nurture an environment conducive to learning mathematics through the decisions they make, the conversations they orchestrate, and the physical setting they create”.

It argues that this environment should support learners' discussion and association, students should be encouraged to justify their thoughts, and if working with conjectures, learners should be exposed to a variety of approaches.

2.4 Theories and Approaches to Mathematics Learning and Teaching

Constructivism theory, with particular attention to socio-constructivism guides mathematics education. An analysis of constructivism, as a theory in education and its contribution to mathematics education provides a guideline on what mathematics learning hopes to achieve. An understanding on how the calculator relates to these theories enables one to show whether a calculator as a teaching and learning aid will be acceptable or unacceptable.

2.4.1 Constructivism

Constructivism theory and the constructivist approach to learning as a learning and teaching theory will be embraced in this research, hence the need to address it in more detail. Xin (2009) points out that the theory of constructivism has an important foundation in distinguishing between relational and instrumental understanding. However, the link between relational understanding knowledge and conceptual knowledge brings the need to analyse constructivism in detail since the research is aimed to enhance learners conceptual understanding.

Furthermore, constructivism will play an important role in designing teaching materials for both groups in this research. Failure for this research to spell out what these theories entail results in no common ground being achieved between teaching calculator-aided instruction and teaching non-calculator-aided instruction. The intervention in both the control and experimental group will be based on these theories, with the only difference being that the experimental group will use a calculator but the constructivist approach will be enforced in both groups. Learners' improved performance in either group reveals that either the calculator had an effect on learner performance or not.

The traditional approach to mathematics teaching and learning has been extensively censured by education critics for failing to recognise learners as persons who are capable of constructing their own knowledge. This critique is grounded mainly on the traditional approach a transmission-type approach which inevitably leads to one-sided knowledge, which is mainly reconstructed objective information, while the intent is that one-sided knowledge should be experienced by the learners as individual constructions and not reconstructed objective knowledge. Murray in (Simon, 1995).

As a learning theory, constructivism describes the course of knowledge creation as an active,

rather than an inactive process. Constructivists strongly believe that learners' minds should not be regarded as blank vessels in which knowledge should just be deposited into, without the learners' active participation in the learning process to create such knowledge (Major, 2012). Hausfather (2001) noted that constructivism is not a technique, it is a conjecture of knowledge and learning and hence it should inform the exercise not stipulate the exercise. The significance of teaching learners in context, the use of previous knowledge, and the active interaction of learners and the content is therefore emphasised in constructivism (Major, 2012). From a constructivist perspective, knowledge is constructed through among other things, the individual's communications with the environment (Major, 2012). The constructivists do not concur with the traditional form of learning wherein the teacher plays an active position in the teaching and learning environment and learners submissively accept the content; instead constructivists advocate a learner-centred approach (Major, 2012). They argue that learners cannot submissively understand information by mimicking the wording or conclusions of others, rather the learner must engage himself or herself in internalising, reshaping, or transforming information via active considerations (Orstein & Hunkins 2004).

Constructivists loathe the teaching philosophy that suggests that learners are blank vessels, which Freire in (Major, 2012:141) refers to as the "banking concept" education. This philosophy results in the teacher dominating the teaching learning environment and hinders learners in making their own constructions, thereby defeating the intention of mathematics education. Mathematics is a subject that requires learners to be fully occupied in order for learning to take place (Major, 2012).

Reys, Suydam, Lindquist, and Smith (1998:19) identified three basic tenets on which constructivism rests. These are:

- knowledge is not passively received but rather knowledge is actively created or invented (constructed) by students.
- students create (construct) new mathematical knowledge by reflecting on their physical and mental activities and
- learning reflects a social process in which children engage in dialogue and discussion with themselves as well as others (including teachers) as they develop intellectually.

Constructivism is divided into three major types, namely, radical constructivism, social-constructivism, and socio-constructivism. However, the latter is mainly embraced in mathematics education, Major, (2012).

2.4.2 Socio-constructivism

According to socio-constructivism theory, mathematics is an inspired human activity and mathematical learning occurs as students build up efficient ways to solve problems. Piaget (1896-1980) in (Geary, Brogan, Singer & Gauvin, 2009) points out that knowledge is an active result of the work of persons operational in the communities, not a rock-solid body of unchangeable details and measures free of mathematicians. In this view, learning is considered more as a matter of meaning making and of constructing one's own knowledge than of memorizing mathematical results and absorbing facts from the teachers' mind or the textbook; teaching is the facilitation of knowledge construction and not delivery of information.

Advocates of socio-constructivism theory argue that when individuals (learners as well as teachers) interconnect with one another in the classroom, they share their views and experiences, and along the way, knowledge is constructed. Knowledge is acquired during the sharing of experiences, therefore it is collectively constructed (Ernest, 1991; Stein, Silver & Smith, 1998).

Cobb, Yackel, and Wood (1992) point out the following characteristics of socio-constructivism:

- mathematics ought to be taught during problem-solving;
- students ought to interrelate with teachers and other students; and
- students are inspired to work out problems based on their own strategies.

Mathematics learning from a socio-constructivism perspective involves interaction between the teacher and learners. The effectiveness of a calculator is noted when it is able to initiate grounds for this socialisation that builds confidence in mathematics according to the socio-constructivism theory. This confidence in mathematics will be observed from learners' performance and their testimonials after using a calculator. Learners' confirmation that the calculator boosted their confidence coupled with improved marks establishes the calculator as an acceptable tool in mathematics education. However, merely increasing confidence and failing to produce improved results implies that calculators affect learners' conceptual understanding, hence confirming teachers' fears that calculators are tools that hinder conceptual understanding.

2.4.3 The Social Constructivist Approach to Mathematics Learning

The social constructivist approach to mathematical learning emphasises classroom learning

as a process of both individual and communal construction. The crucial task of constructivist teacher is to assess the mathematical knowledge of their students and match their teaching methods to the nature of that mathematical knowledge (Xin, 2009). The emphasis of the social cultural approach to mathematical learning is to set mathematical ideas within ethnically controlled activities. Since education is a process of enculturation (or socialisation), engaging learners in communal communication with more knowledgeable experts—in what Lev Vygotsky (1978), in (Xin, 2009) called the “zone of proximal development”—and teachers’ use of ethnically developed symbol systems and ethnically suitable artefacts as emotional tools for instruction is important for learners (Vygotsky, 1978) in (Xin, 2009). Van Oers (1996) in Xin (2009) points out that the managerial features of the shared communication generate the merits of learners’ thoughts and learning.

Vygotsky (1960) in Xin (2009:1) states that internalisation appears first between people as an “intermental” category and then within the child as an “intramental” category. Therefore, it is important that mathematics education embraces the fact that mathematics learning is the initiation into a social tradition of mathematical inquiry, mathematical discovery, and mathematical argument. Solomon in (Xin .2009) points out that the notion that learning is the initiation into social tradition of mathematics inquiry, mathematical discovery, and mathematical argument is relevant to mathematics education.

A teacher who uses the socio-cultural approach to teach mathematics from an enculturation perspective would design learning resources that enable learners to interact with experts, that is, a process of guided participation and interaction of learning by a teacher as the expert via scaffolding through solving problems beyond a student's current capability. Continuing professional development strengthens teachers, teaching assistants, and advanced peers’ expertise in mathematics, while parents can also be trained to become mathematics experts in real classrooms (Xin, 2009).

Preparation of activities and the teaching approaches used during interventions in both the non-calculator-aided and the calculator-aided instruction will embrace the constructivist approach. Learners’ performance will be rated in line with the constructivist approach to learning, and better student performance in one method will confirm that it is better than the other method. As it has already been established that the calculator creates an environment for socialisation, better performance in the calculator-aided instruction confirms that it will not hinder conceptual understanding of fractions, but rather enhance it. This notion is embraced in the teaching of fractions to Grade 8s where the calculator was used in this study in order to enable

learners to interact with learning tasks via scaffolding while the teacher offered facilitation that enhanced understanding.

2.5 Mathematics Education in South Africa

This research is aimed at investigating the effectiveness of a scientific calculator in teaching fractions at Grade 8 level, with the intention of providing recommendations to South African curriculum developers and implementers. It is for this reason that an understanding of the aims of mathematics education in South Africa forms an important part of this research. The ability of a calculator to meet the expectations of the South African mathematics education aims, coupled with improved performance, will enable the researcher to offer well-informed recommendations to mathematics education in the hope of improving learners' performance.

2.5.1 What is Mathematics?

The NCS Curriculum and Assessment Policy Statement, Grade 7-9 (Mathematics) (DBE, 2011:8) states:

Mathematics is a language that makes use of symbols and notations to describe numerical, geometric, and graphical relationships. A human activity, which involves observing, representing and investigating patterns and quantitative relationships in physical and social phenomena and between mathematical objects themselves. It helps to develop mental processes and enhance logical and critical thinking, accuracy and problem-solving that will contribute in decision making.

2.5.2 Aims of Mathematics Education in South Africa

The NCS (DBE 2011:8-9) states the following as the specific aims of teaching and learning mathematics in South Africa. It points out that the teaching and learning of mathematics aims to develop:

- a critical awareness of how mathematical relationships are used in social, environmental, cultural, and economic relations;
- confidence to deal with any mathematical situation without being hindered by a fear of Mathematics;
- an appreciation for the beauty and elegance of Mathematics;

- a spirit of curiosity and a love for mathematics;
- recognition that mathematics is a creative part of human activity;
- deep conceptual understandings in order to make sense of mathematics acquisition of specific knowledge and skills;
- application of mathematics to physical, social, and mathematical problems;
- the study of related subject matter (e.g. other subjects); and
- further study in mathematics.

The NCS (2011:8-9) points out that learners should develop the following in order to develop essential mathematical skills:

- the correct use of the language of mathematics;
- number vocabulary, number concept, and calculation and application skills;
- learn to listen, communicate, think, reason logically, and apply the mathematical knowledge gained;
- learn to investigate, analyse, represent, and interpret information;
- learn to pose and solve problems; and
- build an awareness of the important role that mathematics plays in real-life situations, including the personal development of the learner.

A further study of the new South African document CAPS for Grade 10-12, DBE reveals that its specific aims point out that mathematics education is also aimed at developing fluency in computation skills without relying on the use of calculators.

This does not necessarily mean that the CAPS document prohibits the use of calculators, since the same document – under the topic ‘whole numbers’ – points out that learners can use a range of strategies to perform and check written and mental calculations of whole numbers, including using calculators to do so. Although the curriculum statement for Grade 10-12 mathematics aims at fluency in computation skills without relying on usage of calculators, under the topic ‘statistics’ it is stated that a calculator may be used in the calculation of variance and standard deviation. Moreover, the use of a non-programmable calculator is widely used in mathematics learning and assessment to ease computations, for example in financial mathematics and trigonometry. The CAPS document does not prohibit calculator use but insists its use should not prevent learners from gaining deep conceptual understanding Department of Education, (DBE,2011). The effectiveness of using a calculator in mathematics teaching will be investigated with attention to its appropriate use, its ability to enhance confidence in mathematics, and to improve conceptual understanding, which will be noted through learners’ performance after intervention, since this is a major concern of the policy in terms of calculator usage.

2.6 Research on the role of Calculators

Xin (2009) points out that the use of calculators has a technological contribution to make to learning because it makes learning and teaching attractive, helpful, and proficient for the future (Xin, 2009). Investigation into this topic has helped the researcher to identify the aspects that were covered and their findings, to link previous findings with the researcher's own findings, and to provide well-informed recommendations.

Unfortunately, the researcher could not find recent research that measures the effectiveness of calculators since most of the investigation into this topic was carried out at the time that calculators were introduced, which was about fifteen to twenty years ago. However, most of the recent research is qualitative, basing arguments on what has already been found, and mostly intended to change teachers' and parents' attitudes towards calculators. However, previous research studies were not based on the South African context.

However, this research differs in that it investigates the effectiveness of a calculator with regard to teaching and learning fractions at Grade 8 level (13-15 year olds) in South Africa. Additionally, the researcher embraced the advantages and disadvantages that previous research gathered in terms of the use of calculators in mathematics education, its established advantages as noted by (Hembree & Dessart,1986), and the myths (Pomeranz,1997) associated with its use, thereby considering the full use of calculators in the classroom.

2.6.1 The impact of the calculator in teaching and learning of mathematics

1976 through 1980 about 75 studies were carried out on the effects of a calculator in the teaching of mathematics from late 1960 through the 1970 (Suydam, 1987). These studies investigated achievement within traditional instruction, achievement within special curricula, and students' attitudes towards mathematics. Out of the 95 comparisons made, 47 showed that they were no major differences, 43 showed that the students' test scores in the treatment group that used calculators, scored higher than the control group, which did not use calculators. Based on his studies, Suydam (1987) concluded that that learners who used calculators achieved higher scores than learners who did not use calculators. However, this researcher does not support Suydam's (1987) assertion that the learners who used calculators scored higher marks, since 50% of the studies revealed that there was no difference in

achievement between learners who used calculators and those who did not. Apart from the difference in achievement, (Suydam, 1987) also concluded that with the use of a calculator mathematical concepts like estimation and long division can be introduced earlier to learners, and decimals could be introduced before fractions.

Hembree and Dessart (1986) collated Suydam's (1987) information into one meta-analysis research, which looked at the effects of the calculator on pre-college students. Their study analysed research results of 79 reports on student's achievement and attitudes. One group of students used calculators while the other group did not. Conclusions drawn from this study reflected that calculator usage did not delay learners' attainment of conceptual understanding, instead it notably improved their feelings and self-confidence in mathematics.

Hembree and Dessart's (1986) meta-analysis concluded that aptitude in students using calculators during problem solving increased more than students who did not use calculators. Thus, the calculator was not only helpful in easing computations but it also helped students to select appropriate approaches to a solution. In Grades K12 – with the exclusion of Grade 4 (Hembree & Dessart,1986) concluded that a calculator did not adversely affect students' paper and pencil skills although they had used calculators together with traditional instruction; instead they retain these skills. Hembree & Dessart (1986) also observed that in basic operations and problem-solving across all grades and abilities, calculator use during testing achieved higher achievement scores than did traditional paper and pencil. They concluded that the use of a calculator does not only develop students' conceptual thinking skills, but students also achieve mathematical abilities and self-confidence when using a calculator.

Smith (1996) carried out a meta-analysis research extending (Hembree & Dessart,1986) results on the effectiveness of the handheld scientific calculator. Smith examined 24 research studies carried out between 1984 and 1995 and compared the attitudes and conceptual knowledge of students using calculators to those of students who did not use calculators. Smith (1996) observed that calculator usage increased students' achievements across all grades with statistical significance in the 3rd grade. Similar observations were noted in problem-solving and computations, and he therefore concluded that the use of a calculator did not hamper paper and pencil development skills (Dessart, DeRidder & Ellington, 1999).

This meta-analysis was then followed by Ellington's (2003) meta-analysis of 54 studies.

While Smith's meta-analysis was aimed at extending the conclusions of (Hembree & Dessart 1986), Ellington's (2003) meta-analysis sought to establish whether the effects of the calculator on student achievement established by (Hembree and Dessart 1986) was consistent over time. The following were the results of (Ellington,2003) study:

- students' operational skills and problem-solving skills improved when a calculator was used; and
- the use of calculators improved students' attitudes towards mathematics and the development of basic skills instead of hindering them (Ronau, 2011).

The meta-analysis by (Ellington, 2006) of 42 studies examined graphing calculators in middle, secondary, and post-secondary mathematics. Results of her study indicated that in spite of the form of testing, graphing calculators had a positive influence in students understanding of mathematical concepts. She states that: "There were no circumstances under which the students taught without calculators performed better than the students with access to calculators" (Ellington, 2006:24).

The findings of these four studies were later supported by (Rakes, Ronau, Bush, Niess, Driskell and Pugalee, 2011), who incorporated the studies from (Ellington 2003 & 2006) and (Hembree & Dessart 1986) with an additional 50 studies, including an extensive range of research quality methodologies, and contexts. The results of this study were not contradictory to the results of the previous studies. Rakes *et al.*, (2011:2) argue that: "Few areas in mathematics education technology have had such focused attention with such consistent results, yet the issue whether the calculator is a positive addition to the mathematics classroom is still questioned in many areas of mathematics community, as evidenced by continual studies of the topic".

A laboratory experiment entitled "The Generation Effect" was examined by (McNamara, 1995) at the University of Colorado, and conducted in an elementary classroom. This refers to the findings that when students generate to-be-learned information themselves, both short term and long-term information retention in different situations is enhanced. A pre-test was given to the elementary school children; this was followed by an intervention. The intervention involved elementary school children learning simple multiplication through what (McNamara,1995) referred to as 'generating' (computing the answers) or 'reading' (reading calculator exhibit answers). This was followed by administering a post-test and a retention test after two weeks to both groups, without the use of a calculator, to test which group retained the information faster than the other. Whist one group excelled in the post-test the other excelled

in the retention test, making it difficult to safely conclude whether or not the calculator had an influence on teaching. (McAuliffe, 1995).

A parallel study to substantiate these discussed findings was carried out by (McNamara *et al.*,1995) on adults. The result of the second study did not positively support the previous result, and they concluded that the use of a calculator is neither good nor bad for school children at elementary age. However, this was based on the extent to which basic arithmetic skills were applied (McAuliffe, 1995).

2.6.2 Challenges in the effective use of a calculator

Pomerantz (1997) points out that one factor that hinders the effective implementation of calculator usage in the classroom is that most people believe that mathematics should be hard effort linked to instruction manual computations and manipulations. She points out that calculators can lessen much of that hard work and make it seem revolutionary, hence the stigma and unconstructive words such as “crutches and laziness” are associated with the use of the calculator. Pomerantz (1997) argues that a calculator does not do the mathematical thinking for the learner, the learner looks at the problem, interprets it, formulates the best way to solve it, and later decides whether the answer makes sense or not. Thus, the calculator did not do all the thinking for the learner, it only relieved the computations but the mathematical idea was generated by the students. In other words, the calculator acts much like a television remote control; the person using the remote control decides what he or she wants to watch and then uses the remote control to navigate to the desired channel instead of doing it manually. In support of the use of calculators, Pomerantz (1997) points out that the calculator enables students to look at what she referred to as the “whys” instead of the “hows” of the mathematics problem, they help students to formulate and test conjectures, and to verify their solutions. The use of a calculator instantly clears the student’s confusion in terms of answering and understanding some mathematical concepts, and this enables them to carry out mathematical investigations more easily, giving them an opportunity to make more complex and insightful discoveries.

Operand, in Pomerantz (1997) argues that the use of a calculator makes the problem-solving process easier than paper and pencil because students are able to focus on solving the problem instead of focusing on rote computations and manipulations of symbolic algorithms. For this reason, students who use calculators display a better understanding than learners who use

the paper and pencil method. In addition, Pomerantz (1997) points out that the use of calculators speeds up computations, allowing students more class time to do real mathematics. However, Pomerantz (1997) states that several investigations and studies have since established that the use of a calculator increases students' mathematical abilities and confidence in the work that they will be doing, relieves anxiety in mathematics, makes learners more determined and eager to solve mathematical problems, and creates a positive attitude towards mathematics (Pomerantz, 1997).

Pomerantz (1997) points out that instead of learners passively receiving knowledge from the teacher from examples that the teacher gives, the students tend to be more actively involved when using a calculator, thereby encouraging them to develop their own examples and formulate their own hypotheses. Pomerantz (1997) argues that this provides students who were once discouraged or challenged due to tiresome, time-consuming computations the chance to improve on their understanding and performances in problem-solving.

A study was carried out in Arizona involving 501 7th and 8th Grade students from a middle school located in the suburbs of a large south-western city consisting of Hispanic, White, Native American, African American, and Asian students. The study incorporated calculators into the middle school mathematics curriculum and assessed the effects on student achievements in mathematics and the attitudes of students, parents, and teachers. Bright and Waxman (1994) established that students' mathematical performance improved extensively when they used a calculator, 8th grade students improved in all three of the basic mathematical skills, namely concepts, problem-solving, and computation, while the 7th graders improved in computations. The results were established by observational data and showed that the teacher, who successfully implemented the calculator in her class was the one whose students performed considerably better in all three tests both with and without a calculator (Bright *et al.*, 1994).

Maxwell, Devereax, May, Ryan, Bridgeman, Goss, Foss and King (2004:4) state that the calculator has the following benefits in the teaching and learning of mathematics:

- calculators encourage connectivity to previous calculators, data-gathering devices, computers, and internet;
- a calculator's software can be upgraded;
- calculators are helpful in applications such as simulations, place value, and dynamic geometry activities; and
- are useful in calculating information for several graphic formats such as pie graphs, bar graphs, and scatter plots.

However, Maxwell *et al.*, (2004) emphasise that the teacher must be guided in deciding where and how a calculator should be used in the provincial mathematics curriculum and resource materials. This implies that the use of a calculator should be implemented when it supports curriculum outcomes. Maxwell *et al.*, (2004) point out that although the use of a calculator may be advantageous in developing and consolidating a concept, it may not be always suitable or vital in assessing it.

The NCTM (2000) points out that technology can assist students to gain mathematical knowledge. The NCTM (2000) proposes that computer and calculator usage enables students to make and explore conjectures more easily, since these technologies enable students to examine more examples or representation forms than can be done by hand. NCTM (2000:22) states: “The computational capacity of technological tools extends the range of problems accessible to students and also enables them to execute routine procedures quickly and accurately, thus allowing more time for conceptualizing and modelling”.

The NCTM (2000) provides a vision for the teaching and learning of mathematics in North America. Under the NCTM’s Technology Principle, the (NCTM, 2000:24-25) states “Technology is essential in teaching and learning mathematics; it influences the mathematics that is taught and enhances students learning”.

The NCTM (2000) points out that current research in technology in mathematics education shows that students learn mathematics effectively with the proper use of technology, hence they regard electronic calculators—computers and calculators—as important learning aids for teaching and doing mathematics (Dunham, Dick, Sheets, Boers-van Oosterum, Rojano & Groves in NCTM, 2000).

The NCTM (2000:22) states that:

Technology should not be used as a replacement for basic understandings and intuitions; rather, it can and should be used to foster those understandings and intuitions. In mathematics-instruction programs, technology should be used widely and responsibly, with the goal of enriching students learning of mathematics.

Furthermore, the NCTM (2000) points out that successful mathematics teaching is supported by the efficient employment of technology in mathematics. Teachers should select or create mathematical tasks that embrace the advantages of technology by stipulating whether or not a calculator should be used, at what time, and how it is going to be used, and observe and focus on their thoughts so that technology can enhance their students’ learning. Using technology in

this way allows technology to aid evaluation, allows a teacher to examine the processes used by students in their mathematical investigations and results, and provides the teacher with inspiring information to use in making instructional decisions (NCTM, 2000).

Mbugua *et al.*, (2011) investigated the influence of using a scientific calculator on students' attitude towards mathematics in secondary schools in the Embu District in Kenya. They aimed at establishing whether or not there was a difference in students' attitudes towards mathematics when a calculator was used. The study was carried out in nine secondary schools in the Embu District in Kenya and consisted of 370 students. Attitude questionnaires were used for both the teachers and the students. The findings of this study showed that

- most students used calculators and more so in exams;
- teachers encouraged learners to use calculators where necessary;
- the students believed that not all problems required the use of a calculator;
- students perform better in mathematics and work out more problems when they have calculators;
- students finish their work faster and calculators make mathematics easy;
- calculator do not confuse students, but rather encourage them to think;
- teachers said the use of calculators motivates students; and
- according to student's mathematics is very interesting and enjoyable with calculators.

Mbugua *et al.*, (2011) concluded that in general the scientific calculator improves students' attitudes towards mathematics and enhances their confidence, thereby raising and maintaining their motivation to learn. Mbugua et al. (2011) recommended that calculators be implemented at lower grades of mathematical instruction for effective results, for instance in Grade 8 in the South African education system.

Ochanda and Indoshi (2011) investigated scientific calculator usage challenges and benefits in the teaching and learning of mathematics in Kenyan secondary schools. The investigation sought to establish the contribution of the use of the scientific calculator since there was no significant improvement in learners' performance being noted in the teaching and learning of mathematics. Therefore, the study aimed at establishing the challenges and benefits emanating from the use of scientific calculators in teaching and learning mathematics in secondary schools in Kenya. The study involved 1,680 Form IV students from 24 Emuhaya secondary schools in Kenya, 44 Mathematics teachers, two quality and assurance and standards officers and 24 head teachers.

In this study, (Ochanda & Indoshi 2011) established that calculators have great potential as

instructional aides for the development of mathematical concepts and understanding, especially when learners are proficient in their use, since calculators are just computation tools. They also established that when solving problems with the calculator, students might search for alternative problem-solving strategies, thus involving them in the creative process and avoiding a lot of use of paper and pencil. Ochanda and Indoshi (2011) also concluded that students are able to create and recognise a given mathematical problem, set up patterns through related ideas, make associations as well as experimenting with different ways to communicate mathematical ideas when engaged in discussions with other learners. In addition, Ochanda and Indoshi (2011) concluded that working with a calculator enables learners to create personal hypotheses and to generate problems relevant to what they would have learned; thus, from their perspective, calculators provide the learners with opportunities that enable them to benefit in the learning of mathematics. Ochanda and Indoshi (2011) concluded that scientific calculators are simple tools that make computations faster, hence enabling learners to increase the volume of calculations at a given time, as well as saving on time, especially in the case of large volumes of calculations.

Ochanda and Indoshi (2011) concluded that in order for the learner to fully utilise the benefits associated with scientific calculators, such as improved attitudes towards the subject and effective time management, learners need to use the calculator more frequently. Ochanda and Indoshi's (2011) findings concur with Dunham's (1995) findings that the use of a calculator, rather than paper and pencil, results in more positive feelings and improves learners and teacher's attitudes towards the learning and teaching of mathematics.

Ochanda and Indoshi (2011) point out that the use of a calculator benefits both the learner and the teacher. The following benefits are observed by Ochanda and Indoshi (2011):

- mathematical concepts are well understood, resulting in an increase in the mastery of computing skills and calculation amounts;
- correct answers can be confirmed by using accurate answers displayed on the screen;
- motivates and encourages learners to work on more problems; and
- enhances confidence working for those learners competent in calculator use.

Ochanda and Indoshi (2011) point out that to increase the number of learners competent in the use of the calculator the above advantages should be embraced in teaching and learning of mathematics and to make mathematics education learner-centred and effective in order to improve performance in mathematics.

Risser (2011) examined articles, opinions, and letters written in professional organisation's

mathematics journals between 2001 and 2009. These sources revealed that mathematicians are concerned about the use of technology in the learning and teaching of mathematics. The mathematicians' arguments were centred on the following issues:

- the possibility of technology changing the focal point of mathematics;
- the possibility of technology changing students' perception of mathematics; and
- the possibility that the reward of technology overshadows the disadvantages.

Risser (2011) noted that all the arguments in these journals exposed that the negative effects of technology in learning mathematics were not supported by research. Risser (2011) therefore concluded that post-secondary and years K-12 mathematics instructors practice diverse barriers in employing certain technologies and these strategies result in resistance, which hinders the successful implementation of technology in their classroom. However, Risser (2011) concurs with (Humbree,1986), (Dunham,1995) and (Mbugua *et al.*, 2011) research that the use of a calculator and technology has a positive influence on learners' mathematics education.

2.6.3 Dispelling the myths associated with the use of calculators

As stated in Chapter 1, teachers and parents are not inclined towards the use of calculators because they feel strongly that they do more harm than good in the learning of mathematics. However, teachers' fears towards the implementation of the calculator have been documented by (Pomerantz,1997) as mere myths. According to the Oxford Advanced Dictionary (2010), a myth is something that many people believe but that does not exist or is false. Pomerantz (1997) points out that calculator use in the classroom has faced opposition to full implementation because of the myths regarding their use. She points out these myths only serve to slow the inevitable implementation of technology, thereby disadvantaging learners in a world that is rapidly embracing technology. Pomerantz (1997) points out that research has proved calculators to be valuable learning tools, yet because of half-truths regarding their use, most people continue to think that calculators are detrimental to learners. As much as Pomerantz (1997) dismisses these disadvantages as myths, this researcher does not want to regard them as mere myths. It is important that if a calculator is going to be used appropriately, then this research should guard against the so-called myths in case they are real, because failure to address them will result in uninformed recommendations being given to curriculum developers. Therefore, the researcher will investigate the effectiveness of the calculator in light

of the so-called myths. Pomerantz (1997:1) regards the half-truths that are not based on research as myths. These are summarised as follows.

Myths 1. Calculators are a crutch: They are used because learners are too lazy to compute the answers on their own; they do the work for the students

Pomerantz (1997) argues that rote computations do not involve mathematical thinking. Pomerantz (1997) states that understanding the demands of a question, an insight on solving the problem, deciding on suitable operations, and being decisive in terms of whether or not the given answer makes sense, results in true mathematical understanding. She further points out that students use calculators as tools to solve problems. By eliminating tiresome computations involved in the traditional paper and pencil method that discourages most students, calculators allow more students to solve problems and value the power that mathematics has in today's world. Pomerantz (1997) argues that the suitable use of calculators enhances learning and thinking instead of replacing it.

Myths 2: Calculators do all the work for the student, he or she will not be stimulated or sufficiently challenged

Pomerantz (1997) argues that calculators can only do low-level tasks for calculations, and that they do not reflect or instruct students what to do, but rather that the student instructs the calculator what to do. Calculators speed up the learning process by allowing students to work on a lot of problems, which allows them to find out and detect patterns in mathematics, which rarely happens using the paper and pencil method. Pomerantz (1997) argues that this enables students to have more time to concentrate on valuable concepts and theories learnt in class. Pomerantz (1997) states that previously, mathematics involved very little thinking or investigation and problem-solving because it was characterised by memorising regulations and formulas. Pomerantz (1997:4) states: "With appropriate use of calculators, many more students' will have the opportunity to get past the mechanics of computation and manipulation and learn about the true meaning and value of mathematics".

Myths 3: If I didn't have to use technology to learn maths, then neither does my child.

After all I turned out just fine

Pomerantz (1997) argues that this thought persists because during the parent's education the calculator was not yet being used. Education is dynamic, and technology has rapidly rendered old-fashioned many of the methods and techniques that were previously used. Technology has allowed current students to do real mathematics and understand its meaning and value. She argues that these parents think of mathematics as involving algorithms, drills, and paper and pencil manipulations, not realising that the calculator eliminated the need for such an important skill according to paper and pencil arithmetic computations and algebraic manipulation. These skills are no longer regarded as core to a modern, proper mathematics education. Pomerantz (1997) points out that since technology is being implemented in classrooms across the world, students must be made to understand the technology and taught how to use it appropriately in order to prepare them for the technology that they will need to make use of in the years to come.

Myth 4: The use of calculators prevents students from learning the basic mathematics that they will need in the workforce

Pomerantz (1997) argues that apart from eliminating the needless and tedious paper and pencil calculations, calculators facilitate the learning process by allowing students to familiarise themselves with technology and therefore increases their comfort and familiarisation with technology. This, Pomerantz (1997) argues, is what gives students an advantage over those who were never exposed to technology, and the understanding of the limitations and benefits of technology increases students' openness and fosters a willingness to explore other forms of technology. This skill will eventually help students in terms of employment, since most employers want workers who can think, solve problems, and work as a team (Pomerantz, 1997).

Myth 5: People become so dependent on calculators that they will be rendered helpless without one (e.g. What if the battery dies or the students have to perform a computation when no calculator is available?)

Pomerantz (1997) argues that mind calculations and paper and pencil skills should continue to

be to be taught in schools, if it is the most suitable problem-solving method. Pomerantz (1997) argues that apart from its benefits, the calculator will never substitute the human mind in terms of reading and understanding a problem situation, writing a suitable equation, deciding on a suitable problem-solving approach, interpreting the answer, and deciding whether or not an answer is suitable. The use of calculators, together with suitable mental, paper and pencil, and estimation skills, equips the students with the tools to help them to carry out computations and manipulations necessary to solve a problem (Pomerantz, 1997).

Whilst it is true that some of the mentioned concerns are myths, some of these concerns need special attention to prove that calculators will not affect learners as has been suggested. These myths will definitely be embraced in this research to ensure that the learning materials will support learning and that the learners demonstrate deep conceptual understanding.

2.7 Mathematics Anxiety

Mathematics cannot be discussed without mentioning mathematics anxiety. As stated in Chapter 1, the researcher's objective is to increase learners' confidence in doing mathematics and to approach mathematics without fear. In light of mathematics anxiety, calculators increase learners' confidence, and this will be observed in learners' performance as well as the way in which learners present their work. Learners' ability to present their work neatly clearly shows that learners are confident and do not suffer from mathematics anxiety.

“Mathematics anxiety is defined as a feeling of tension and anxiety that interferes with the manipulation of mathematical problems in a wide variety of ordinary life and academic situations” (Richardson & Suinn in Thijsse, 2002:13). Mathematics anxiety's initial stages originate from unenthusiastic classroom experiences and mathematics teaching, (Stodolsky, 1985 & Williams, 1988, in Thijsse, 2002). Greenwood in Thijsse (2002:20) states that: “The principal cause of mathematics anxiety lies in the teaching methodologies used to convey basic mathematical skills”. He argued that the real source of mathematics anxiety disorder is the “explain practise memorise” teaching concept (Thijsse, 2002:20). Greenwood in Thijsse (2002), points out that teachers generate anxiety by stressing formulae memorisation, using drill and practice in learning mathematics, and applying rote learning. Butterworth in Thijsse (2002:21) believes that “A lack of understanding is the

cause of anxiety and avoidance and that understanding based learning is more effective than drill and practice”.

Furthermore, the level of precision at which numbers can be manipulated creates uneasiness in mathematics classes and tasks, resulting in mathematics anxiety (Ashcraft & Faust in Thijsse, 2002). Mathematics anxiety affects learners’ ability to take information or deal with it efficiently Goleman (1996) in (Thijsse 2002:21) states that “The working memory becomes swamped when extreme emotion is present and the learner is unable to hold in mind all information relevant to the task in hand which results in not being able to think straight”.

Skemp (1986) point out that anxiety debilitates performance and higher mental activities and perceptual processes. Wells (1994) points out that strong emotion blocks reasoning, and that learners are under pressure to remember rather than understand, resulting in them becoming mathematically handicapped. Ashcraft & Faust (1994) in Thijsse (2002) maintains that precision suffers under of mathematical anxiety, because most learners give up precision in favour of completing the task, resulting in poor performance.

Gentile and Monaco in Thijsse (2002) state that the teacher can diminish mathematics anxiety in the classroom by the teaching methods he or she employs, as well as by providing learners with successful experiences and boosting their confidence and motivating them by encouraging the use of manipulative tools, such as calculators, in the classroom.

2.8 Research on the Fraction Concept

2.8.1 What is a fraction?

The Department of Computer Science at George Mason University, USA, defined a fraction as “a way of representing divisions of a whole into parts. It has a form $\frac{\text{numerator}}{\text{denominator}}$ where the numerator is the number of parts chosen and denominator is the total number of equal parts”. McLeod and Newmarch (2006) state that a fraction can be defined as a number in its own right by showing it on the number line, and they can also be defined as a part of a whole, or fractions can be considered a way of sharing or grouping.

Kendall and Hart (2012), define a fraction as part of a whole. Bruce et al. (2013) points out that a fraction is a number which can tell us about the relationship between two quantities. These two quantities provide information about the parts, the units we are considering and the whole.

2.8.2 Fundamental Facts about Fractions

Some fundamental facts on fractions that were embraced in the teaching and learning of fractions in the current study are:

1. Fractional parts are equal shares or equal-sized portions of a whole or unit (Van de Walle in McLeod & Newmarch, 2006). There are two main ways of finding these types of numbers (numbers that are not whole numbers). Firstly, in measurement, the length, height, width, capacity, etc. of an object may fall between two whole numbers. Secondly, situations where quantities are shared often require numbers other than whole numbers.
2. Fractions can also represent for quantities larger than one, that is, $\frac{3}{2}$ or $\frac{5}{4}$.
3. Fractions can represent a ratio of two whole numbers for example $\frac{8}{15}=8:15$
4. Fractions can also be a division of a total, or a position on a number line for example $\frac{4}{5}=4 \div 5$.
5. Fractions can mostly be measured in three broad categories: rational fractions that $\frac{2}{3}$, fractions as operators for example $\frac{2}{3} \times 12 = 8$, and equivalent fractions for example $\frac{4}{8} = \frac{3}{6}$ (Suggate, Davis & Goulding in PDST, 2012).

Rational fractions are basically a way of indicating sizes that are not whole numbers, for example, if a pizza is cut into five equal parts and you ate one slice of the pizza, you didn't eat the whole pizza, you ate one slice of the five slices ($\frac{1}{5}$).

Fractions as operators refer to instances where the fraction acts like an operator in that they inform us to do something with the whole number, for example, 30 sweets divided equally amongst 6 pupils – the fraction is telling us to do something with the 30 and the link with division is clear. The 30 needs to be divided by six – giving each child five sweets. Or taking a reduced number of 24, the fraction is telling us to divide 24 into eight equivalent groups and then to emphasise or choose three of these groups. Thus, the denominator is the divisor and the numerator is a multiplier (indicating a multiple of the particular fractional part ($\frac{3}{8}$)).

Equivalent fractions involve using two or more ways of unfolding the different-sized partial parts. Diverse representations of the similar fraction can be obtained from the ratio between diverse numbers, for example $\frac{1}{3}, \frac{2}{6}, \frac{4}{12}$, *et cetera*. Proper time and energy should be used to stand

for the equivalent fraction concept in a significant way during early stages of learning, because the equivalent fraction concept is vital later when pupils have to add and subtract fractions (PDST, 2012).

6. All rational numbers (every number that can be expressed as a ratio of two whole numbers) have equivalent representation as fractions.
7. Fractions need to belong to the same or equivalent fractions in order to add or subtract them, that is, the denominator must be the same. In some instances, this requires adjusting the fractions so that they have a common denominator. It is important that this adjustment preserve the ratio between the numerator and the denominator. This adjustment to the “same family” is not necessary when multiplying or dividing fractions.
8. It is usual to express a fraction in its lowest terms, for example, in $\frac{5}{20}$ both the numerator and the denominator are divisible by five, so it can be written in its lowest terms as $\frac{1}{4}$. The lowest term means that there are no common factors in the numerator (top) or the denominator (bottom) (PDST, 2012).

2.8.3 Possible Learners Misconceptions of Fractions

An understanding on the already established misconceptions on the teaching and learning of fractions will help in designing learning materials guarding against such misconceptions. These misconceptions will also be observed in learners’ post-test scripts and the assignments of both the control and the experimental group. The appearance of more of these misconceptions in either group implies that the learners are still struggling with grasping the concept. Since this research is attempting to inform the teacher in using the calculator appropriately instead of the calculator being used as a ‘crutch’ the expectation would be a learner will have these misconceptions on the working out but somehow get the answer correct. The occurrence of these misconceptions in the experimental group would confirm that the calculator negatively affected learners’ conceptual understanding of the fraction concept but the failure to observe such misconception will imply that the use of a calculator through learners monitoring their work has indeed enhanced learners conceptual understanding.

“A Guide to Teaching and Learning Fractions in Irish Schools” (PDST, 2012) identified the following misconceptions that learners have in the teaching and learning of fractions. A discussion of these misconceptions will enable the researcher to make informed decisions on the use of calculators, since the absence of such misconceptions result in high performance of either paper and pencil or calculators in the teaching and learning of fractions. The PDST

(2012) in Irish Schools identified the following misconceptions which learners make:

- Even when pupils grasp the basic concept of fractions they may still believe that $\frac{6}{14}$ is bigger than $\frac{4}{8}$ just because the numbers are bigger.
- Taking pupils' prior knowledge of whole numbers into consideration, and due to the fractions' counter-intuitive nature—e.g. the larger the denominator then the smaller the fraction size—pupils frequently find it hard to grasp the fraction concept. Whole number information can in fact meddle with the development of fractions in the early stages.
- It might be equally difficult for learners to understand that the similar fraction may be written in a variety of ways after they have learnt that the whole number can be written in only one way, for example, $\frac{1}{3} = \frac{2}{6} = \frac{3}{9} = \frac{4}{12} = \frac{5}{15} = \frac{6}{18} = \frac{25}{75}$, etc. A lot of practise and dialogue is required to ensure understanding of the concept of equivalence.
- Social conventions can limit the probable fractions within a situation, e.g. pupils can suppose that a visual diagram always represents the number (Anghileri, 2007).

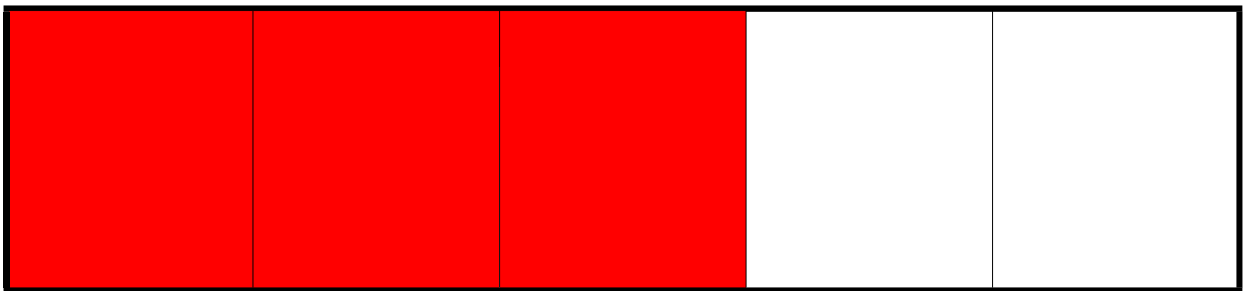


Figure 2.1: Possible Learners Misconceptions of Fractions (PDST, 2012)

Thus, a pupil may identify this fraction diagram (correctly) as representing $\frac{3}{5}$ or $\frac{2}{5}$ both. However, they are less likely to see other possible representations, e.g. $1\frac{2}{3}$ or $2\frac{1}{2}$ or $\frac{3}{2}$, these latter representations are made possible when it is understood that the whole unit can represent numbers other than the number 1.

Pupils may be tempted to add fractions that have different denominators without subdividing them into parts (or families) which are the same size, e.g., $\frac{1}{2} + \frac{2}{3} = \frac{3}{5}$ because they just add the numerators and the denominators separately. Similarly, in subtraction pupils may be tempted to use the same procedure, e.g. $\frac{5}{6} - \frac{1}{2} = \frac{2}{4}$.

In multiplication, pupils may attempt to use the procedure that they learned for adding,

e.g. $\frac{2}{3} \times \frac{1}{6} = \frac{4}{6}$ instead of $\frac{2}{3} \times \frac{1}{6} = \frac{1}{9}$.

Or the procedure learned in division e.g. $\frac{2}{3} \times \frac{1}{6} = \frac{2}{3} \times \frac{6}{1}$ which is incorrect.

2.8.4 Research on the Teaching and Learning of Fractions in South Africa

Lukhele, Murray and Olivier, (1999:88) investigated the problem of fractions in primary school and established the following problems):

- the abstract way in which fractions are presented;
- fractions do not form a normal part of learners' environment;
- the tendencies to introduce the algorithms for the operations on fractions before learners have understood the concept;
- the abstract definition of the operations on fractions; and
- the formulation and practicing of computational rules receiving too much attention, whereas the fundamental concept of fraction is ill-developed.

Lukhele *et al.*, (1999) in their document "Learners' Understanding of Addition and Subtraction of Fractions" aimed at characterising learners' conceptions and limiting constructions when adding fractions using the Mathematics and Learning Initiative (MALATI). Murray, Olivier, and Human in Lukhele *et al.*, (1999:88) referred to limiting constructions as "prior exposure to situations which give the learner a narrow view of a concept which hampers further thinking, for example, only dealing with halves and quarters for some time before introducing thirds".

Lukhele *et al.*, (1999) established that limiting constructions originated from the whole number schemes that might have possibly blocked out entirely the short and outward introduction to the implication of fractions that learners might have received. They understood that the learners' errors reported in the article could be traced back to these two causes (Lukhele *et al.*, 1999:87):

- a weak or non-existent understanding of the fraction concept and in particular, no understanding of the symbolical representation of a fraction; and
- the urge to use familiar (even if incorrect) algorithms for whole number arithmetic.

Lukhele *et al.*, (1999:87) used two types of analyses. First, in learners' responses to various tasks, emphasis was placed on the errors learners made, since this gave researchers insight into learners' understanding of the concept in question. Second, researchers monitored learners' responses to an addition task after the teaching intervention. This research will use this approach and use the findings of (Lukhele *et al.*, 1999) in alleviating these challenges in the learning and teaching of fractions during intervention.

Newstead and Murray (1998) described the Mathematics Learning and Teaching Initiative (MALATI) approach to teaching and learning in general and fractions in particular as developing different meanings of fractions and operations using a rich variety of carefully selected problems, supported by a learning environment that encourages reflection and social interaction.

Lukhele *et al.*, (1999) point out that the conceptual fundamentals of the MALATI approach to teaching and learning of fractions are found in research by Streefland (1982) and Kamii and Clark (1995). Streefland's approach in Lukhele *et al.*, (1999:88) can be described as follows:

- Developing the concept of a fraction by exploring distribution, or sharing situations and performing equal distribution, or sharing with focus on the twin meanings of fractions.

A multi-faceted approach towards the concept of a fraction was adopted based on the frequent performing and describing of fractions provoking problem situations, where the careful development of language for fractions aimed at the prevention of after-effects of the meaning of the symbols used due in both the figures and the operational signs having already acquired a definite meaning for the learners within the context of natural numbers. All these are done using contexts as source and domain of application for fractions.

Lukhele *et al.*, (1999) point out that Streefland's approach recognises and values the use of less complicated methods for solving problems relating to fractions, given that it fully describes the actions for developing the concept of fractions at very early stages, and addresses the restrictive constructions that teachers might anticipate from the learners as they get involved in the problems.

Kamii and Clark (1995) in Lukhele *et al.*, (1999) describe this approach as:

1. A teaching that encourages children to invent their own solutions by starting with practical problems so that fractions can develop in their own thinking. Not presenting a fraction with pictures of circles, squares, and rectangles that have been previously partitioned to children instead of encouraging them to logico-mathematise their own reality.
2. Children have to set their personal thoughts on paper rather than being provided with readymade pictures or manipulative sets. This will enable students to represent their personal circles perhaps like those in the textbook, except that these pictures will represent the children's personal work and their own understanding instead of those offered in the textbooks, which represent someone else's thoughts instead of their own.

3. Contrary to traditional instruction that waits for a lengthy time to present mixed numbers and addition concerning different denominators, equivalent fractions can be made-up in relation to whole numbers from the very beginning. Halves and quarters, which are easier to understand and formulate, form Streefland's approach.

The MALATI programme covers the following materials (Lukhele *et al.*, 1999:89)

- developing the fraction concept through grouping situations; and
- introducing realistic problem situations for operations involving fractions (e.g. division by a fraction) and comparison of fractions and equivalence of fractions.

The study involved 95 Grade 5 and 6 learners from a MALATI project schools in a township near Cape Town. A pre-test was given to the learners in February 1998 before any MALATI instruction had been given, but learners had experienced fractions in their previous grades as per curriculum requirement.

After learners' responses in both the test and the MALATI activities, Lukhele *et al.*, (1999) established that learners do not apply the method as they were taught. Instead, learners construct their own strategies – whether wrong or right – and use them to solve various problems in spite of the methods being appropriate. Lukhele *et al.*, (1999) established that none of the 95 learners involved in the study performed badly in the 12 contextualised questions given in the pre-test. In a problem like $(\frac{7}{8} + \frac{7}{8})$, all the learners and got a variety of answers, such as $(\frac{14}{16}, \frac{8}{11}, 165)$. Learners manipulated the algorithms they knew by either adding or subtracting whole numbers, by using numerators only and denominators separately, or vertical addition, and finding the lowest common denominator and not knowing how it should be used and where it should be positioned. Lukhele *et al.*, (1999) point out that learners' misconceptions in this regard clearly shows that they did not understand the fraction concept and failed to assess obtained answers.

Lukhele *et al.*, (1999) concluded that the conventional teaching of fractions of presenting a variety of algorithms to learners is the wrong approach towards learners' perspective of fractions. They pointed out that teachers enforce rules on learners that do not make sense when they give them algorithms to find lowest common denominator. The imposing of algorithms in finding lowest common denominator leads learners' acquisition of flawed knowledge of the algorithms that interfere with their thinking in the following ways:

- Learners are kept from drawing on their informal knowledge of fractions from the real

world context by the knowledge of number procedures.

- Since traditional instruction results in learners' not making sense of mathematics, learners' do not bother to question the suitability of the answers obtained using the faulty algorithms. (Lukhele *et al.*, 1999).

Therefore, Lukhele *et al.*, (1999) concluded that a strong fraction concept should be developed in learners in order to enable them to think and successfully deal with the addition of fractions in a way that makes grasping the concept of addition of fractions meaningful, without rules and algorithms that they do not understand.

Lukhele's *et al.*, (1999) approach to fraction learning addresses the aims of mathematics education in South Africa as well as the NCTMs recommendation to mathematics education. Considering that its approach to the teaching and learning of fractions addresses the aims of mathematics education in South Africa, this research embraces this approach to eventually produce learners that meet South Africa's aims of mathematics education both locally and internationally.

2.9 Conclusion

The definition and principles of learning are very important in the teaching and learning of fractions in mathematics. It provides the point of departure of its problems and remedies. The learning principles proposed by (Ambrose *et al.*, 2010) and the National Council of Mathematics Education provides the researcher with insight into how students learn. This knowledge is vital in the comprehension of fractions, and it is this knowledge that the researcher will use to improve learners' performance. Although the principles might aid with understanding, the principle behind the learner's learning is insufficient to design effective teaching methods. Constructivism theory, which is embedded in Vygotsky theories of how learners learn, effectively enables the researcher to design learning materials that create teaching environments that yield maximum results.

The aims of mathematics education, both locally and internationally, are of significance to this study because these learners should be able to compete and use their mathematics, not only in their classrooms, but also in the broader community and the world at large. Furthermore, relational understanding instead of instrumental understanding is pursued in this research study because it enhances conceptual understanding. Adopting a constructivist approach to

mathematics education allows the students to gain relational understanding when grappling with mathematics problems and leaves them with the residual of mathematics' (Murray, *et al.*, 1999).

Research by Suydam (1987), Hembree and Dessart (1986), Smith (1995, and McNamara (1995) point out that a calculator is a valuable tool in the teaching and learning of mathematics, it provides learners with a chance to observe and investigate patterns, it enables learners to work with very large numbers or very small numbers, like fractions, that are likely to be encountered in a real life situation, and it releases learners from the tedious computations of the pencil and paper method. This implies that calculators increase learners' confidence and motivates them, thereby eliminating mathematics anxiety in the process. In CAPS, mathematics as a human activity requires learners to actively participate in the learning process while a calculator enables learners to carry out investigations, identifying patterns, and to construct conjectures without a given algorithm or formula.

However, Pomerantz (1997) noted that despite a calculator being a powerful tool in the learning process, its effective implementation has been marred by myths. She points out that most teachers and parents are sceptical about using a calculator as a learning aid because it promotes laziness, and suggests that learners will not be sufficiently challenged if they use a calculator, yet she argues that the use of a calculator enables learners to do the mathematics that is needed in the workforce. She argues that these advantages are nothing but myths that are not supported by research, since research has shown beyond a reasonable doubt that a calculator improves mathematics learning. Thus, the performed research described and the aims of mathematics education advocate for calculator implementation in the classroom.

Although the South African education system has undergone several reviews, it has never disputed the use of calculators in the classroom, but it does stress that over-dependency on calculators should be avoided. The DBE and the National Council of Teachers of Mathematics urge that the calculator should be used appropriately in the classroom. It should not replace the teacher; the teacher needs to weigh his or her options with regard to the calculator and use it only when it enhances learning. Estimation and computation skills need to be practiced in class so that the learners will be able to check the reasonableness of their answers.

The teaching of fractions has been documented in research, and the reasons behind its failure to be effectively learned have been attributed, among others, to the teachers for introducing algorithms before learners effectively understand the concept. Apart from this anomaly,

research has also indicated that learners confuse addition and multiplication of fractions, fail to correctly add and subtract fractions with different denominators, and have a tendency to apply the algorithm incorrectly because they misunderstood them at inception.

The research done in South Africa by Luklele, *et al.*, (1999) in the mathematics learning and teaching provides the research with background knowledge of the problems that have been encountered in the teaching and learning of mathematics in South Africa. This research intends to investigate the best teaching method to improve learners' performance in fractions, while guarding against previously identified problems and separating the myths from facts.

CHAPTER 3: RESEARCH DESIGN AND METHODOLOGY

3.1 INTRODUCTION

Chapter 2 covered the literature review relating to the use of calculators, the problems associated with fractions; learners' different learning principles; and mathematics education's aims and objectives. This chapter is devoted to outlining the research methodology and design.

The current research is characterised by a strong empirical attitude and approach. The word 'empirical' has both a technical and a lay meaning. The lay meaning of 'empirical' is guided by practical experiences, not by research. McMillan & Schumacher (2010) state that to the researcher 'empirical' means to be guided by evidence obtained from systematic research methods, rather than by opinions and authorities. This research is empirical and educational; it focused on the problems that need to be solved to improve practice, hence the reason why its main purpose was to improve learners' performance in mathematics.

McMillan and Schumacher (2010) point out that research design describes the procedures for conducting the study, including when, from whom, and under what conditions the data were obtained. Generally, the research design indicates the general plan, how the research was set up, what happens to the subjects, and what methods of data collection were used. The purpose of a research design is to specify a plan to generate empirical evidence that is used to answer the research questions. The intent is to use a design that will result in drawing the most valid, credible conclusions from the answers to the research questions (McMillan & Schumacher 2010).

In this research, four Grade 8 classes were used to determine the effects of using a calculator in the teaching and learning of mathematics. The classes were intact or already organised for instructional purpose. The classes were not allocated randomly, and each class has different teachers and different learners. The researcher had no control over the learners that were enrolled at the school, and instead just used the classes that were already intact.

3.2 Demarcation of the study

The target population was all Grade 8 learners at a high school in the Johannesburg East district, Gauteng Province, in South Africa. The school had a total of 160 Grade 8 learners. Considering that the population was very large, a sample of learners was used.

3.2.1 Sampling

McMillan and Schumacher (2010) describe a sample as a group of subjects or participants from whom data are collected. The sample can be selected from a population, or can simply refer to the group of subjects from whom data is collected. A diagnostic test was given to all Grade 8 learners. Based on the diagnostic test results, a sampling frame was chosen from learners who had not performed well in the diagnostic test. Apart from being used to select the sampling frame, the diagnostic test was also used to establish the concepts that learners were struggling with so that attention could be given to them during the intervention.

A sampling frame was selected using non-probability and purposeful sampling, which consisted of all learners who obtained less than 40% in the diagnostic test. A non-probability technique does not include any type of random selection from the population. Rather, the researcher used subjects who were accessible, or who may represent certain types of characteristics (McMillan & Schumacher, 2010). In purposeful sampling the researcher selects particular elements from the population that will be representative or informative about the topic of interest. The researcher selected learners with a score of less than 40%, because these learners' diagnostic test scores showed that the learners were struggling with fractions, as evidenced by their low marks in the diagnostic test.

After the sampling frame was identified, the researcher used random sampling to determine which learners were going to be in the experimental or control group. It was from this sampling frame that the final sample for the research was derived. This was achieved as follows: After the sampling frame was identified, the researcher compiled the learners' names in alphabetical order. The researcher then randomly selected 30 learners for the research. After all 30 learners were selected, the researcher put cards labelled either A or B in a box and asked learners to pick a card in the box and card A represented the control group and card B represented the experimental group.

A sample of 15 learners was allocated to each group and these were the learners that were used

for the research. The research was restricted to 15 learners due to the fact that in each class there were about 40 learners and working with all of them would have affected the implementation of the intervention, since the class would be too big. Secondly, not all 40 of the learners were struggling with fractions. Since the research was mainly aimed at helping those learners who were having problems to grasp the fractions, the researcher decided to use learners who obtained less than 40% (D.B.E, 2011).

3.3 Research Methodology

A randomised post-test only comparison group design was used in the research. The purpose of a random assignment was to equalise the experimental and the control groups before introducing the intervention. Although there are certain cases in which it is best to use a pre-test with random assignment, if the groups have 15 subjects each it is not essential to have a pre-test to conduct a true experimental study, McMillan *et al.*, (2010).

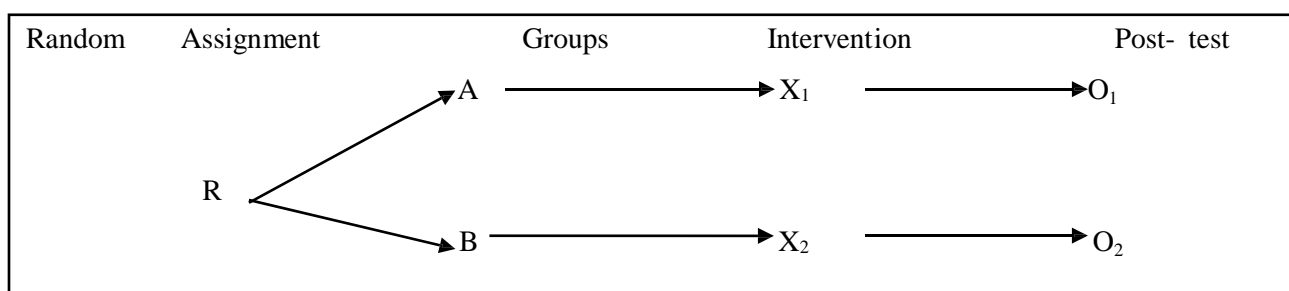


Figure 3.1: Randomised Post-test Only Comparison Group Design

Where: “R” is the random assignment “A” is the experimental group “B” is the control group.

“X₁” is the independent variable or treatment given to the experimental group.

“X₂” is the independent variable is the treatment given to the control, O₁ is the observation of dependent variable in the experimental group.

“O₂” is the set of observation of the dependent variable in the control group.

3.4 Hypothesis

To determine whether the use of scientific calculators has an influence on learners' conceptual understanding and performance in fractions at Grade 8 level, the following hypothesis was investigated

H_0 : There is no significant difference in performance and conceptual understanding of fractions in calculator-aided instruction and non-calculator-aided instruction.

H_1 : There is a significant difference in learners' performance and conceptual understanding of fractions in non-calculator-aided instruction and in calculator-aided instruction.

3.5 Variables

The independent variable was learners' exposure to calculators, while the dependent variable was the learners' test scores. Thus, the experimental design attempts to investigate the cause-effect relationship between the use of calculators and learners' test scores.

3.6 Process of Data Collection

3.6.1 Procedure

The researcher requested permission from Gauteng Department of Education to conduct research at the selected school. The Department's permission was used to apply for ethical clearance from UNISA, and then the researcher approached the school's principal and participants for permission and consent.

An informed consent form was given to the principal and the parents or legal guardians of the learners to be used in the study. The learners were asked to assent to the study, and since they were minors parental or legal guardian approval was sought via the informed consent. The consent form included, among other things, the purpose of the study, description of the procedures, and the length of time needed (see Appendices A, B, C, D, and E).

Two tasks a post-test and an assignment were given to both the control group and the experimental group. A Pearson chi-square was used to test whether or not there was an association between the performance of the control group and the experimental group. The results of the chi-square test helped to determine whether or not there was a significant difference between the performances of the control group and the experimental group in these tasks.

The control group was taught strictly using the traditional paper and pencil method, and no calculators were used. The experimental group was taught using the same method, but calculators were used to verify answers and to help with calculation, however all necessary steps were supposed to be shown. As stated in Chapter 2, the South African curriculum policy stresses that mathematics education is aimed at learners achieving deep conceptual understanding, and as such, they need to master the computational skills so that there will not be over-dependency on calculator usage.

In order to achieve this objective, a calculator was used only to ease computations and to verify their answers where possible. Whilst no calculator was used at any point during the intervention in the control group, for example, to verify answers and make basic computations like multiplication, addition, subtraction, division, and reducing fractions to their lowest terms. The teacher supervising the control group stressed the use of paper and pencil to do all basic computations such as multiplication, addition, subtraction and division. In the addition of fractions without the same denominators, learners in the control group were expected to find the lowest common denominator and perform all mathematical calculations using paper and pencil. However, the experimental group did not stress using the lowest common denominator; instead learners were allowed to just multiply the denominators and use them as common denominators and thereafter use the calculator to reduce. In multiplication and division, the teacher taking the control group stressed cross-multiplication where possible, before multiplying the numerators by numerators and denominators by denominators. However, in the experimental group learners could simply do the multiplication and then use their calculators to reduce where possible. All mathematical calculations in the experimental group were done using a calculator.

In the concepts of reducing the fraction to its lowest terms, converting mixed numbers to improper fractions and improper fraction to mixed numbers, addition and subtraction of fractions, multiplication, division, and equivalent fractions, the experimental group was taught the procedure involved in these concepts as well as how to verify their answers using

a calculator. They were expected to verify their solutions on their own where possible during intervention. To ensure that deep conceptual understanding was achieved, answers only from the experimental group were not accepted in the assessments given at the end of the intervention. Learners were supposed to show all the necessary working out. On the other hand, the control group was not expected to use the calculator at any point during the intervention and assessments; all mathematical calculations were done using the paper and pencil method and learners were not required to verify their answers.

Both the calculator-aided method and the traditional paper and pencil method was used an hour per day for 16 days. The learners were taught the following topics on fractions:

- addition and subtraction of fractions;
- equivalent fractions;
- multiplication and division of fractions;
- comparison of fractions;
- reducing fractions to their lowest terms;
- converting fractions from mixed to improper and improper to mixed;
- types of fractions;
- word problems involving fractions; and
- algebraic fractions.

Teaching and testing took place at the same time for both groups, but with different teachers in each class after school. This was the only time that was suitable, since it did not interfere with the school timetable. The researcher prepared all the teaching and learning activities for all the sessions, and the marking memorandums for the assignment as well as the test to enhance uniformity. To ensure that the learners were doing the same thing at the same time, the researcher prepared the lesson plans and worksheets for both sessions and the lessons took place at the same time to avoid weather and time variability, which might have affected the learners' performance.

The researcher trained both teachers in the best way to conduct their lessons and to ensure uniformity in the lesson delivery. The researcher held a memo discussion before the teachers started marking the tasks. To ensure that the teachers followed the memorandum, the researcher moderated the learners' scripts. The researcher and the teacher responsible for the group taught the experimental group calculator skills before the lessons commenced.

A questionnaire was used to determine learners' attitudes towards the use of a calculator in relation to learning fractions, since learners' motivation towards their mathematics lessons is fundamental in learners' understanding (Murray, *et al.*, 1999). The questionnaire was also used

to determine the effectiveness of a calculator from the learners' perspective.

3.7 Research Instruments

Several instruments were used to collect data in the research project. These are: a fractions diagnostic test that was also used to select the sampling frame, a post-test and assignment, which consisted of both procedural and conceptual questions to assess learners' performance and the questionnaire which was only administered to the experimental group after intervention. The assignment was completed in class and learners could refer to their books, whilst the post-test was a controlled test and exam rules applied. Results from both the post-test and the assignment were used to investigate whether or not there was a significant difference between the learners' performance in calculator-aided instruction and non-calculator-aided instruction. This enabled the researcher to conclude whether or not the calculator had an influence on learners' performance. Learners completed a questionnaire and their responses were used to investigate the effectiveness of a calculator in teaching and learning fractions from the learners' perspectives.

3.7.1 Diagnostic test

The researcher used standardised test conditions to administer the diagnostic test. This test was written by all 120 grade learners at the school. The diagnostic test was used by the researcher to identify the sampling frame, that is learners who obtained less than 40% on the diagnostic test. The same concepts as tested in the post-test on **Table 3.1** were tested in the diagnostic. However, the diagnostic test had 11 questions in which both question 10 and 11 were word problems. The questions tested both the procedural and conceptual skills of fractions.

The diagnostic test was prepared by the researcher and validated by the school head of department and the mathematics subject specialists at the district office in Johannesburg East, to check if the test adhered to the assessment guidelines and to also assess its level of difficulty in accordance to the assessment guidelines. The same teachers that were used for marking the post - test were used for consistency following training by the researcher.

The diagnostic was marked according to the memorandum. A full, partial, or no mark was

allocated according to the specifications of the memorandum.

3.7.2 Post-test Task 1

The researcher used standardised test conditions to administer the post-test. McMillan and Schumacher (2010) point out that standardised tests are uniform procedures for administering and scoring. The same or parallel questions are asked each time the test is used, following a set of directions that specifies how the test should be administered. This would include information about the qualifications of the person administering the test and the conditions of administration, such as time allowed, materials that can be used by the subjects, and whether or not questions about the test could be answered during testing. Standardised tests might be large-scale and be set by experts, or they might be locally developed, but the administering will be standardised. A locally developed test will be specific to the researcher's context, and may be much more sensitive to the objectives of the research, (McMillan & Schumacher. 2010).

The standardised tests were prepared by the researcher and validated by the school's head of department and the mathematics subject specialists at the district office in Johannesburg East, to check if the test adhered to the assessment guidelines and to also assess its level of difficulty in accordance to the assessment guidelines. The idea of having the district mathematics specialists' validation meant that careful attention was paid to the nature of the norms, suitability of content to the age group involved, and whether or not the tests complied with the South African assessment standards. This resulted in instruments that are "objective" and relatively uninfluenced and undistorted by the administering person, (McMillan & Schumacher, 2010).

McMillan and Schumacher (2010) point out that whilst it is not always evident how achievement tests differ from aptitude tests, achievement tests have a more restricted coverage, they are more closely tied to school subjects, and they measure more recent learning than do aptitude tests. Additionally, the purpose of the achievement test is to measure what has been learned, rather than to predict future performance. Since the aim of the research was to test the effectiveness of calculators in teaching and learning fractions in mathematics, the achievement tests were concerned with measuring achievement in a single content area. McMillan and Schumacher (2010:192) state that "If the research is concerned with achievement in a specific school topic, then it would be best to use a test that measures

only that topic rather than a survey battery”. The questions in the post-test were asked in a way that intended to measure both conceptual and procedural skills in fraction solving. The following procedural or conceptual skills were tested per question:

Question	Concept addressed
1	Types of fractions: learners were tested to see if they were able to identify types of fractions, i.e. improper, proper, and mixed.
2	Expressing fractions in simplest form.
3	Finding an equivalent fraction.
4	Finding a missing value given two equivalent fractions.
5	Comparing two fractions by expressing both fractions with the same denominator or expressing as a decimal fraction.
6	Expressing fractions as mixed numbers in their simplest form.
7	Converting mixed numbers to improper fractions.
8	Addition and subtraction of fractions, including algebraic fractions.
9	Division and multiplication of fractions including BODMAS.
10	Word problems involving fractions.

Table 3.1: Concepts tested per question on the post-test

The post-test was marked according to the memorandum. A full, partial, or no mark was allocated according to the specifications of the memorandum.

3.7.3 Assignment (Task 2)

An assignment was used to test learners’ knowledge, understanding, and skills. Paper and pencil tests have a tendency of increasing mathematics anxiety, resulting in some learners not performing well (Thijsse,2002). Two assessments were given to ensure that the results of one assessment complements the other.

To guard against mathematics anxiety normally associated with controlled tests, an assignment was given assessing the same concepts as in the test except that learners were supposed to complete the task in class, but not under controlled test conditions. This implies that learners from both groups were allowed to consult their textbooks during the assessment task and only the experimental group was allowed to use the calculator as in the post-test. This was intended to make the environment conducive to learners who suffered from mathematics anxiety, so that they would be able to fully express themselves and demonstrate

their understanding clearly without the fear associated with tests. Each assignment question addressed a certain concept more or less the same as the ones that were addressed in the post-test. Questions were also designed in such a way that they reflected learners' procedural and conceptual skills. The table below shows the concepts that were assessed in each question.

Question	Concept Addressed
1	Arranging fractions in order of size by first expressing them with the same denominator or as decimal fractions, then assessing them.
2	Comparing fractions using the symbols.
3	Expressing fractions in their simplest form.
4	Converting mixed numbers to improper fractions.
5	Converting improper fractions to mixed numbers.
6	Addition, subtraction, multiplication, and division of fractions.
7	Word problems.

Table 3.2: Concepts Tested per Assignment Questions

The assignment was also marked according to the memorandum.

3.7.4 Questionnaires

McMillan and Schumacher (2010) point out that for many good reasons, the questionnaire is the most widely used technique for obtaining information from subjects. McMillan and Schumacher (2010) state that a questionnaire is a written set of questions, it is relatively economical, has the same questions for all the subjects, and can ensure anonymity. Questionnaires can use statements or questions, but in all cases, the subjects respond to something written for specific purposes.

The main aim of this research was to determine whether or not a calculator has an influence on learners' performance and conceptual understanding in the teaching and learning of fractions in a Grade 8 class. Although this researcher's main focus is on learners' performance and conceptual understanding, apart from the marks obtained, the researcher will also look at the learners' responses in both the post-test and the assignment, to investigate whether the disadvantages mentioned in Chapter 2 are true or merely myths as stated by Pomerantz, (1997). In order to investigate the authenticity of most people's fears

towards a calculator, a questionnaire was used to measure the effectiveness of a calculator from learners' perspectives. Knowing the influence of the calculator from learners' perspectives is important, because understanding how learners perceived a calculator's influence on their learning enables the researcher to explain learners' performance from the learners' perspectives, and by being able to explain learners' performance, the researcher is able to measure the influence of using a calculator from learners' perspectives. Apart from the scores that reflect learners' performance, learners are the only ones who are able to fully inform the research how effective the calculator was in their learning. Research has shown that a learner's performance is largely influenced by the classroom's conduciveness to teaching and learning (Murray,*et al.*, 1999). Therefore, the questionnaire was used to monitor the influence of a calculator in the teaching and learning of fractions from the learners' perspective. Cronbach's alpha was used to test the reliability of the questionnaire in determining the influence of a calculator in learning fractions from a learners' perspective.

Only the experimental group completed the questionnaire. The questionnaire was on the use of calculators and hence was not given to the control group. Previous research, textbooks, and the supervisor were consulted regarding the formulation of questions, and a pilot test was performed on the questionnaire and misinterpretations were rectified.

To ensure that the questionnaire was appropriate and clearly worded for the learners, the following were taken into consideration before administering it to the learners:

3.7.4.1 Items to be used

Scaled items were used in the questionnaire. MacMillan (2010) points out that a scale is a series of gradations, levels, or values that describe various degrees of something. Scales are used extensively in questionnaires because they allow fairly accurate assessments of beliefs or opinions. This is mainly because many of our beliefs or opinions are thought of in items and gradations (McMillan and Schumacher, 2010). Likert type scales were used mainly because they provided great flexibility and the descriptors on the scale can vary to fit the nature of the question or statement (MacMillan & Schumacher, 2010).

3.7.4.2 Structure of the questionnaires

The questionnaire was meant for the learners in the experimental group. The questionnaire

consisted of Section A and B. Section A sought general and personal information about the respondents, while Section B consisted of 15 statements that had to be rated based on the respondents' experiences when learning fractions. These questions were designed to investigate the following in learners after the calculator-aided session.

- learners' perceptions in learning fractions with the aid of a calculator;
- the perceptions learners had of learning fractions after learning with a calculator;
- the learners' perceptions on finding the common denominator after using a calculator; and
- whether or not the use of a calculator was better than using paper and pencil when learning fractions.

3.7.4.3 Testing the clarity of the questions on the learners' questionnaire (Conducting a Pre-test)

Once the researcher developed a set of possible items, a pre-test was conducted by asking three colleagues to read and respond to the questions. These colleagues were later asked about the clarity and wording of the questions, including the following:

- Were the items clearly worded?
- Was the meaning of the items clear?
- Were there any spelling or grammatical errors?
- Were the response scales appropriate?
- What suggestions are there for making improvements to the items?
- Based on the response to these questions, the items were revised and administered to learners.

3.7.4.4 Conducting a Pilot Test of the questionnaire on the learners

After the items were revised, an actual draft of the questionnaire was created and formatted, with instructions and headings. Ten learners were selected randomly from the remainder of learners who were not participants of the study, although they scored less than 40%. This was mainly because these learners were most likely to have similar abilities to the learners that were going to be used for the research, but that they did not form part of the final sample. The pilot test was the same as the one used in the final research, and the respondents were given space to write comments about items and the questionnaire as a whole. The pilot test was aimed at investigating whether or not the instructions and items were clear, and to assess how long it would take the learners to complete the questionnaire.

3.8 Technical Adequacy

Quantitative measurements use instruments or devices to obtain numerical indices that correspond to characteristics of the subjects. The numerical values are then summarised and reported as the results of the study. It is imperative, then, to understand what makes measurements strong or weak. Whether one chooses instruments to conduct a study or to evaluate results, it is necessary to understand what affects the quality of the measure (McMillan & Schumacher, 2010). In this study, two technical concepts validity and reliability were used as important criteria to determine quality for both cognitive and non-cognitive assessment. McMillan and Schumacher (2010) point out that reliability is a necessary condition for validity. Scores cannot be valid unless they are reliable. However, to ensure that validity is met in this research, reliability tests were performed on learners' scores of the two tasks and the responses to the questionnaire.

3.8.1 Test Validity

Test validity is the extent to which inferences made on the basis of numerical scores are appropriate, meaningful, and useful. Validity is a judgment of the appropriateness of a measure for specific inferences or decisions that result from the scores generated. It is assessed according to the purpose, population, and environmental characteristics in which measurement takes place (McMillan & Schumacher, 2010). To ensure that validity has been adhered to in the current study, three major types of evidence were used to support intended interpretations to eliminate any rival hypothesis regarding what is being measured. These are evidence-based on test content, evidence-based on response processes, and evidence-based on relations to other variables (McMillan & Schumacher, 2010).

The randomised post-test only comparison group design controls four sources of internal validity. Threats related to history are generally controlled insofar as events that are external to the study affect all groups. Selection and maturation are controlled because of the random assignment of subjects. Statistical regression and pretesting are controlled because any effect of these factors is equal for all groups (McMillan & Schumacher, 2010).

Instrumentation is not a problem when the same standardised report procedures are used. Attrition is not usually a threat unless a particular treatment causes systematic subject drop out

(McMillan & Schumacher, 2010). In the research, learners wrote the tasks at the same time and a marking memorandum prepared by the researcher was used. The researcher decided to use the randomised post-test only comparison because it controlled all four sources of threats to internal validity that is history, selection; maturation and attrition.

Diffusion was ruled out as a threat because these lessons took place in two different classes and were conducted by different teachers, which eliminated the possibility of experimenter effects. The researcher was responsible for the preparation of teaching resources and the marking memorandum to ensure uniformity of the content being taught, as well as the marking in both classes. Two different teachers conducted lessons at the same time due to time constraints and to limit the threats from diffusion. The researcher trained both teachers on how to conduct their lessons effectively, that is the delivery of content per group from the introduction to the conclusion of the lessons, the lesson objectives per lesson to minimise the difference of the two teachers' methodology compromising the results. The researcher conducted similar lessons per group while the teachers observe with those students who had not been selected for the research.

Evidence based on test content demonstrates the extent to which the sample of items or questions in the instrument is representative of some appropriate universe or domain of content or tasks (McMillan & Schumacher, 2010). To ensure that content was suitable for the Grade 8 level, the researcher used experts to examine the content, namely the research supervisor and the mathematics subject specialist, and the Grade 8 mathematics teachers were used to moderate both the teaching materials, the diagnostic test post-test, and the assignments. The researcher prepared activities using the National Curriculum Assessment Policy Grade 7-9 (Department of Education, 2011) to ensure that appropriate content was used.

3.8.2 Test Reliability

Test reliability refers to the consistency of measurement, the extent to which the measures are free from error. Multiple assessment (post-test and assignment) procedures were used to ensure that learners who had mathematics anxiety were not disadvantaged. An assignment was completed in class under a teacher's supervision to guard against mathematics anxiety, which is usually associated with controlled tests (Thijsse, 2002). To ensure that learners would not solicit help from families and friends, these assignments were completed in class under the

teacher's supervision. This assignment was mainly intended to cater for those learners who had mathematics anxiety or whose performance would be affected by the exam conditions. To alleviate anxiety associated with controlled test for instance the post-test, learners were allowed to consult their textbooks when answering doing the assignment.

To ensure that the assignment and post-test scores were reliable, the researcher established standard conditions for data collection of both tasks. The lessons were administered at the same time and on the same day, that is, for two hours after school. A work schedule was prepared by the researcher and handed to the teachers to ensure uniformity. All assessments were written on the same day at the same time and had for the same duration. The researcher monitored lessons to ensure that the teachers adhered to the times, work schedule, and lesson plans given. Although different teachers were used for teaching the different groups, the researcher trained the teachers to deliver the lessons and to score the tasks, prepared the lesson plans and learning resources, and prepared the memorandums used for scoring the tasks. This was done to minimise teachers compromising the reliability of the results. The teachers were responsible for marking their learner groups' assignments and tests adhering to the marking memorandum prepared by the researcher and the guidelines from the memo discussion. The researcher moderated the scripts to ensure that the teachers adhered to the memorandum. These measures were meant to assure comparability between groups and remove bias in marking.

When two equivalent or parallel forms of the same instrument are administered to a group at about the same time and the scores are related, the reliability that results are the coefficient of equivalence. Even though each form is made up of different items, the scores attained by each individual would be similar for each individual (McMillan & Schumacher, 2010). Equivalence reliability was used to test the learners' overall scores in the post-test and assignment from the experimental group and the control group. More than one task was used in order to complement the results of the other, consistency of results in both tasks makes each task reliable. Cronbach's alpha determines the agreement of answers on questions targeted by a specific trait. It is used when answers are made on a scale of some kind, rather than right or wrong answers. (McMillan & Schumacher, 2010). Cronbach's alpha at a cut-off point of 0.7 was performed to test internal consistency of questions 1 to 15 of the questionnaire. The results obtained indicated that the questions on the questionnaire were reliably testing the influence of calculators in learners' learning and the teaching of fractions (see Table 3.3).

Average item-test				item-rest	inter item	
Item	Obs	Sign	correlation	correlation	correlation	alpha
q1	15	+	0.8372	0.8034	0.3929	0.9006
q2	15	+	0.2708	0.1753	0.4555	0.9213
q3	15	+	0.5944	0.5242	0.4197	0.9101
q4	15	+	0.6464	0.5826	0.4140	0.9082
q5	15	+	0.8900	0.8662	0.3870	0.8984
q6	15	+	0.6775	0.6180	0.4105	0.9070
q7	15	+	0.8286	0.7932	0.3938	0.9009
q8	15	+	0.3373	0.2451	0.4482	0.9192
q9	15	+	0.8768	0.8505	0.3885	0.8989
q10	15	+	0.6168	0.5494	0.4173	0.9093
q11	15	+	0.7566	0.7089	0.4018	0.9039
q12	15	+	0.6582	0.5960	0.4127	0.9077
q13	15	+	0.6440	0.5800	0.4143	0.9083
q14	15	+	0.7352	0.6842	0.4042	0.9047
q15	15	+	0.6982	0.6416	0.4083	0.9062
Test scale					0.4112	0.9129

Table 3.3: Test for Internal Consistency

The table above clearly shows that the items question 1 through question15 are reliably testing the influence of the calculator on learning fractions with a Cronbach’s alpha = 0.9129.

3.9 Design Validity

McMillan and Schumacher (2010) indicate that in the context of research design, the term ‘internal validity’ refers to the degree to which scientific explanations of phenomena match reality. This implies that it refers to the truthfulness of findings and conclusions. The study sought to control four types of quantitative research design validity, these were:

- a) statistical conclusion validity, which refers to the appropriate use of statistical tests to determine whether or not purported relationships are a reflection of actual relationships;
- b) internal validity, which focuses on the validity of causal links between independent and dependent variables; and
- c) external validity, which focused on the ability to generalise the results and conclusions to other people and locations (McMillan and Schumacher, 2010).

The researcher incorporated these procedures into the research design. Therefore, the researcher considered who was to be assessed (subjects), what they would be assessed by (instruments), how they would be assessed (procedures for data collection), and how experimental interventions would be administered. The sections below indicate in detail how statistical conclusion, internal validity, and external validity were used to validate the study.

3.9.1 Statistical Conclusion Validity

In quantitative research, statistics are used to determine whether or not a relationship exists between two variables, that is, the extent to which the calculated statistics accurately portray the actual relationship (McMillan & Schumacher, 2010). Statistical power denotes the ability to detect relationships and differences as statistically significant. Statistical power increases the likelihood that the researcher is correct in concluding that there are no differences, allowing findings to be statically significant (McMillan & Schumacher, 2010).

To minimise bias, the researcher used standardised protocol. All activities were done during the same time, but at different venues. The research used reliable instruments that provided reliable scores, namely achievement tests in the form of a post-test and an assignment. The research used learners who scored less than 40% in the diagnostic test, which implied that they had similar abilities and all the learners were in Grade 8. The researcher also increased the intervention effects by ensuring that the experimental group was the only group that used a calculator, whilst the control group did not use a calculator at all during intervention and assessments.

In addition, the researcher used careful data coding and entry to control statistical conclusion validity. Learners in the control group were identified as student control SC1 to SC15, and learners in the experimental group were named SE1 to SE15. McMillan and Schumacher (2010) propose that accurate coding and entry of data is a relatively easy and inexpensive way to reduce errors. To guard against human error, the researcher used the Strata V11 statistical software to determine whether or not a significant difference existed between performance of the control and experimental groups.

3.9.2 Internal Validity

Two conditions must be present to establish that the threat is plausible or probable, that is, the threat must influence the dependent variables, and the threat must represent a factor or variable that differs in amount or intensity across levels of the independent variables. Thus, a factor could influence the dependent variables, but would not be a threat if it affected the dependent variables for each group equally (McMillan & Schumacher, 2010).

History is a category of internal validity that refers to uncontrolled events or incidents that affect the dependent variables. Events or incidents could occur during the study in addition to the intervention that plausibly affects the dependent variables. Some disruptions can occur in one group, but not affect the other group. This will affect the conclusion in such an experiment, since this would have impacted negatively on the investigation (MacMillan & Schumacher 2010). In this research, history as a form of internal validity, was controlled, because the tests, assignments, and teaching took place during the same time but at different venues. To avoid selection threats, a random assignment was used to ensure that learners in the experimental group had statistical equivalence with the control group's characteristics. Since only comparison design was used in the post-test, threats to statistical regression were not applicable. The results of the diagnostic test were only intended for selection purposes and preparation of intervention resources.

Threats to instrumentation were controlled, since there was no observation involved. Threats to instrumentation were also controlled by the fact that the same teachers who taught were the ones who marked their group's assessment tasks. Attrition was not a threat since the research only took place over 16 days. Since the research was completed over a short period of time, attrition was not considered a threat (McMillan & Schumacher, 2010). Mortality threats were not regarded as a threat since there were no drop-outs. Maturation threats were not considered a serious threat since both groups were affected in the same way as activities took place after school. Most learners were tired, but both groups were subject to this effect. Diffusion of an intervention threat was controlled since the two groups had lessons at different venues that were situated some distance away, although the times were the same. No learner from one group knew what transpired in the other group.

Based on parents' comments during parents' meetings at the school, most parents were against the idea of the use of the calculators. This made it possible for the researcher to establish that these learners are all affected equally by parental influence. From these observations, the

researcher also established that some learners were against the use of calculators and some approved of the use of calculators. The random selection of learners in either the control group or experimental group eliminated the possibility of those who did not want to use the calculator in one group, and those who liked using it in the other group. Therefore, this factor was not considered a threat, since it affected the dependent variables of the group equally.

The fact that participants were taken from a group of learners who obtained scores below 40%, it was possible that each group had learners who scored 40% and others who scored 20%, but being in the same grade – Grade 8 – eliminated the possibility of different abilities. The use of random sampling ensures that learners of mixed abilities are combined, and therefore the possibility of having learners of the same abilities in one group is not considered a threat.

The researcher used a research supervisor to check the credibility of the approaches being used, and she used the Grade 8 teachers and senior teachers to check the reliability of the content against the requirements of the South African curriculum. More than one activity was used to make inferences, namely the assignment, the post-test, and the questionnaire, which clearly established whether or not a significant difference existed in non-calculator-aided instruction and calculator-aided instruction.

3.10 Data Analysis

The data collected using an assignment (Task 2) and a post-test (Task 1) was analysed using Pearson chi-square (χ^2). The Pearson product moment correlation is used when both variables use continuous scales, such as achievement tests (McMillan & Schumacher, 2010). Chi-square is a common non-parametric procedure that is used when data is in nominal form. This test is a way of answering questions about association or relationship based on frequencies of observation in categories. The researcher thus forms the categories and then counts the frequency of observations or occurrences in each category, (McMillan & Schumacher, 2010). If the data is not interval or ratio, or is not distributed normally, the researcher should consider using a non-parametric analogy to the parametric test. The interpretation of the results is similar, what differs are the computational equation and tables for determining the significance level. Parametric tests are used with large samples (McMillan & Schumacher, 2010).

Since the researcher used a small sample of 15 and used nominal data, a non-parametric test was suitable. The researcher decided to use a group of 15 learners because a smaller number of learners was easier to control in terms of discipline. If a large group of learners was used, the teachers would not have been able to attend to learners individually, and that could have affected the results of the investigation. Fewer learners than 15 would result in a group that is too small to make valid conclusions. Hence the researcher decided on 15 learners.

The single-sample chi-square test was used with only one independent, which was learners' performance, with two categories—the calculator-aided group and the non-calculator-aided group (McMillan & Schumacher, 2010). Statistical tests compare the reported or observed frequencies with some theoretical or expected frequencies. In this research, the reported frequencies were observed from the learners who used calculator as learning aids (experimental group) and the learners who did not use calculators as learning aids (control group), as well as the two groups of all 30 learners combined. In this research the frequencies of 15 in each category was the same. The null hypothesis that was tested revealed that there was no difference in the performance of learners who used the calculator as a learning aid and those who did not use the calculator as a learning aid. To obtain the level of significance, the researcher computed a formula to obtain a chi-square value (X^2). The analyses were done using the Strata V11 statistical software, and the confidence interval was calculated at a 95% interval with a null hypothesis being rejected at p. The formula used for finding the chi- square was:

$$X^2 = \sum \frac{(f_o - f_e)^2}{f_e}$$

Where:

X^2 is the chi-square statistic.

\sum is the sum of.

F_o is the observed frequency.

F_e is the expected frequency.

3.11 Descriptive Statistics

Quantitative research relies heavily on numbers in reporting results, sampling, and providing estimates of score reliability and validity. The numbers are often manipulated by statistics, and statistics lead to conclusions (McMillan & Schumacher, 2010). Statistics are methods of organising and analysing quantitative data. Descriptive statistics is a category of statistics that transforms a set of numbers or observations into indices that describe or characterise the data. It portrays and focuses on “what is” with respect to the sample data (McMillan & Schumacher, 2010).

A frequency table showing a compound bar chart was used to show the experimental group’s responses in the questionnaires in the following three categories:

- a) Category A: where responses reveal learners’ attitudes towards learning fractions using calculators;
- b) Category B: where responses reflect how the calculator increases learners’ performance in dealing with any mathematical situation without being hindered by a fear of mathematics and
- c) Category C: where learners’ responses reflect whether or not calculators affect learners’ conceptual understanding of fractions.

The researcher grouped the responses in terms of ‘agree’, ‘strongly agree’, ‘strongly disagree’, and ‘disagree’, and drew the responses as a percentage on the compound bar graph. A pie chart was used to show learners’ results in the post-test for each group, following the National Curriculum Statement, CAPS Grade 7-9 assessment guideline (Department of Education, 2011).

Measures of variability show how spread out the distribution of scores is from the mean of the distribution. Variability tells us about the difference between the scores of the distribution. A box and whisker plot is used to give a picture or image of the variability. A box is formed for each variable. The size of this rectangular box is determined by the first and the third quartiles (i.e. 25th and 75th percentiles) (McMillan & Schumacher, 2010).

Making a conclusion based only on the mean is not enough to make a conclusive conclusion (McMillan & Schumacher, 2010). Therefore, unorganised data on the post-test were collected and recorded separately. A five number summary to show the spread of data about the median and a box and whisker plot was drawn to give a picture or image of the variability of learners’

results in both tests. A comparison of the two tests using the chi-square statistical tests enabled the researcher to decide whether or not there was a difference in the post-test of both groups, thereby enabling the researcher to safely conclude that one intervention was better than the other or that there was no difference at all.

Learners' post-test scores were further compiled, and a frequency distribution of the scores was done for each group using the National Curriculum Statement (CAPS) assessment scale of a pass being 40% and above (Department of Education, 2011). A pie chart representing learners' performance on the post-test was drawn to show the difference in post-test scores between the two groups. Last, a frequency polygon was drawn to represent learners' assignment results for both groups on one graph, with the intention of identifying a pattern in learners' assignment performance. The researcher intended to visibly deduce whether or not there was a difference in learners' assignment scores for each group. The learners' results in the assignment were drawn on a single line graph and were then used to compare the scores of the control and the experimental group in the assignment.

3.12 Conclusion

In this chapter the procedure of conducting the research was discussed. This included the description of the target population and sampling methods. The instruments used in collecting data and a description of how validity and reliability were ensured was provided. A method to indicate whether or not there was a significant difference in learners' performance and conceptual understanding in both assignments and post-tests using the Pearson chi-square was provided. The procedure for the use of a questionnaire to determine learners' attitudes towards the use of a calculator in teaching fractions was also provided. Last, the descriptive statistics that were used to visualise learners' performance as well as learners' responses to the questionnaire were also provided. The next section deals with the presentation, analysis, and interpretation of the results from the study

Chapter 4 DATA PRESENTATION, ANALYSIS, AND INTERPRETATION

4.1 Introduction

In chapter 1, the problem of the influence of a calculator in learners' conceptual understanding in the teaching and learning of fraction concepts in Grade 8 was established. In Chapter 2, literature on theories of education and learning with particular reference on mathematics education internationally and in South Africa was reviewed, the advantages and disadvantages of using a scientific calculator was discussed, and the fraction concept was analysed. The study procedure was discussed in Chapter 3. A set of questionnaires was used with the experimental group to determine learners' attitude towards the use of calculators in teaching fractions. An assignment and a post-test task were used to determine learners' performance after the different interventions. In this chapter the results of the investigation are presented, analysed, and interpreted.

4.2 Students' Responses to Tasks

4.2.1 Post-test (Task 1)

The learners' responses to the post-test and assignment were marked according to the memorandum (Appendix I), where a full, partial, or no mark was allocated. The learners' scores and the descriptive statistics were calculated, and a null hypothesis was tested. Table 4.2.1 presents the scores of the control group (non-calculator-aided group) and experimental group (calculator-aided group) in the post-test.

The researcher analysed the learners' responses to the post-test by using frequency tables. An analysis by group test for association was then followed by a summary of statistics.

Table 4.2.2 shows all the learners' responses to specific questions. As stated in Chapter 3, each question addressed a certain concept on fractions, and the way in which learners performed was also noted to establish whether one group had an advantage over the other, depending on the intervention implemented.

Control Group		Experimental Group	
Student	Total Marks	Student	Total Marks
SC1	33%	SE1	75%
SC2	38%	SE2	46%
SC3	21%	SE3	36%
SC4	33%	SE4	31%
SC5	25%	SE5	63%
SC6	14%	SE6	9%
SC7	34%	SE7	36%
SC8	19%	SE8	70%
SC9	12%	SE9	58%
SC10	21%	SE10	70%
SC11	27%	SE11	52%
SC12	30%	SE12	40%
SC13	31%	SE13	57%
SC14	41%	SE14	74%
SC15	61%	SE15	90%

Table 4.1: Control and experimental group’s post-test result

Table 4.1 shows that eight learners in the control group scored 30% or less, while only one learner scored 30% or less in the experimental group. This implies that more than half of the learners, i.e.: 53.3% of the learners in the control group scored 30% or less, while in the experimental group only 6.67% of the learners scored 30% or less.

Table 4.1 shows that six learners scored between 30% and 40% in the control group, and a total of 14 learners scored 40% or less in the control group. Thus, 93.3% of learners in the control group scored 40% or less in the post-test. In the experimental group only four learners scored between 30% and 40%, thus a total of only five learners scored 40% or less. This implies that, 30% of learners in the experimental group scored 40% or less, which is lower than the 93.3% from the control group.

Table 4.1 shows that nine learners from the experimental group scored 50% and above—that is 60% of the learners – while in the control group, only one learner – which is 6.67% of the learners—scored above 50.

4.2.2 Analysis of the Learners Post-test Results according to the South African, National Curriculum Assessment, Grade 7-9

The learners' post-test results were grouped according to 'pass' or 'fail', according to National Curriculum Statement CAPS, Grade 7-9 (Department of Education, 2011). The number of learners who passed was expressed as a percentage and then graphically presented on one pie chart to clearly show which group had a higher percentage pass rate according to the South African assessment standards. The experimental group had a 73% pass rate compared to the control group that had a 13% pass rate (Table 4.2). Furthermore, the experimental group had more learners with a 40-100% mark, indicated by a 37% out of the total of 44% in that category on the pie chart, compared to the 7% in the control group (see Figure 4.2).

Mark Interval	0-39	Percentage of the Total	40-100	Percentage of Total	Percentage Pass
Control Group	13	43%	2	7%	13%
Experimental Group	4	13%	11	37%	73%
Total	17	56%	13	44%	88%

Table 4.2: Post-test results pass rate according to NCS, CAPS (Department of Education, 2011)

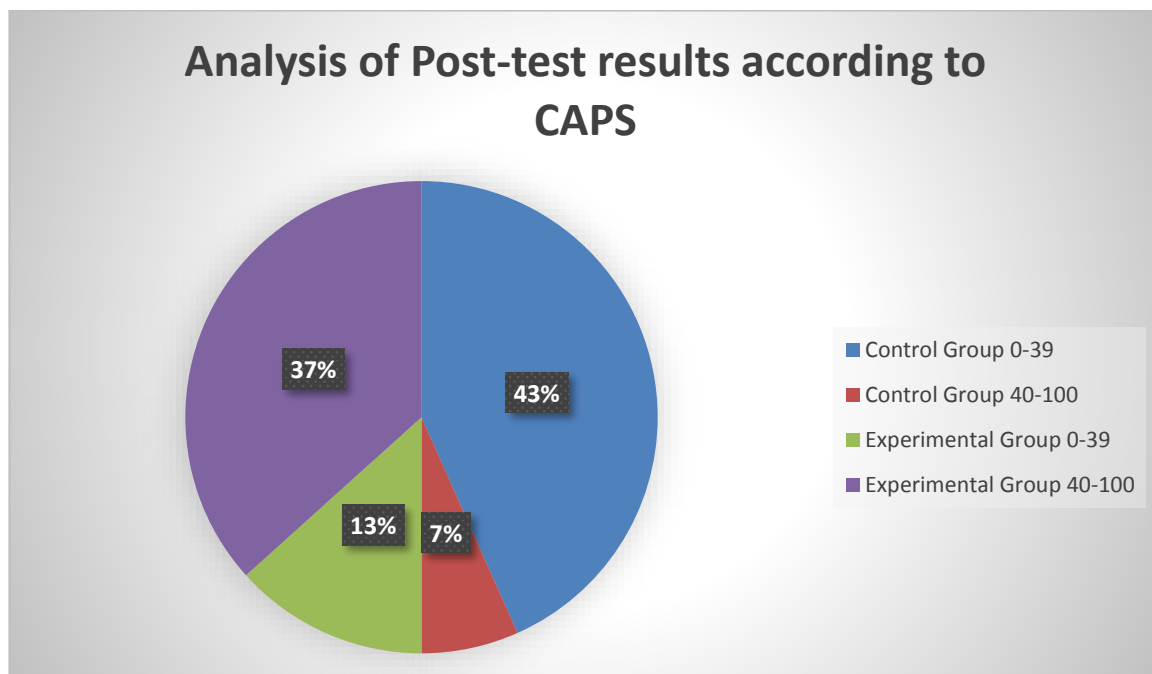


Figure 4.1: Analysis of post-test results according to NCA, CAPS, Grade 7-9 (Department of Education, 2011)

The pie chart (Figure 4.1) shows that more learners in the experimental group passed the post-test than the control group (Figure 4.1). The percentage of the learners who failed (0-39%) in the control group is 43%, and 13% in the experimental group, out of a total of 56% of all the learners who failed the post-test. The pie chart above clearly indicates that according to the South African Grade 8 Assessment, the control group had a higher failure rate than the experimental group.

4.3 Statistical Analysis

Strata VII was the statistical software package used to analyse the data gathered from the post-test, assignment, and questionnaire. Pearson's chi-square test was used to test for association within categorical variables. A rank-sum test was used to compare the overall scores between the two groups, and the results were presented in a tabular format. The interpretation was performed at 95% confidence limit.

The results from the statistical analysis were noted. Table 4.3 shows the frequency tables for post-test for the whole groups performance per question as a percentage. Table 4.4 provides an analysis of the post-test results by group. Table 4.5 shows the test for association, while Table 4.5 shows the summary statistics and Table 4.6 shows the overall comparison of groups according to the Strata VII statistical software.

Question	Correct		Incorrect		Question	Correct		Incorrect	
	Frequency	%	Frequency	%		Frequency	%	Frequency	%
Q1.1	30	100	0	0	Q8.1	16	53.33	14	46.67
Q1.2	30	100	0	0	Q8.2	15	50	15	50
Q1.3	29	96.67	1	3.37	Q8.3	12	40	18	60
Q1.4	28	93.33	2	6.67	Q8.4	12	40	18	60
Q2.1	18	60	12	40	Q8.5	4	13.33	26	86.67
Q2.2	15	51.72	14	46.47	Q9.1	14	46.67	19	53.33
Q3.1	14	46.67	16	53.33	Q9.2	14	46.67	19	53.33
Q3.2	13	56.67	17	43.33	Q9.3	7	23.33	23	76.67
Q3.3	10	33.33	20	66.67	Q9.4	10	33.33	20	66.67
Q4.1	7	23.33	23	76.67	Q9.5	13	43.33	17	56.67
Q4.2	18	60	12	40	Q9.6	13	43.33	17	56.67
Q5.1	18	60	12	40	Q10.1	8	26.67	22	73.33
Q5.2	24	80	6	20	Q10.2	non	0%	30	100
Q5.3	15	50	50	50	Q10.3	1	3.33	29	22
Q6.1	25	16.67	5	16.67	Q10.4	non	0%	30	100
Q6.2	27	90	3	10	Q11.1	8	26.69	22	73.33
Q6.3	27	90	3	10	Q11.2	8	26.67	22	73.33
Q7.1	28	93.33	2	6.67					
Q7.2	25	83.33	5	16.67					

Table 4.3: Frequencies and percentages of all the learners per question in the post-test

The researcher analysed the performance of learners per question per group, and the percentages were represented on Table 4.3. The table above indicates that almost all learners were able to identify the type of fraction given. See Questions 1.1, 1.2, 1.3, and 1.4 in Table 4.3. Almost all the learners did not perform well in Question 10, which involves word problems involving fractions (see Questions 10.1, 10.2, 10.3, and 10.4 in Table 4.3).

Question	Correct		Incorrect		Question	Correct		Incorrect
	Control Group	Experimental Group	Control Group	Experimental Group		Control Group	Experimental Group	
Q1.1	100	100	non	non	Q8.1	26.67	80	73.33
Q1.2	100	100	non	non	Q8.2	33.33	66.67	66.67
Q1.3	100	93.33	non	6.67	Q8.3	40	60	60
Q1.4	100	86.67	non	non	Q8.4	26.67	53.33	73.33
Q2.1	33.33	86.67	66.67	13.33	Q8.5	non	26.67	100
Q2.2	21	80	78,57	20	Q9.1	20	73.33	80
Q3.1	33.33	60	66.67	40	Q9.2	33.33	60	66.67
Q3.2	20	66.67	80	33.33	Q9.3	13.33	33.33	86.67
Q3.3	13.33	53.33	86.67	46.67	Q9.4	20	46.67	80
Q4.1	66.67	86.67	33.33	13.33	Q9.5	26.67	60	73.33
Q4.2	33.33	86.67	66.67	13.33	Q9.6	20	66.67	80
Q5.1	40	80	60	20	Q10.1	20	33.33	80
Q5.2	40	100	60	non	Q10.2	non	non	100
Q5.3	40	60	60	40	Q10.3	non	6.67	100
Q6.1	80	86.67	20	13.33	Q10.4	non	non	100
Q6.2	80	100	20	non	Q11.1	20	33.33	80
Q6.3	86.67	93.33	13.33	6.67	Q11.2	14.29	60	85.71
Q7.1	93.33	93.33	6.67	6.67				
Q7.2	86.67	80	13.33	20				

Table 4.4: Analysis of performance in the post-test per group as a percentage

N.B the control group (non-calculator-aided group) and the experimental group (calculator-aided group).

Table 4.4 shows that of all the 36 questions the learners answered, the experimental group (the group that used calculators) performed better than the control group in about 30 questions, while the control group only excelled in one question. All learners in the experimental group could complete questions 5.2 that involved a comparison of fractions and question 6.2 that involved expressing fractions as mixed numbers in their lowest terms (see Table 4.4 above).

4.3.1 Post-test (Task1) Test of Association

A test of association refers to testing whether patterns of performance of both groups on each item are the same. It shows whether the pass rate on each item of both groups is the same. A test of association was conducted on the post-test results of the experimental and the control groups.

The test of association was aimed at deciding whether or not there was a significant difference in learners' performance per group per question. The interpretation was performed at 95% confidence limit where group membership was significantly associated if $p \leq 0.05$.

The test of association showed that in nine out of 36 questions given, the performance of learners in the experimental group was significantly higher than that of the control group. The number of learners with correct answers in the experimental group was higher than the control group, thus the test of association performed at 95% showed that group performance was significantly different.

Table 4.5 shows the results from the post-test, the test of association of the nine questions where the performance of the experimental group was significantly different to that of the control group.

Pearson chi2	Control group		Experimental group			
	Correct	Incorrect	Correct	Incorrect		
2.1	33.33	66.67	86.67	13.33	8.8889	0.003
2.2	21.43	78.57	80	20	9.9488	0.002
4.2	33.33	66.67	86.67	13.33	8.8889	0.003
5.1	40	60	80	20	5.0000	0.025
8.1	26.67	73.33	80	20	8.5714	0.003
8.5	0	100	26.67	73.33	4.6154	0.032
9.1	20	80	73.33	26.67	8.5714	0.003
9.6	20	80	66.67	33.33	6.6516	0.010
11.2	14.29	85.71	60	40	6.4277	0.011

Table 4.5: Test of association of significantly different post-test results

Question 2 of the post-test tested the learners' ability to reduce a given fraction to its simplest terms. It was observed that in responding to Question 2.1, 86.67 % in the experimental group answered correctly, while only 27.78% answered correctly in the control group. The results of the test of association showed that the group membership of Question 2.1 was significantly associated ($p = 0.003$). Thus, it was observed that the pass rate was higher for experimental group than the control group in Question 2.1, and the pass rate is significantly different. This implies that the learners who used the calculator performed better than the learners who used paper and pencil (see Table 4.4).

Similar observations were observed in Question 2.2 where learners were required to reduce a given fraction to its simplest form. While 80% of the learners in the experimental group answered question 2.2, only 20% from the control group answered it correctly.

The results from the test of association showed that the learners who used a calculator had a higher pass rate than the learners who used the paper and pencil method in reducing the fraction to its lowest terms.

Question 4.2 tested learners' ability to find a missing value in equivalent fractions. It was observed that only 33.33% of the learners in the control group correctly performed this procedure, while 86.67% of the experimental group performed the same procedure correctly. A test of association performed on Question 4.2 showed that the learners' performance in the levels of Question 4.2 were significantly higher with ($p = 0.02$). Thus, the results of the test of

association showed that the performance of learners in Question 4.2 was significantly different, that is, the learners who used a calculator performed better than the learners who used the paper and pencil method to find the missing value in equivalent fractions.

Apart from reducing fractions to its simplest form and equivalent fractions, it was also observed that the learners who used a calculator achieved better results in Question 5.1. Question 5.1 tested learners' ability to compare fractions. Learners were required to express fractions with the same denominator and then compare the fractions. It was observed that 80% of the learners in the experimental group could perform the procedure correctly, while 40% in the control group performed the procedure correctly. The test of association performed on question 5.1 indicated that learners' performance in Question 5.1 was significantly different, with ($p = 0.025$). Thus, there was a significant difference between the experimental group and control group's performance. The results of the test association showed that the experimental group performed significantly better than the control group (see Table 4.3).

Table 4.3 clearly shows that the control group and the experimental group's performance in question 8.5 was significantly different ($p = 0.032$). Thus, the performance of learners in dealing with algebraic fractions was significantly different in the levels of Question 8.5. It was observed that the experimental group's performance in the algebraic question was significantly better than that of the control group, even though they were not able to verify their answers. In the experimental group, 26.67% answered the question correctly, whilst no answered correctly in the control group. The results of the test association showed that the learners' performance in the experimental group was significantly different to the performance of the control group, with $p = 0.032$.

In Questions 9.1 and 9.6 the test of association was observed and showed that the performance of the experimental group was significantly better than that of the control group in multiplication and division of complex fractions. While 21.43% answered Question 9.1 correctly in the control group, 78.57% answered correctly in the experimental group, with ($p = 0.003$). Thus, there was a significant difference in learners' performance.

Similar observations were observed in Question 9.6, where 23.08% in the control group answered correctly while 76.92% in the experimental group answered correctly, with ($p = 0.010$), which shows that the performance of the two groups differs significantly (see Table 4.3).

Table 4.3 reveals that in Question 11.2 that tested learners' ability to identify misconceptions in a given question, then answered the question correctly. The learners who used the calculator performed significantly better than the learners who used paper and pencil. While 60% of the experimental group answered Question 11.2 correctly, only 14.29% of the control group answered correctly, with $p = 0.011$.

4.4 Measures of Variability or Dispersion of the Post -test

A box and whisker plot was used to represent the variability of learners' post-test scores. Tables 4.6 and 4.7 represent the five number summaries for the learners' post-test results for the control and experimental groups respectively. Figures 4.4.1 and 4.4.2 show the box

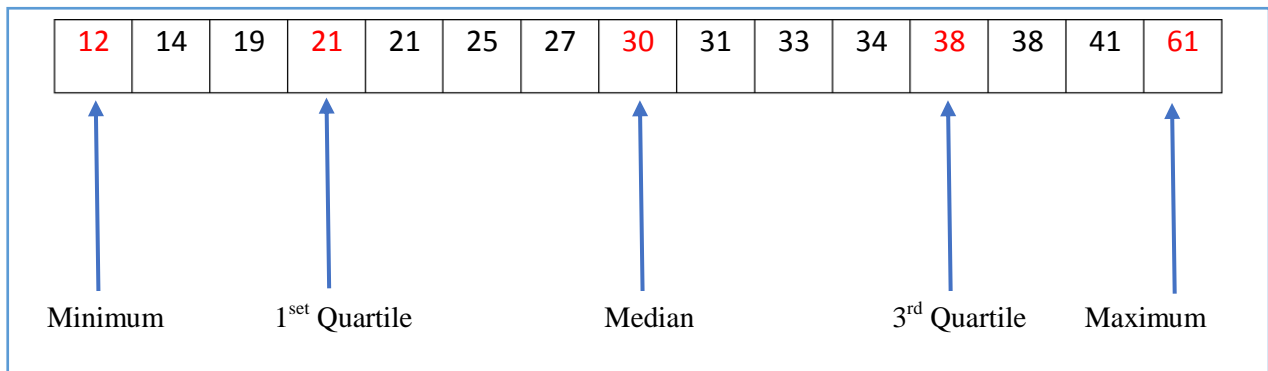


Table 4.6: Control group post-test results' five number summary

It was observed that the minimum mark from the control group was 12%; 25% of the learners achieved 21% or less, 50% of the learners achieved 30% or less, 75% of the learners achieved 38% or less while the maximum mark in the control group was 61% (See table 4.6).

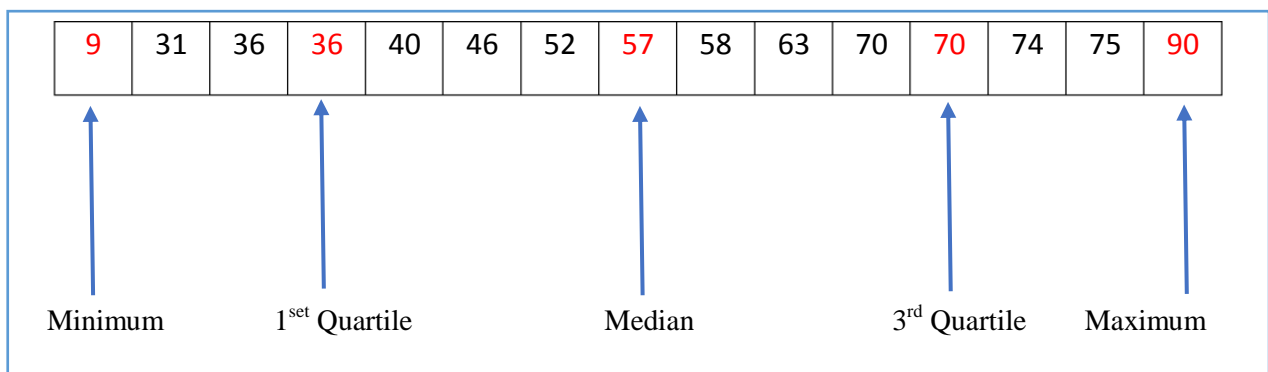


Table 4.7: Experimental group post-test results' five number summary

Whilst in the experimental group the following was observed, the lowest mark in the experimental group was 9%, 25% of the learners in the experimental group achieved 36% or less, while 50% of the learners achieved 57% or less, 75% of the learners achieved 70% or less, while the maximum score in the control group was 90% (see Table 4.3).

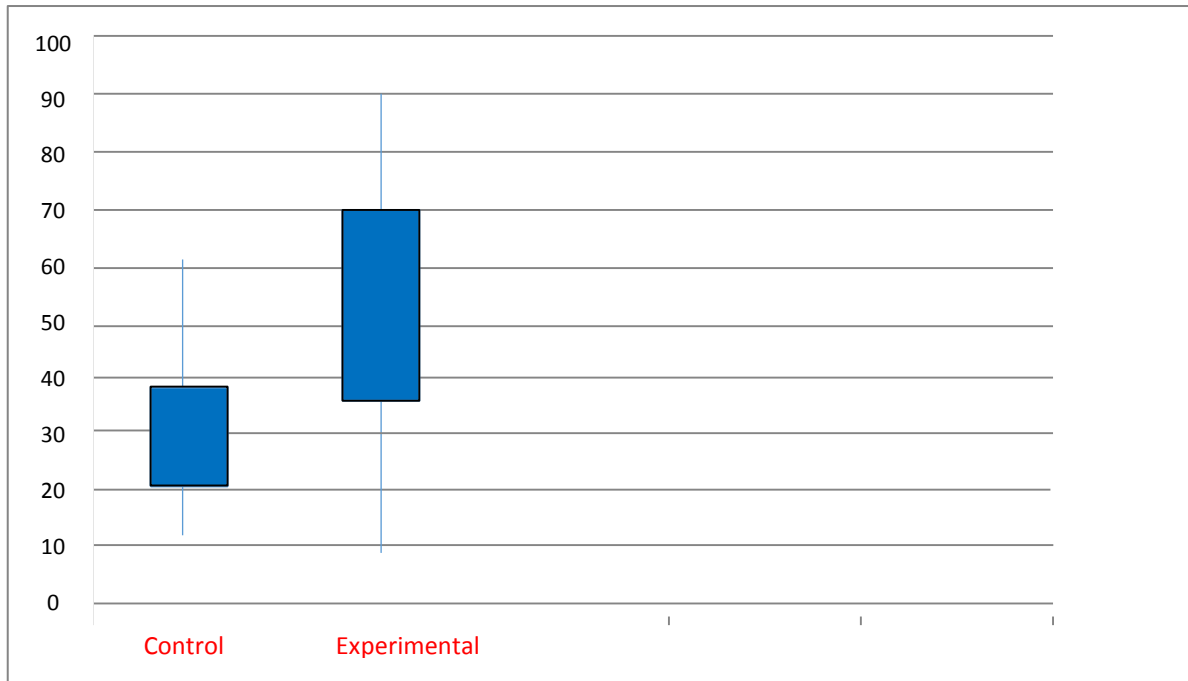


Figure 4.2: Box and whisker plot comparing post-test results

4.4.1 Synthesis of the Box and Whisker Plot of the Post-test

Control group

The box and whisker plot representing the control group clearly shows that the data were symmetrically skewed. This implies that 50% of the learners achieved the average mark of 30%.

Experimental group

The box and whisker plot representing the experimental group is negatively skewed, which implies that more than 50% of the learners achieved more than the average or mean of 54%.

Therefore, the box and whisker plots above (table 4.2.1) illustrates that the quality of results obtained by the experimental group were far better than the experimental group's results, due mainly to the following:

- the experimental group had a bigger mean compared to the control group, i.e. 54% and

30% respectively;

- more than half of the group achieved 57% or less in the experimental group, while in the control group half of the group achieved 30% or less;
- 25% of the control group achieved below 36% in the experimental group, while in the control group 25% of the learners achieved 21%, which was less than that of the experimental group;
- at least 25% of the learners achieved between 70% and 90% in the experimental group, while in the control group no one achieved 70%;
- the maximum mark in the control group was 61%, whilst in the experimental group it was 91%; and
- at least 75% of learners in the control group achieved 38% or less, while in the experimental group 75% of the learners achieved 70%.

4.5 Summary of Statistics of Post-test Results by Strata V11 Program

A summary of the statistics on the post-test was conducted and the following results were found (see Table 4.7). The mean from both the experimental and the control groups combined (30 learners) was 41.9%, the standard deviation was 21.24626, and the minimum and the maximum marks for both groups was 9 and 91, respectively.

Variable	Observation	Mean	Standard Deviation	Minimum	Maximum
Overall	30	41.9	21.24626	9	90

Table 4.8: Summary statistic for post-test results for the experimental and control group

A summary of the post-test results per group was also conducted using the Strata V11 statistical program, and the following results were established (see Table 4.8). The mean in the control group was 29.66667, thus it was lower than that of the experimental group, which was 54.13333. Apart from the mean, the experimental group had a higher median than the control group—57% and 30% respectively. Furthermore, the experimental group’s highest score was 91%, compared to the control group’s score of 61%, which is far below 91%. From these results it can be concluded that learners who used the calculator performed better than the learners who used the traditional paper pencil.

Group	Variable	Observation	Minimum	Mean	Median	Maximum
1	Overall	15	12	29.66667	30	61
2	Overall	15	9	54.13333	57	91
Total	Overall	30	9	41.6	37	91

Table 4.9: Summary statistics of post-test results per group

A two-sample Wilcoxon rank-sum (Man-Whitney) test was conducted to compare the overall results of the post-test results per group. A null hypothesis established that there was no significant difference between the overall scores of the experimental and the control groups and was tested at $z = 0.0014$. Thus, the null hypothesis was rejected at probability $> |z| = 0.0014$. Probability was found at $z = -3.196$.

The null hypothesis that there was no difference in the experimental group was not rejected since calculated probability was not greater than 0.0014, instead $-3,196 < 0.0014$ (see Table 4.9). The results of the Wilcoxon rank-sum (Man-Whitney) shows that there was a significant difference between the overall scores of the control group and the experimental group's results. Therefore, the learners who used the calculator as a learning aid (experimental group) performed better than the learners who used the traditional paper and pencil (control group)

Group	Observation	Rank Sum	Expected	z	P
Control Group	15	155.5	232.5	-3.196	0.0014
Experimental Group	15	309.5	232.5		
Combined	30	465	465		
Unadjusted Variance	581.25				
Adjustment ties	-0.65				
Adjusted variance	580.60				

Table 4.10: Post-test (Task 2) Comparison of groups' overall scores

4.6 Analysis of Task 2(Assignment) Results

The learners' assignment was marked according to the assignment memorandum (Appendix J). The results of the learners' scores were compiled as follows: Table 4.10 presents learners scores

in the assignment for the control and experimental groups respectively. Figure 4.3 presents the scores on a line graph for both the experimental and control groups.

Control Group (Group 1)		Experimental Group (Group 2)	
Student	Student	Mark	
SC1	12	SE1	34
SC2	13	SE2	23
SC3	15	SE3	17
SC4	12	SE4	17
SC5	10	SE5	23
SC6	4	SE6	10
SC7	12	SE7	17
SC8	20	SE8	28
SC9	5	SE9	27
SC10	5	SE10	20
SC11	15	SE11	19
SC12	12	SE12	13
SC13	14	SE13	19
SC14	21	SE14	40
SC15	26	SE15	37
Average	13.066	Average	22.533
Overall Total	50		50

Table 4.11: Assignment results (Task 2)

It was observed from Table 4.11 that the highest learner in the control group achieved 52%, while in the experimental group the highest learner achieved 80%, which was higher than that of the control group. It was also observed that at least four learners in the control group, making up a total of 26.67% of learners in the control group achieved 10% or less in the assignment (Task 2), while only one learner in the experimental group achieved 10%, thus 6.67% of the learners in the experimental group. It was observed that while the lowest mark in the control group was 8%, in the experimental group it was 26%. The average mark in the control group was 13.066 while in the experimental group it was 22.533. Generally, it was observed that both groups did better in the test than the assignment, ruling out the possibility of mathematics anxiety during the tests in both groups.

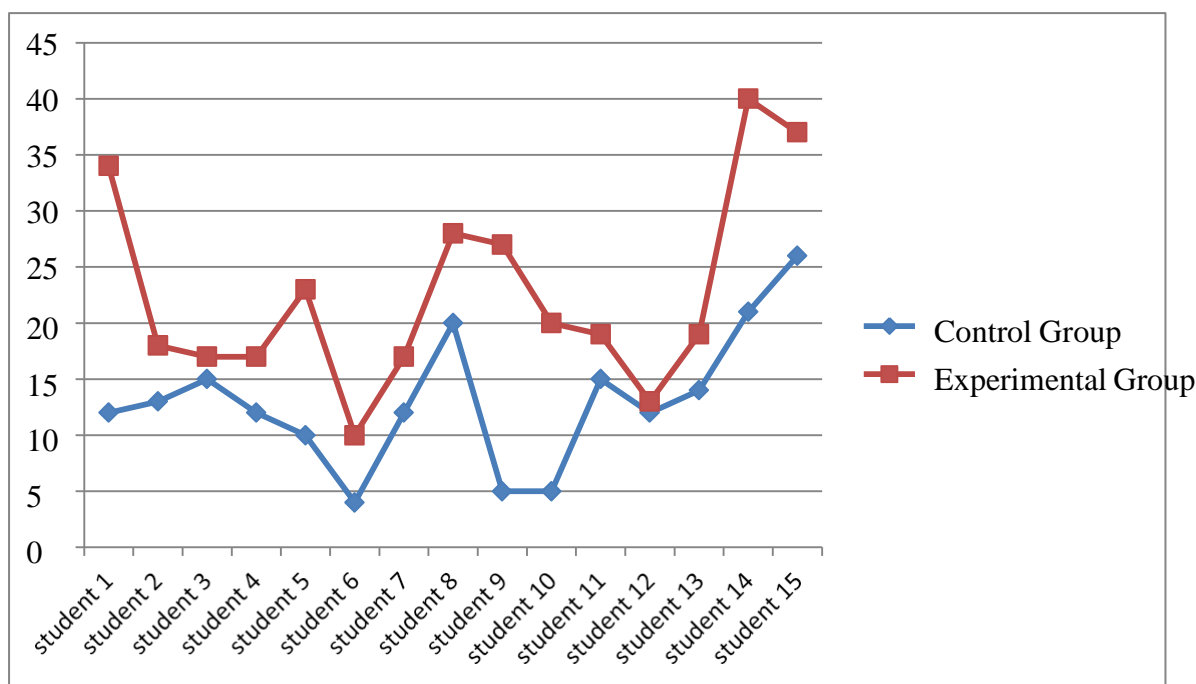


Figure 4.3: Line graph to compare learners' assignment results

Figure 4.3 shows that the line graph representing the assignment results of the experimental group were above those of the control group. Thus, the assignment results of the experimental group were higher than those of the control group. (see Figure 4.3).

Statistics	Control Group	Experimental Group
Minimum	4	10
Maximum	26	40
Range	22	30
Mean	13.066	22.533
Standard Deviation	5.662	8.1613

Table 4.12: Descriptive statistics for assignment results for control and experimental groups

Table 4.12 shows that the lowest mark in the control group was 8% and the maximum mark was 52%, with a range of 22, a mean of 13.066, and standard deviation of 5.662. In the experimental group the lowest mark was 20%, maximum 80%, with a range of 30, a mean of 22.533, and standard deviation of 8.1613. The summary of statistics reflects that that the experimental group's results were better than those of the control group.

4.7 Analysis of Task 2 (Assignment) By Groups

The researcher looked at the percentage of learners who answered each question correctly in Task 2 per question, per group, and compared it to the performance percentage of the whole group. Table 4.12 Represents learners' performance on Task 2, per question, per group, in comparison to the whole group performance as a percentage.

Question	Control Group		Experimental Group		Total Performance for the whole	
	Correct	Incorrect	Correct	Incorrect	Correct	Incorrect
1	non	100	20	80	10	90
2.1	26.67	73.33	66.67	33.33	46.67	53.33
2.2	13.33	86.67	66.67	33.33	40	60
3.1	26.67	73.33	93.33	6.67	60	40
3.2	20	80	86.67	13.33	53	46.67
4.1	6.67	93.33	93.33	6.67	93.33	6.67
4.2	66.67	33.33	93.33	6.67	80	20
5.1	86.67	13.33	100	non	93.33	6.67
5.2	73.33	26.67	93.33	6.67	83.33	16.67
6.1	13.33	86.67	33.33	66.67	23.33	76.67
6.2	40	60	40	60	60	40
6.3	33.33	66.67	26.67	73.33	30	70
6.4	40	60	53.33	46.67	46.67	53.33
6.5	non	100	26.67	73.33	13.33	86.67
6.6	66.67	33.33	73.33	26.67	70	30
6.7	66.67	33.33	73.33	26.67	70	30
6.8	26.67	73.33	66.67	33.33	46.67	53.33
7.1	21.43	78.57	53.33	46.67	37.93	62.07
7.2	non	100	20	80	10	90

Table: 4.13: An analysis of learners' performance per group per question as a percentage

Table 4.13 clearly shows that the experimental group performed better than the control group in all questions. In questions 1 and 7.2 none of the learners in the control group answered correctly, whilst at least 20% of the learners in the control group answered correctly in each case.

4.8 Test of Association According to Strata V11 Software

As in the post-test results, an association test was performed on the assignment results per question to test if there was a significant difference in the results between the experimental group and the control group. The researcher established that the same trend of results was identified in the assignment as in the post-test. Table 4.14 shows that the test of association results are significantly different in the assignment. Table 4.14 shows the learners who answered the question correctly and incorrectly as a percentage per group and the Pearson χ^2 .

Question	Control group		Experimental group		Pearson χ^2	Pr
	Correct	Incorrect	Correct	Incorrect		
2.1	26.67	73.33	66.67	33.33	4.8214	0.028
2.2	13.33	86.67	66.67	33.33	8.8889	0.003
3.1	26.67	73.33	93.33	6.67	13.8889	0.000
3.2	20	80	86.67	13.33	13.3929	0.000
6.5	0.00	100	26.67	73.33	4.6154	0.032
6.8	26.67	73.33	66.67	33.33	4.8214	0.028

Table 4.14: Test of association of significantly different assignment results

The test of association on the assignment results showed that learners in the experimental group still performed better than the learners in the control group when comparing fractions (Questions 2.1 and 2.2). In Question 2.1 only 26.67% of the learners' in the control performed the procedure correctly while 66.67% performed the same procedure correctly in the experimental group, with $p = 0.028$. Thus, the performance of the experimental group learners in Question 2.1 was significantly different from that of the control group. Similar results were observed in Question 2.2, where 66.67% of the experimental group performed the procedure correctly, while only 13.33% in the control group performed the procedure correctly, with $p = 0.003$. This observation implies that there was a significant difference in learners' performance in question 2.2. (see Table 4.14).

Question 3 tested learners' ability to reduce fractions to their simplest form. The results of the test of association performed on the assignment in this procedure were consistent with the observations in the post-test. In the experimental group, 93.33% and 86.67% of the learners

answered Question 3.1 and Question 3.2 correct respectively, while in the control group only 26.67% and 20% respectively answered the same questions correctly, with $p = 0.000$ in both questions. These observations showed that the performance of the learners in the experimental group was significantly different to that of the control group.

Question 6 tested learners' abilities in the addition and subtraction of complex fractions, and the observations were consistent with the results in the post-test. The experimental group performance in Questions 6.5 and 6.8 were significantly different from those in the control group, with $p = 0.032$ and 0.028 respectively.

4.9 Summary of Statistics on Task 2 (assignment)

A sum overall of the learners' assignment results was compiled for all learners in both groups together, followed by a sum overall by group (see Tables 4.14 and 4.15).

Variable	Observation	Mean	Std. Dev	Minimum	Maximum
overall	30	36.26667	17.58317	8	80

Table 4.15: Sum overall for the whole group

It was observed that out of all the 30 learners who wrote the assignment, the mean mark was 36.26667, the standard deviation that represented the deviations from the mean was 17.58317, the minimum mark for all the learners (experimental and control group) was 8%, and the maximum mark was 80%.

Table 4.16 is a summary of the statistics of the overall assignments per group as a percentage

Group	Variable	Minimum	Mean	Median	Maximum
Control	overall	8	26.4	24	52
Experimental	overall	20	46.13333	40	80
Total	overall	8	36.26667	34	80

Table 4.16: Summary statistics of assignment by group

The observation from the assignment results per group revealed that the control group had a minimum mark of 8%, and a maximum mark of 52 %, a mean of 26.4%, and 50% of the learners achieved less than 24%. While the experimental group had a minimum of 20% and a maximum of 80%, a mean of 46.13333%, which was higher than the mean for both the

experimental and control groups, which was 36.26667%. Half of the learners in the experimental group (50%) achieved 40% or less compared to 24% in the control group.

A two-sample Wilcoxon rank-sum (Mann-Whitney) was used to test the null hypothesis that there was no significant difference between the overall scores of the experimental group and the control group at probability $> |z| = 0.0017$. Thus the null hypothesis was rejected when

$z \leq 0.0017$. The test showed that $z = -3.141$. The results of the two-sample Wilcoxon rank-sum test suggested that there was a statistically significant difference between the underlying distribution of the experimental and control group's overall scores. The experimental group scored significantly higher than the control group (see Table 4.17).

	Observation	Rank Sum	Expected	z	P
Control Group	15	157	232.5	-3.141	0.0017
Experimental Group	15	308	232.5		
Combined	30	465	465		
Unadjusted Variance	581.25				
Adjustment ties	-3.36				
Adjusted variance	577.89				

Table 4.17: Assignment (Task 2): Comparison of groups' overall scores

The results of the assignment concur with the results of the post-test. In both tasks the experimental group performed better than the control. Responses to the algebraic questions that were meant to test learners' conceptual understanding of the topic clearly show that learners in the experimental group could perform the procedures better without the calculator, contrary to teachers' beliefs that working out fractions with a calculator hinders learners' understanding of the fraction concept (see Chapter 1).

4.10 The Influence of the Calculator on Learners' Conceptual Understanding of Fractions

The observations from the learners' scripts showed that working out fractions with a calculator eliminates misconceptions and calculation errors. These misconceptions and calculation errors were observed mainly in the following procedures in the control group, but not in the experimental group.

4.10.1 Expressing Fractions in their Simplest Form

While most learners in the experimental group could express fractions in their simplest form, almost all the learners in the control group could not express fractions in their simplest form, resulting in all learners in the control group getting question 2 on the post-test wrong (see Figure 4.4a and Figure 4.4b, Question 2). Instead of finding the highest common factor most learners in the control group either divided the numerator and the denominator, giving them $1 \frac{21}{49}$ instead of $\frac{4}{7}$ (see Figure 4.4a from SC 8's script on the post-test from the control group).

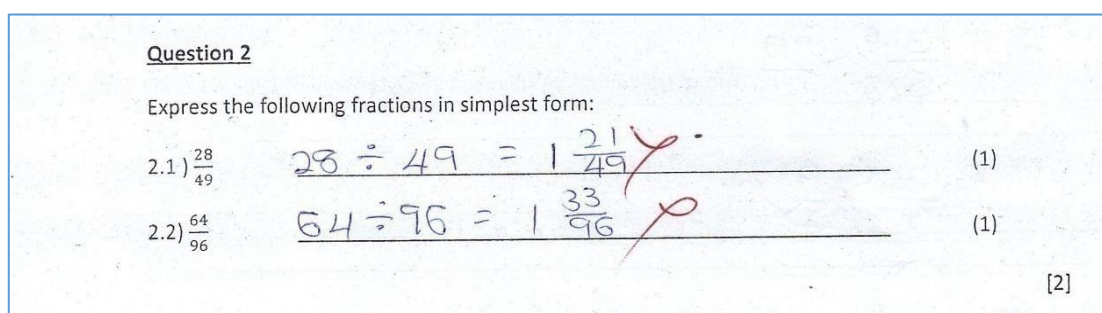


Figure 4.4a: Misconception on reducing fractions to their simplest form

Calculation errors were also noted in conjunction with the numerator and denominator division misconception in question 2 in the control group. Learners worked the question as follows:

$49 \div 28 = 1 \frac{22}{28}$, instead of 21 most of them got 22 and made the denominator 28 (see Figure 4.4b from SC 14 from the control group).

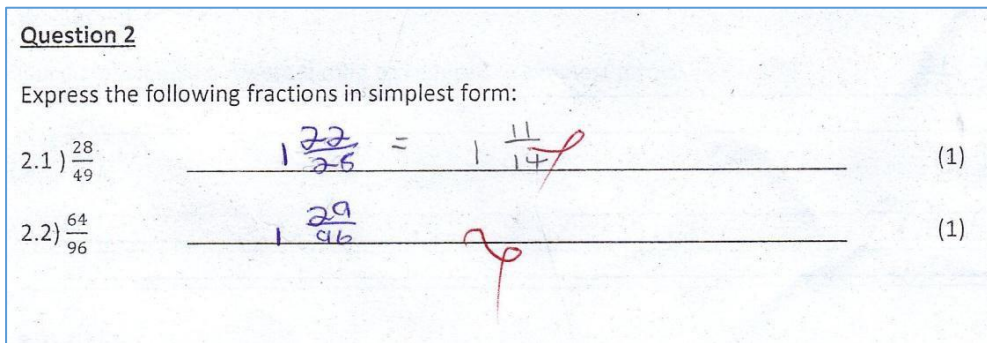


Figure 4.4b: Misconception and calculation errors on reducing fractions

Additionally, a few learners from the control group subtracted the numerator and the denominator, i.e. $49 - 28 = 21$ and left it as that, which was a major misconception of the actual concept (see Figure 4.4c). No problems were noted from the experimental group, since this concept could also be performed on the calculator.

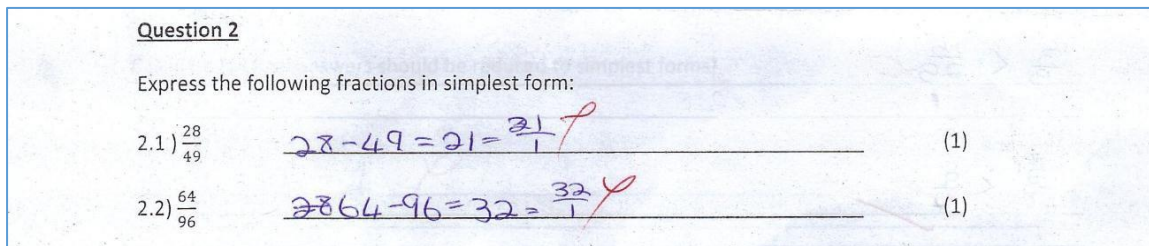


Figure 4.4c: Misconception on reducing fractions to simplest form

4.10.2 Changing Mixed Numbers to Improper Fractions

Most learners in the control group made calculation errors, for instance $\frac{41}{8} = 4 \frac{7}{8}$, this indicates that the learner was aware of the method but made subtraction errors, and got 7 instead of 9. Also, when dividing $41 \div 8$, the learner got 4 instead of 5 (see Figure 4.5a from SC4).

Question 6

Express the following fractions as mixed numbers to their lowest terms

6.1) $\frac{23}{7}$ (2)

$3\frac{2}{7}$ ✓✓

6.2) $\frac{41}{8}$ (2)

$4\frac{7}{8}$ ✓

6.3) $\frac{34}{6}$ (2)

$5\frac{4}{6}$ ✓✓

Figure 4.5a: Calculation errors in converting fractions

Some learners from the control group multiplied the numerator and the denominator, for example in $\frac{28}{7}$ $28 \times 7 = 69 = 6\frac{9}{7}$ after multiplying the learner took the first digit as a whole number and the second as a fraction, which is a major misconception in converting fractions (see Figure below 4.5b from SC10).

Question 6

Express the following fractions as mixed numbers to their lowest terms

6.1) $\frac{28}{7}$ (2)

$28 \times 7 = 69 = 6\frac{9}{7}$

6.2) $\frac{41}{8}$ (2)

$41 \times 8 = 328 = 32\frac{8}{8}$

6.3) $\frac{34}{6}$ (2)

$34 \times 6 = 14 = 1\frac{4}{6}$

[6]

Figure 4.5b Misconceptions in converting improper fractions to mixed numbers

4.10.3 Misconceptions related to Converting Mixed Number to Improper Fractions

Most learners in the control group had major misconceptions when converting mixed numbers to improper fractions with negatives, more so than learners in the experimental group. Apart from the calculation errors, the major misconception that was observed in this concept was that in Question 7.2 most learners said $-65 + 4$ gave them $\frac{-61}{5}$, instead of $-\frac{69}{5}$.

Some learners from the control group, for example SC9, actually wrote the correct answer but ignored the negative sign completely, while some learners did not do anything with the numerator and left it at $-\frac{65}{5}$ (see Figure 4.6a).

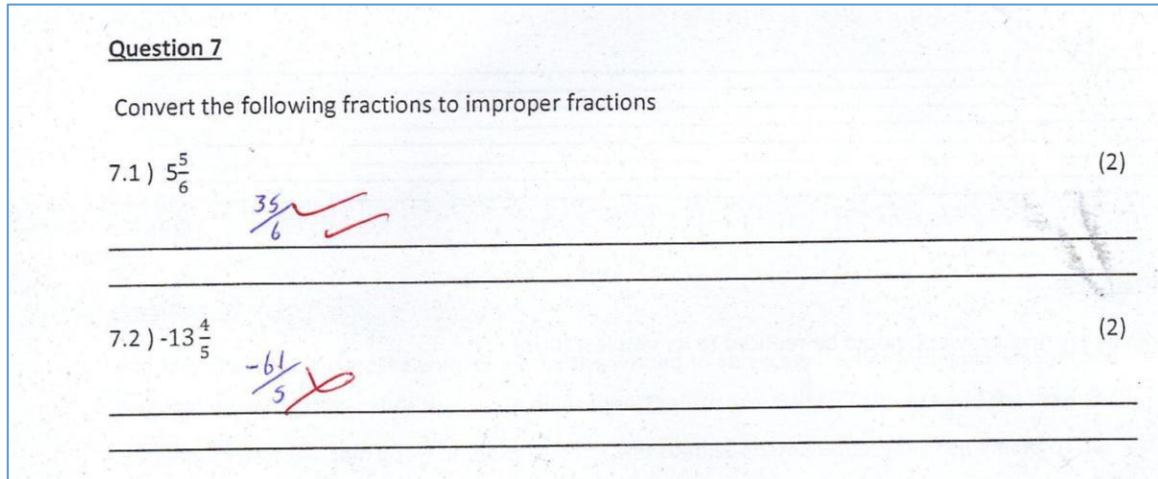


Figure 4.6a Misconception of fractions involving integers

In Figure 4.6b below, the SC10 learner decided to ignore the negative sign completely and wrote the answer correctly without the negative.

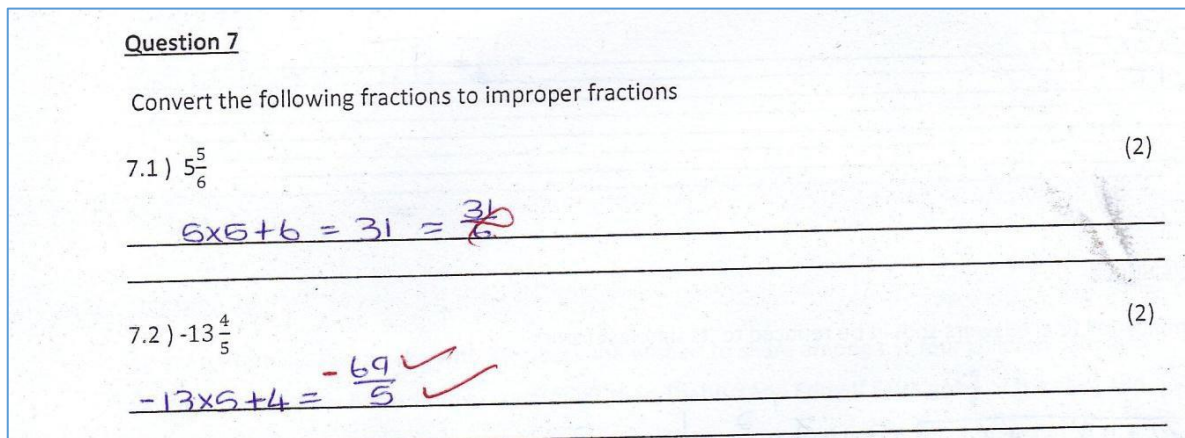


Figure 4.6b Misconception of fractions involving negative integers

Additionally, most learners in the control group experienced challenges when converting improper fractions to mixed fractions. Instead of multiplying the whole number and the denominator in Question 7.1., some learners multiplied the whole number and the numerator and then add the denominator, i.e.: $5\frac{5}{6} = (5 \times 5) + 6 = \frac{31}{6}$ (see Figure 4.6c from SC10's script).

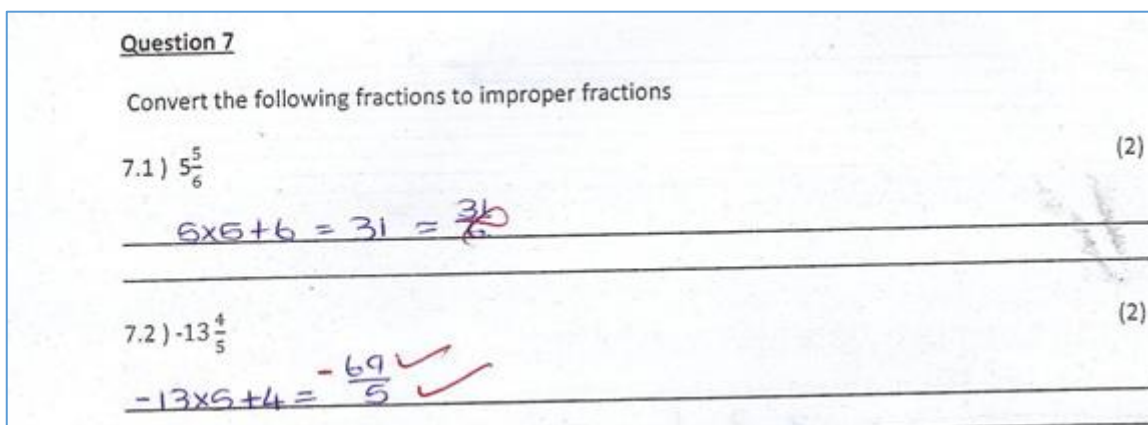


Figure 4.6c: Misconception on fractions involving negative integers

4.10.4 Addition and Subtraction

In comparison to the experimental group, most learners in the control group performed very poorly in addition and subtraction of fractions. In the post-test at least nine of the 15 learners, representing 60% of the learners, achieved 10 out of 23, with at least one of them achieving 23/23. In the control group only two learners achieved 10 and above, resulting in only 13% of the learners getting 10 and above in the control group (see Table 4.12).

Most learners in the control group expressed frustration in finding the common denominator; some had to literally do the times table, but to no avail. Figure 4.7 clearly shows how frustrated learners got when working without a calculator. Not only were the learners' working-out very untidily presented, revealing the learners' frustrations, but the learners tried to do a times table calculation on the script, without success. The learners' desperate attitude eventually led to fatigue and boredom, and most importantly time was wasted and learners never finished in time, as evidenced by the time taken by the control group to finish. It was through the work of such learners that the researcher concluded that working without a calculator was time-consuming and affects learners' performance, as was evidenced by the control group's overall poor performance in contrast to the experimental group (see Figure 4.7 below from SC9 in the post-test).

Handwritten student work for Figure 4.7. At the top, there are multiplication tables for 15: $15 \times 2 = 30$, $15 \times 3 = 45$, $15 \times 4 = 60$, $15 \times 5 = 75$, $15 \times 6 = 90$, $15 \times 7 = 105$, $15 \times 8 = 120$, and $15 \times 9 = 135$. Below this, a fraction division is shown: $\frac{15}{2} \div \frac{125}{6} = \frac{8}{3} = \frac{4}{1}$. To the right, there is a multiplication table for 7: 7, 14, 21, 28, 35, 42, 49, 56, 63, 70, 77, 84, 91, 98, 105. Below that, another fraction division is shown: $\frac{4}{9} \div \frac{36}{48} \div \frac{3}{8}$. To the right of this is $36 \times 4 = 144$ (5). At the bottom, there are several lines of calculations: $\frac{4}{9} \div \frac{36}{48} = \frac{2}{3}$, $\frac{3}{8} \div \frac{1}{4} = \frac{3}{2}$, $\frac{2}{3} \times \frac{6}{12} \times \frac{1}{4} = \frac{12}{144} = \frac{1}{12}$, $\frac{6}{3} = \frac{3}{1}$, $\frac{36}{48} = \frac{3}{4}$, and $\frac{36}{48} = 12$.

Figure 4.7: Frustrations involving addition and subtraction without a calculator

4.10.5 Conceptual Understanding

No learner in the control group managed to answer the algebraic fraction question in Question 8.5 (see Table 4.13), whilst in the experimental group at least six learners answered the question correctly and some achieved partial marks while others achieved full marks. This question clearly showed that the learners were aware of the concept involved when adding and subtracting fractions and that they did not merely rely on the calculator. Most of the learners in the control group left out the variable, paid no attention to it, and continued with the question as if the variable did not exist, e.g. in question 8.5 of the post-test (see Figure 4.8 from SC8).

Handwritten student work for Figure 4.8. The question is 8.5) $3\frac{2}{3x} - 2\frac{3}{4}$. The student's work shows: $\frac{8}{2x} - \frac{11}{4}$, $\frac{8 \times 4}{3x \times 4} - \frac{11 \times 3}{4 \times 3} = \frac{32}{12x} - \frac{33}{12}$. Below this, there is a line with $\frac{-1}{12x}$ and another line with $1 \frac{-1}{12x}$ with a red checkmark.

Figure 4.8: Errors associated with addition and subtraction of algebraic fractions

4.10.6 Division and Multiplication

It was observed from both the post-test and the assignment that most learners in the control group went ahead and applied the concept in finding common denominators when multiplying fractions with different denominators. Thus, these learners had a misconception in terms of how to multiply fractions and incorrectly used the procedure for addition and subtraction of fractions

with different denominators. This was also observed in the division of fractions where the learners incorrectly used the addition and subtraction procedure. This misconception was observed mainly in the control group and not in the experimental group. i.e.: $\frac{2}{3} \times \frac{3}{10} = \frac{20}{30} \times \frac{9}{30} = \frac{180}{30}$. (see the Figure 4.9a from SC8's script from the control group).

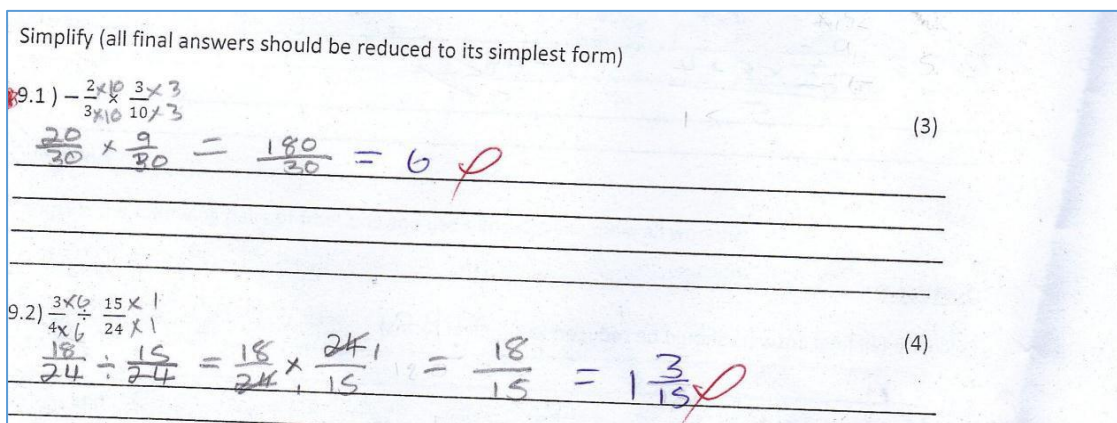


Figure 4.9a: Misconception on the multiplication of fractions

Some learners—mainly in the control group—applied the concept of division of fractions and addition and subtraction of fractions when multiplying fractions and then changed the multiplication sign to a division sign, in the same way you change division to multiplication i.e. $\frac{2}{3} \times \frac{3}{10} = \times \frac{9}{30} = \frac{20}{30} \div \frac{9}{30} = \frac{20}{30} = 2\frac{2}{30}$ (see Figure 4.9.11b below from SC11's script from the control group).

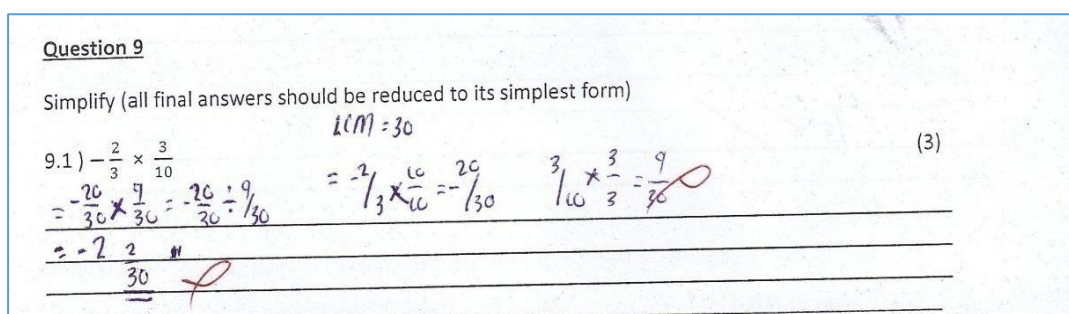


Figure 4.9b: Misconception on the multiplication of fractions.

Some learners, such as SC11, from the control group used the addition and subtraction method with different denominators procedure in the division of fractions together with the division of fractions procedure. Thus, they changed both fractions to the same denominator, then changed the division sign to a multiplication sign and proceeded (see Figure 4.10a below from SC11).

9.2) $\frac{3}{4} \div \frac{15}{24}$ (4)

$LCM = 24$

$\frac{3}{4} \times \frac{15}{24} = \frac{18}{24}$ $\frac{15}{24} \times 1 = \frac{15}{24}$

$\frac{18}{15} = \frac{3}{24} = \frac{1}{8}$

9.3) $\frac{15\frac{1}{2}}{5\frac{3}{6}}$ (5)

Figure 4.10a: Misconception of division of fractions

Some learners such as SC7 from the control group, like SC11, used the common denominator in the division of fractions, then failed to change the sign and instead divided the numerators and maintained the common denominator, like is done in converting fractions – a misconception of both procedures (see Figure 4.10b from SC7 of the control group).

9.2) $\frac{3}{4} \div \frac{15}{24}$ (4)

$\frac{3}{4} \div \frac{15}{24}$ $LCM = 24$

$= \frac{18}{24} \div \frac{15}{24}$ $= \frac{3}{4} \times \frac{6}{6} = \frac{18}{24}$

$= \frac{18}{15} = 1\frac{1}{4}$ $= \frac{15}{24} \times \frac{1}{1} = \frac{15}{24}$

Figure 4.10b: Misconception of the division of fraction

In Question 9.3 regarding the division of fractions involving mixed numbers, when converting the mixed fraction some learners divided the whole number and the denominator; the learners' working out is shown in the insert below (see Figure 4.10c from SC11 from the control group).

$15 \div 2 = 7\frac{1}{2}$ $125 \div 6 = 20\frac{5}{6}$

$\frac{19}{2} \times \frac{128}{6}$ $LCM = 6$

$\frac{19 \times 3}{2 \times 3} = \frac{57}{6}$

Figure 4.10c: Misconception of the division of fractions involving mixed numbers

In Question 9.3, some learners—like SC 7 from the control group—correctly converted the mixed number to an improper fraction and then found the common denominator by using the addition and subtraction method of fractions, and then divided the numerator and maintained the same denominator. This was a major misconception that involved the incorrect use of three procedures, namely the addition and subtraction of fractions, the division of fractions, and converting an improper fraction to a mixed number (see Figure 4.10d from SC7 from the

control group).

$$\begin{array}{l} 15 \frac{1}{2} \\ 5 \frac{3}{6} = 15 \end{array} \quad \text{LCM} = 6$$

$$= 15 \frac{1}{2} \div 5 \frac{3}{6} = \frac{31}{2} \div \frac{33}{6}$$

$$= \frac{93}{6} \div \frac{33}{6} = \frac{3}{6}$$

$$= \frac{1}{2}$$

$$= \frac{31}{2} \div \frac{3}{3} = \frac{93}{6}$$

$$= \frac{33}{6} \div \frac{1}{1} = \frac{33}{6}$$

Figure 4.10d: Misconception of the division of fractions involving mixed numbers

4.10.7 Synthesis of Findings

In general, the control group work was very untidily presented with a lot of cancelling and the use of a pencil, which might be due to the fact that the learners were frustrated with their work and/or very uninterested; this was not evident in the experimental group's scripts. This implies that learners who worked without the aid of a calculator found working through fractions tiresome and frustrating. While most learners in the experimental group had their work neatly presented, it showed they experienced little frustration with their work and they seemed to enjoy what they were doing.

Additionally, learners in the experimental group did not use the calculator as a means to an end nor did they use it to get the answers, as anticipated by most educators (see Chapter 2). Most learners in the calculator-aided group had all the necessary working out shown, even though they could have just used the calculators to find the answers.

Compared to the experimental group, the rate at which the control group made more calculation errors clearly shows that the use of a calculator might have helped the experimental group with the tiresome calculations; unfortunately, the same cannot be said of the control group. This might be attributed to the experimental group performing better than the control group, which is evidenced by the results the experimental group obtained.

The learners from experimental group's performance in Question 8.5 clearly shows that the use of a calculator did not hinder learners' understanding of the concept, because they could even apply the concept in questions where the calculator could not be used.

Item		Strongly Disagree	Disagree	Agree	Strongly Agree	Total
1	Freq	1	4	5	5	15
	%	6.67	26.67	33.33	33.33	100
2	Freq	0	2	10	3	15
	%	0	13.33	66.67	20	15
3	Freq	2	2	8	3	15
	%	13.33	13.33	53.33	20	15
4	Freq	0	2	8	5	15
	%	0	13.33	53.33	33.33	100
5	Freq	0	1	8	6	15
	%	0	6.67	53.33	40	100
6	Freq	0	0	10	5	15
	%			66.67	33.33	100
7	Freq	1	0	9	5	15
	%	6.67	0	60	33.33	100
8	Freq	9	4		2	15
	%	60%	26.67		13.33	100
9	Freq	1	2	7	5	15
	%	6.67	13.33	46.67	33.33	100
10	Freq	0	1	8	6	15
	%		6.67	53.33	40	100
11	Freq	1	4	7	3	15
	%	6.67	26.67	46.67	20	100
12	Freq	1	3	5	6	15
	%	6.67	20	33.33	40	100
13	Freq	2	6	3	4	15
	%	13.33	40	20	26.67	100
14	Freq	2	8	4	1	15
	%	13.33	53.33	26.67	6.67	100
15	Freq	0	2	8	5	15
	%		13.33	53.33	33.33	100

Table 4.18 Learners' responses in the questionnaire as a percentage

4.11 Questionnaire

The learners in the experimental group responded to items in the questionnaire on the following four point Likert type scale: strongly disagree, disagree, agree, and strongly agree. The main purpose of the questionnaire was to establish the influence of a calculator in learning fractions from the learners' perspectives. Frequencies and distribution of learners' frequencies were calculated (see Table 4.16) presented in tables and compound bar graphs.

4.11.1 An Analysis of Questionnaire: Items 1 to 15

An analysis of learners' responses in the questionnaire showed that most learners felt that learning fractions with a calculator was better than using the traditional paper and pencil method. Most learners agreed that working out fractions with a calculator is better than working out fractions with the paper and pencil method (see Table 4.16 Item 9). Table 4.16 clearly shows that a total of 80% of the learners either agreed or strongly agreed with the fact that working out fractions with a calculator is better than working them out with the paper and pencil method.

Furthermore, most learners (33.33% and 53.33% respectively) either agreed or strongly agreed with the question that finding a common denominator was easier when using a calculator than when not using a calculator (see Table 4.16 Item 2).

Table 4.16 clearly indicates that contrary to the researcher's experience (see Chapter 1) that most learners have problems with finding common denominator in fractions, which results in them becoming frustrated with their work. 80.67% of the learners who participated in this research either agreed or strongly agreed with the idea that finding a denominator with a calculator is made easier, which implies less frustrations in dealing with the concept as a whole and the subject at large.

Furthermore, most learners either agreed or strongly agreed with the fact that using a calculator definitely makes addition and subtraction much easier, which is contrary to the researcher's experience that most learners experienced problems with addition and subtraction of fractions (see Chapter 1). Most learners (73.33%) either agreed or strongly agreed with the fact that a calculator makes addition and subtraction of fractions easier (see Item 3 in Table 4.16).

The learners' responses in the questionnaire shows that using a calculator in fraction teaching improves learners' attitude towards the concept. When asked whether learners find working with fractions more interesting with the calculator, 86.66% of the learners either agreed or strongly agreed with the statement (see item in Table 4.16).

As noted by Pomerantz (1997) (see Chapter 2), most learners either agreed or strongly agreed with the fact that the use of a calculator helps learners deal with tedious computations. When asked whether the calculator makes calculation easier when dealing with large numbers, 93.33% either agreed or strongly agreed with the statement (see Item 7 in Table 4.16).

When asked whether a calculator enables learners to complete tasks much faster than the paper and pencil method, 73.33% of the learners either agreed or strongly agreed with the statement. Thus, the use of a calculator gives learners the necessary confidence and removes the anxiety that is associated with the learning of mathematics as a subject.

Finally, when learners were asked whether their understanding of fractions had improved with the use of a calculator, 93, 33% either agreed or strongly agreed with the statement, contrary to teachers' beliefs that working with a calculator hinders learners' understanding of the subject (see Chapter 1).

Table 4.16 clearly shows that most learners agreed with the fact that mathematics learning with the aid of a calculator is more interesting and less frustrating than learning mathematics with the paper and pencil method. The frequency table shows the frequency of learners who agreed with the fact that using a calculator is beneficial in the learning of fractions based on their responses in the questionnaire.

4.11.2 Learners' Responses to the Questionnaire according to Category A, B, and C

Learners' responses were categorised into the following categories and then their responses were drawn on a compound bar graph per category.

- a. Category A - responses that show the calculator's influence on learners' attitudes towards fractions (Table 4.17 and Figure 4.11);
- b. Category B - responses that show the calculator influence on learners' confidence and performance to deal with any mathematical situation without being hindered by a fear of mathematics (Table 4.18 and Figure 4.12); and
- c. Category C - learners' responses to the influence of calculators on learners' conceptual understanding of fractions (Table 4.19 and Figure 4.13).

Item	Strongly Disagree	Disagree	Agree	Strongly Agree
1	(1) 6.67%	(4) 26.67%	(5) 33.33%	(5) 33.33%
4		(2) 13.33%	(8) 53.33%	(5) 33.33%
9	(1) 6.67%	(2) 13.33	(7) 46.67	(5) 33.33%
10		(1) 6.67%	(8) 53.33%	(6) 40%
11	(1) 6.67%	(3) 26.67%	(7) 46.67%	(3) 20%
14		(2) 13.13%	(8) 53.33%	(5) 33.33%

Table 4.19: Category A: Frequency and percentage table showing learners’ responses to the influence of a calculator in learning fractions

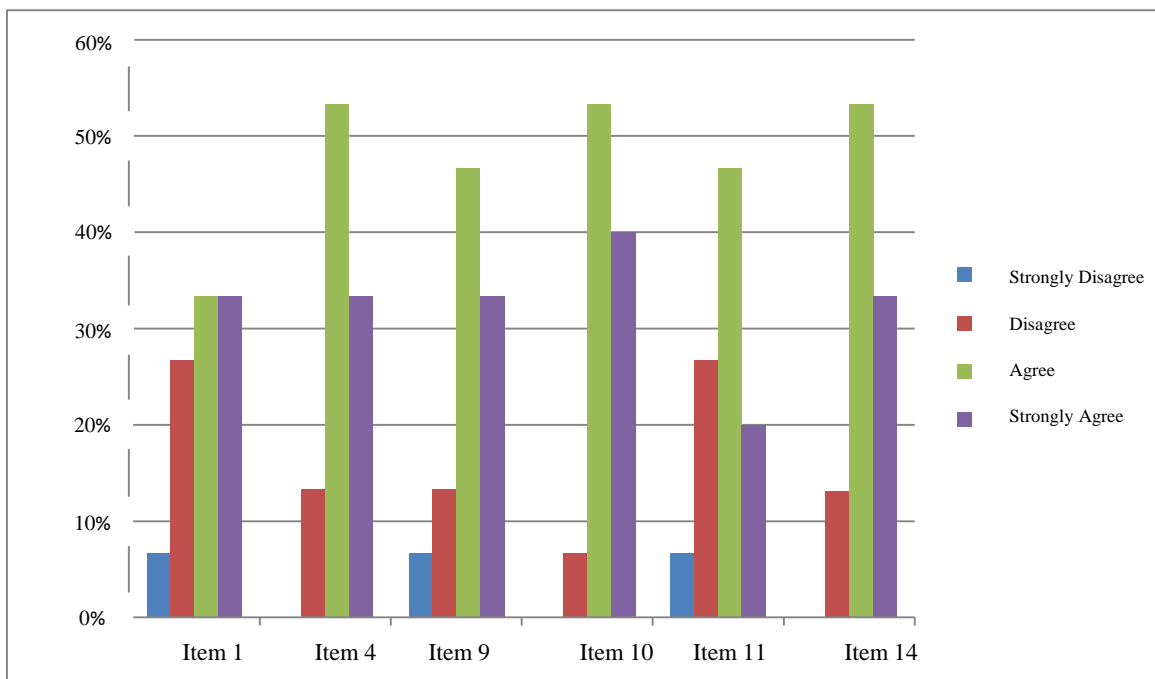


Figure 4.11: Category A: Compound bar graph of the influence of a calculator in learner’s attitudes in working with fractions

Both Table 4.19 and Figure 4.11 show that most learners developed a positive attitude towards fractions after learning the procedure with the aid of a calculator (see Table 4.19 and Figure 4.11).

Item	Strongly Disagree	Disagree	Agree	Strongly Agree
2		(3) 13,33%	(10) 66.67%	(3) 20%
3	(2) 13.33%	(3) 13.33%	(8) 53.33%	(3) 20%
6			(10) 66.67%	(5) 33.33%
7		(4) 26.67%	(9) 60%	(2) 13.33%
12	(1) 6.67%	(2) 20%	(4) 33.33%	(5) 40%
13	(3) 13.33%	(6) 40%	(4) 20%	(5) 26.67%
15		(2) 13.33%	(8) 53.33%	(5) 33.33%

Table 4.20: Category B frequencies and percentages to show the influence of the calculator in increasing learners’ confidence and performance to deal with any mathematical situation without being hindered by a fear of mathematics

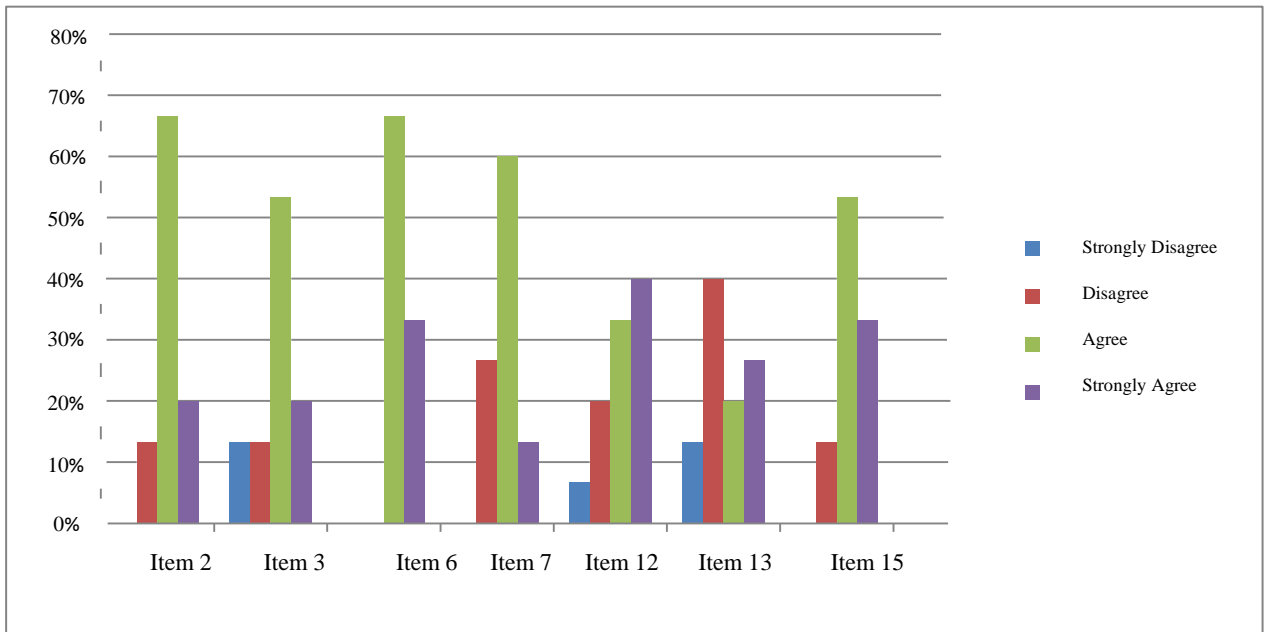


Figure 4.12: Category B: Compound bar graph representing the distribution of responses regarding how the calculator increases the learners’ confidence and performance in fractions

Items 3;6;7;12;13 and 15 on the questionnaire were aimed at investigating whether the calculator increase learners’ confidence in dealing with any mathematical situation without a few of mathematics. Table 4.18 and Figure 4.12 indicated that most learners agreed with the fact that doing fractions with the aid of a calculator increased their confidence to deal with any mathematical situation without a fear for mathematics.

Item	Strongly Disagree	Disagree	Agree	Strongly Agree
5	(1) 6.67%		(8) 53.33%	((6) 40%
8	(9) 60%	(4) 26.67%	(2) 13.33%	

Table 4.21 Category C: Learners' responses to the influence of a calculator in the conceptual understanding of fractions

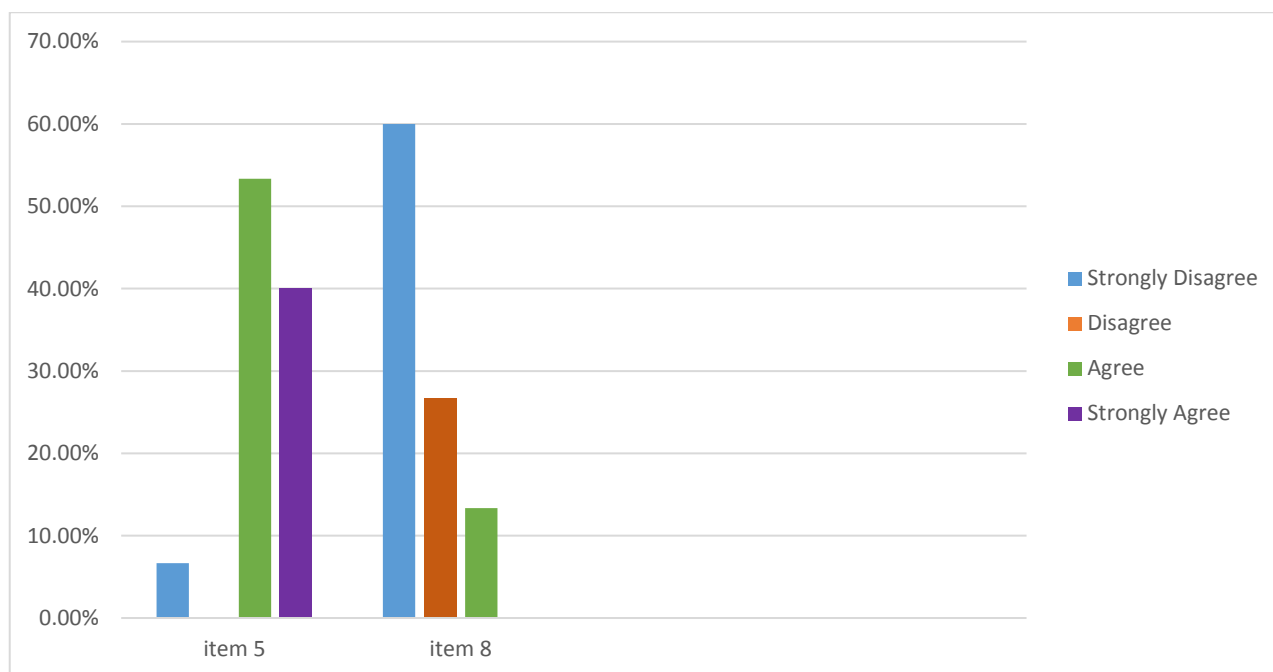


Figure 4.13 Category C: Compound bar graph of learners' responses to whether or not calculators affect conceptual understanding of fractions

Table 4.21 and Figure 4.13 above indicates that while most learners either agree or strongly agree with the fact that the calculator can be used to verify learners' answers in fractions, most of the learners disagreed or strongly disagreed with the fact that the calculator provides answers to questions they do not understand.

4.12 Conclusion

The main aim of this study was to investigate the influence that a calculator has on the teaching and learning of fractions at Grade 8 level. A diagnostic test was given to all learners to enable the researcher to use learners of the same capabilities based on the

results of the diagnostic test. The researcher sampled learners with scores of less than 40% because their results indicated that these learners lacked the necessary skills required to excel in fractions. These learners were later randomly assigned to the control or experimental groups. The test was moderated by the Grade 9 Mathematics subject specialist at the local district, the school's head of department, the research supervisor, and the teachers to ensure the reliability of the test at Grade 8 level. The results showed that the test was appropriate at the Grade 8 level, and the selection of learners with less than 40% shows that the learners were on the same level academically regarding this topic.

The test and the assignment were also moderated by the Grade 9 Mathematics subject specialist, the school's head of department, and the Grade 8 teachers to establish its reliability to grade 8 levels. The moderators agreed that the test and assignment content was reliable at Grade 8 level.

The analysis of the post-test (Task 1) and the assignment (Task 2) shows that the calculator influences learners' performance (achievement) positively. In both Tasks 1 and 2 the mean performance, the median, and the highest mark of the experimental group were significantly higher than the control group. A test of association done on both groups based on the test and the assignment shows that there was a significant difference in learners' performance in questions involving the following questions:

- Comparison of fractions;
- Reducing of fractions in simplest forms;
- Solving algebraic fractions;
- Addition and subtraction of fractions;
- Identifying misconception in a given question (Question 11);
- Multiplication and division of fractions; and
- working with large numbers or complex questions.

The results of the chi-square investigation showed that there was a significant difference in learners' performance after using the calculator than learners' performance without using a calculator; learners' performance in the experimental group was significantly different to that of the learners who were in the control group. These results showed that the use of a calculator had a positive influence on the learners' performance (achievement).

An overall comparison of groups was also done using a two sample Wilcoxon rank-sum test to establish whether or not there was a statistically significant difference between the underlying distributions of the overall scores of the control group and the experimental group.

The test showed that there was a statistically significant difference between the groups, with the experimental group performing significantly better than the control group. These results were noted in both Task 1 and Task 2, and these observations indicate that the calculator had a positive influence in learners' performance (achievement).

The questionnaire was administered to the entire experimental group. An analysis of the questionnaire data indicates that the learners thought the calculator could positively influence the learning and teaching of fractions in terms of:

- Calculation of large numbers;
- Finding the common denominator;
- Addition and subtraction;
- Confidence, motivation, and performance in any mathematical problem without the fear of mathematics;
- Helping learners' conceptual understanding of the fraction concept and was better than using paper and pencil.
- Attitudes towards fractions.

The results from the test, the assignment, and the questionnaire indicate that the use a calculator in the teaching and learning of fractions has a positive influence in learners' performance. The results from the questionnaire indicate that most learners enjoy doing mathematics with a calculator and they specifically use it for calculations and not for answers, as most teachers believe (see Chapter 2).

Chapter 5: Summary, Conclusions, and Recommendations

5.1 Introduction

The study's main purpose was to investigate whether the use of a calculator in teaching and learning enhances learners' conceptual understanding of fractions as reflected in their performance, confidence, motivation and attitude. This chapter summarises the findings, draws conclusions, and makes recommendations based on the literature reviewed in Chapter 2, the research design and methodology discussed in Chapter 3, and the findings derived from the data analysis in Chapter 4.

5.2 Discussion

The study involved an analysis of learners' performance in the teaching and learning of fractions at Grade 8 level. The researcher used two groups – the control group, which did not use a calculator as a learning aid, and the experimental group, which used a calculator as a learning aid. The researcher compared the learners' performances of the two groups using two different tasks, namely a test and an assignment. A questionnaire was administered at the end of the intervention, and assessment on the experimental group to establish learners' attitudes towards the use of a calculator. The current study points to calculators having the following merits over paper and pencil:

- a calculator enables the learners to perform better than paper and pencil;
- It eases computation when dealing with complex questions;
- It enhances learners conceptual understanding of the fraction concept;
- It improves learners' attitudes towards mathematics; and
- It enables learners to finish their tasks faster.

The current study points to the benefits of using a calculator over the use of traditional paper and pencil, as is highlighted in the interpretation and analysis of the two tasks and the questionnaire in the Chapter 4. These are summarised and categorised as follows:

5.2.1 Performance

The use of a calculator enabled learners to perform better than the paper and pencil method. The results of the class test and the assignment given to the learners after intervention showed that the use of a calculator had a significant difference towards learners' performance in fractions. Major differences were observed in:

- The comparison of fractions;
- Reducing fractions to their simplest form;
- Algebraic fractions;
- Addition and subtraction of fractions; and
- Division and multiplication of fractions.

The experimental group learners' performance in the above concepts outweighed that of the control group by a significantly wide margin in both the tasks (see Tables 4.1 and 4.11 in Chapter 4). These findings are consistent with those of (Hembree & Dessart, 1986), (Bright *et al.*, 1994), (Smith, 1997), and (Ellington, 2003 & 2006) who observed that learners who used calculators achieved better in mathematics than those who did not use calculators. The current study observed that calculators are a preferable alternative method to the paper and pencil method in the teaching and learning of mathematics, as suggested by (CITed, 2007), hence learners' performance was better than those who used the traditional paper and pencil method of learning.

5.2.2 Attitude

Results gathered from the questionnaire showed that the use of calculators improved learners' attitudes towards the subject. At least 66%, 86%, 79%, and 93% either agreed or strongly agreed respectively with the items 1, 4, 9, 10, 11, and 14, which items investigated whether or not a calculator had a positive impact on learners' attitudes in their learning of fractions (see Table 4.19 in Chapter 4). Based on these observations the researcher concluded that the use of a calculator improves learners' attitudes in the learning and teaching of mathematics. These results were similar to the findings by (Hembree & Dessart, 1986) and (Pomerantz, 1997), who indicated that the use of a calculator increased learners' attitudes and self-concepts in mathematics. Mbugua *et al.*, (2011) and (Orchand *et al.*, 2011) had similar.

Findings in their investigation of learners' attitudes and the benefits of the scientific calculator on Kenyan students.

5.2.2.1 Confidence

The current study found that the use of a calculator improved learners' confidence in working out fractions in mathematics. At least 46% and 34% of learners agreed and strongly agreed respectively with Item 9 that asked whether using a calculator was better than traditional paper and pencil method. Similar observations were noted in item 15 that investigated whether learners' confidence was better after using a calculator; learners' responses showed that the use of a calculator increased their confidence in mathematics, with an emphasis on item 15, which specifically asked whether learners' confidence increased with the use of a calculator, and 86.66% learners agreed or strongly agreed (see Table 4.20 and Figure 4.12 respectively in Chapter 4). The conclusions in the current study concur with (Hembree & Dessart, 1986), (Pomerantz,1997) and (Orchand *et al.*, 2011) who concluded that the use of a calculator makes students more confident in their mathematical abilities (see Chapter 2 for details).

5.2.2.2 Motivation

The researcher found that the use of a calculator motivates learners when working out fractions. In item 4, up to 86.66% of the learners either agreed or strongly agreed that the use of a calculator makes fractions more interesting than when they use paper and pencil (see Table 4.18). The questionnaire that was administered to the experimental group clearly shows that the use of calculators in the teaching and learning of mathematics motivates learners and thereby improves their attitudes. Most learners, about 80% and above, agreed that calculators should be used in the teaching and learning of fractions and that using a calculator is better than using the paper and pencil method when working out fractions (see Table 4.18).

5.2.3 Conceptual Understanding

The learners' results in the experimental group showed a better performance than the control group on the algebraic fraction concept, which shows that the calculator did not hinder learners' conceptual understanding of the fraction concept, instead it appeared to enhance the understanding of the concept. At least 26.67% of the learners who used calculators got the answer to Question 8.5 correct as opposed to 0% from the non-calculator group, and the difference between the groups was statistically significant in the test of association (see Table 4.3). The results of the current study mirror the findings of Ellington (2003 and 2006), Hembree and Dessart (1986), Smith (1997), Bright *et al.*, (2004), Pomerantz (1997), and Orchard *et al.*, (2011) who concluded that the use of a calculator does not hinder learners' concept of basic skills in mathematics, but instead calculators enhance learners' conceptual development. The misconception regarding the application of the concepts in fractions observed in section 4.9 in Chapter 4 from the control group supports the NCTM (2000) that learners who memorise facts or procedures without understanding are often not sure when and how to use them (see section 4.9).

The findings from the questionnaire (see Table 4.21) showed that learners agreed that their knowledge of fractions has improved since the use of a calculator. They also indicated that the calculator had the following advantages compared to the paper pencil:

- It enabled them to find a common denominator more easily;
- It made addition and subtraction easier;
- It made working with fractions more interesting; and
- It made working with big numbers and complex questions easier.

5.2.4 Enhances Mathematical Thinking and Learning

The findings reflect that the calculator improves learners' attitudes towards mathematics learning by motivating and increasing learners' confidence, and this, according to (Ambrose, *et al.*, 2010), defines effective learning. Similar attributes and conceptual understanding entails the effective learning and teaching of mathematics according to the NSC (CAPS), (D.B.E, 2011) and the (NCTM, 2000) (see Chapter 2). The fact that these attributes were observed in the group that used calculators postulated that learning did take place, despite people's beliefs that calculators hinder effective learning (see Chapter 1). Despite the existence of these attributes a large number of misconceptions observed in the control group's work, unlike

the experimental group's work, indicated that indeed learners in the experimental group had better understanding of the concept than the control group (see Table 4.5: Question 8.5). At least 26% of the learners answered Question 8.5 correctly, while none of the control group's learners answered correctly. It can be concluded that instrumental understanding is a useful procedure in the learning of mathematics, as stated by (Skemp, 1976) and (Xin, 2009). These observations support (Pomerantz, 1997) findings and the NSC's aims of mathematics education, implying that if the NCS aims of mathematics are met, the use of a calculator will enable teachers and learners to enhance learning in South Africa.

5.2.5 Computation and Accuracy

The current study established that the use of a calculator improves learners' computation of both complex, large numbers and real life problems, and increases the volume of calculations accomplished over a given time. It is evident from the results from learners' work (see Figures 4.4b and 4.5a) and learners' responses to Items 6 and 7 in the questionnaire where at least 90% of the learners either agreed or strongly agreed with the statement, that the calculator enables learners to work with large numbers (see Table 4.16). Figure 4.7 does not only show computation and accuracy errors associated with paper and pencil it also shows learners' frustrations associated with the tedious computations, as stated by Pomerantz (1997), Smith (1976), Hembree and Dessart (1986) and Ellington (2003) concluded calculators are tools that make computations easier, enabling learners to concentrate more on important mathematical concepts. Learners in the experimental group performed better in almost all of the questions asked in the two tasks (see Tables 4.4 and 4.12). The study showed that the use of a calculator in teaching fractions makes computations easier than the paper and pencil method. A critical analysis of learners like SC9's (see Figure 4.7) work in Chapter 4 clearly shows that the learners in the control group struggled with the computation of complex or large numbers. This was evidenced in the control group by scribbles of the times table evident on their answer sheets (see Figure 4.7), untidily presented work, and taking longer than the experimental group to finish. This frustration in the control group eventually resulted in them being unable to grasp the concept in the same way as the experimental group, leading them to perform poorly against the experimental group, as evidenced by the results of the two tasks (see Tables 4.1 and 4.11).

5.2.6 Calculator Usage Enables Learners to Complete Tasks Faster and Increases the Volume of Work during a Given Time

The study did not only establish that the use of a calculator enables learners to calculate problems of different nature more easily, but it also enables them to finish their tasks faster than the paper and pencil group. In both the post-test and the assignment tasks, the experimental group had the fastest learner, and almost all of them finished before the control group (see section 4.2.1). Apart from the results of the post-test and the assignment, most learners either agreed or strongly agreed with statement that the calculator helps them to finish their work faster (see Table 4.18 and Item 12 of the questionnaire). These observations support (Mbugua *et al.*, 2011), (Pomerantz, 1997), and the (NCTM,2000) findings that the use of technology, namely a calculator and a computer, enables learners to examine more examples or representational forms than those that are possible by hand, and learners are able to carry out routine procedures quickly and accurately.

5.2.7 Checking the Suitability of a Solution

The response from learners to item 5 of the questionnaire shows that most learners use calculators to verify the suitability of their solutions (see Table 4.18). Contrary to most people's beliefs, and Pomerantz's (1997) findings that calculators give learners the answers, results from the item 8 of the questionnaire, which asked this question, showed that 60% strongly disagreed with the statement whilst 26,27% agreed (see Table 4.18). In this study it was observed that most learners only used the calculator to verify their answers (See Table 4.16, items 5 and 12 respectively), and learners who used a calculator finished earlier than the learners who did not use a calculator. These findings support the (Mbugua *et al.*, 2011) findings that learners do not use the calculator for every problem, and further support Pomerantz's (1997) argument that learners do not use a calculator as a means to an end but as a tool to ease computation. The process of verifying the suitability of their solutions enhances interaction between the learning material and the learner, and this interaction enhances learning, as advocated by the constructivism theory (Murray *et al.*, 1999). The learners' verification of their answers affords the learners the opportunity to interact with the content.

5.2.8 Problem Solving

The current study established that the use of a calculator as a teaching aid enables learners to solve problems more effectively than without a calculator. Although the experimental group generally performed much better in all questions than the control group, major differences were observed in Questions 10 and 11 of the post-test and Question 7 of the assignment, learners who used calculators performed significantly better than those who did not use calculators. In Question 10 of the post-test and Question 7 of the assignment, a few learners from the experimental group answered these questions correctly and no one from the control group answered correctly (see Figures 4.4 and 4.12). This observation supports Pomerantz's (1997) conclusion that the calculator cannot replace a human mind. In other words, it does not do the thinking for the learner, instead the learner looks at a problem and creates a proper equation, decides on how to solve it, interpret the solution on the calculator, and determines whether the answer is appropriate or not. Similar findings that the calculator did not replace a human mind were found by Smith (1997), Pomerantz (1997), NCTM (2000), Dunham and Dick (1994) and Humberg and Dessart (1986).

5.2.9 Increases Persistence and Enthusiasm

A critical survey of experimental group's learners' scripts in both the post-test and the assignment shows that most learners persevered, they were not easily discouraged, and they displayed much enthusiasm in their work. Most learners from the control group either visibly showed frustration in their work even though both groups were taught and wrote assessments at the same time, although they had different teachers, or they simply gave up and were unwilling to continue (see Figures 4.10a and 4.17 respectively).

5.2.10 The use of Calculators Helps Eliminate Mathematics Anxiety

It was observed that the use of a calculator eliminates mathematics anxiety. As stated before in Chapter 2, learners' poor performance, untidy work, and lack of confidence in their mathematical abilities, taking too much time to complete and not eager to complete (see Appendix M), calculation errors, confusion or misinterpretation of concepts, as well as the use of desperate measures to find answers could be a result of mathematics anxiety (see Chapter 2

and Chapter 4). Unlike the control group, most learners in the experimental group achieved high marks (see Table 4.1 and 4.11 in Chapter 4), no misinterpretation of concepts was evident, and they finished their tasks earlier (see Chapter 4). Therefore, it was concluded that as much as calculators increase learners' confidence and motivation, as noted from the questionnaire responses, it also eliminates mathematics anxiety.

The researcher thereby concluded that not only does the calculator improve learners' performance in fractions, it also improves learners' attitudes towards the concept, and definitely enhances learners' conceptual understanding of the fraction, more so than using the paper and pencil method. The research supports Pomerantz's (1997) conclusion that the calculator helps ease computations and allows the learner to concentrate more on learning the concept.

5.3 Limitations of the Study

The use of a small sample and the use of two different teachers to conduct the lessons in the groups were a major limitation. The researcher accepts that the teachers might differ in how they teach the learners. To counter this limitation, the researcher trained both teachers before they started teaching, and later on prepared the lesson plans to be used during the session, and monitored the teachers during the sessions to ensure that they were adhering to the lesson plans. The experimental period was also short, such that the researcher could not monitor the learners' performance over a long-term period from the time of intervention to see if they still retained the concepts. To counter the time-frame of the experiment the researcher used a variety of tasks to check learners' retention of concepts. The following challenges were also encountered:

- some learners could not attend the lessons after school because of transport problems and others had to attend sports meetings; and
- most learners had very little knowledge of how to use a calculator, so a lot of time was spent trying to equip learners with calculator skills.

The learners took a long time to appreciate the use of a calculator, they preferred working out problems with paper and pencil, so time was taken to get them to appreciate working with a calculator, which they finally did.

5.4 Recommendations

In consideration of the findings of the current study, the following recommendations are proposed for consideration on the use of calculators in the teaching and learning of mathematics.

School mathematics curriculum designers, teachers, and parents should be made aware of the role and influence the scientific calculator has in the learning and teaching of fractions in mathematics, so that their perceptions regarding the use of calculators in the teaching and learning of mathematics can be improved.

Many South African learners are not trained to use scientific calculators in their learning of mathematics. Thus, they also need to be taught the skill of using the scientific calculator so that they will be confident to use it appropriately in class.

More studies should be done to investigate the influence of the use of scientific calculators on South African students' learning of fractions and other mathematical concepts across all grades, especially at primary school.

Since the effective use of a calculator highly depends on its appropriate use in the classroom, the learner's stage of development and the merits of using a calculator as opposed to its disadvantages. However, it is recommended that curriculum developers in education stipulate how, when and where a calculator should be used, and they should ensure that they set out assessment tasks that assess its effective use in schools to ensure proficiency in the skill.

More research should be done on how mathematics teachers can appropriately incorporate the use of calculators in the teaching and learning of mathematics so that they will embrace its benefits, thereby fostering a positive attitude towards its implementation within their learners to ensure its effective use in mathematics learning.

The Department of Education should provide calculators to all learners because not all learners can afford to buy them, and the lack of affordability will also hinder its effective implementation in the classroom.

5.5 Conclusion

The aim of the investigation was to establish the influence a calculator has in the teaching and learning of fractions. The findings of the study show that the learners who used the calculator performed better than those learners who did not use a calculator. It also shows that the use of a calculator helps learners to develop a positive attitude towards the learning of fractions. In addition to this, it showed that computation is made easier, that learners are able to finish their tasks faster, and learners experience improved confidence to carry out mathematical procedures. The research highlights how the use of a calculator enhances a learner's conceptual understanding of fractions. Most importantly the research reveals that learners enjoy doing fractions with a calculator, more so than without a calculator. The findings of this research showed that the use of a calculator improves learners conceptual understanding and performance of the fractions.

Bibliography

- Ambrose, S. A., Bridges, M. W., DiPietro, M., Lovett, M. C., & Norman, M. K. (2010). *How Learning Works 7 Research-Based Principles for Smart Teaching*. San Francisco, California Jossey-Bass.
- Anghileri, J. (2007). *Developing number sense. Progression in the middle years*. Continuum, NY.
- Aushcraft, M., & Faust, F. (1994). Mathematics anxiety and mental arithmetic performance. An exploratory investigation. *Cognition and emotion*, 8(2), 97-125.
- Boon, L. K., Yong, J., Han, C. T., & Gaik, T. K. (2009). *The effectiveness of Using Scientific Calculator in Solving Non-Linear Equations by Newton-Ralphson Method*. Retrieved From Math Hand Tech website :<http://www.atcm.mathandtech.org>.
- Branford, J., Ann, D., Brown, L., & Cocking, R. (1999). *How People Learn: Brain, Mind, Experience, and School*. Washington, DC: National Academy Press.
- Bright, G. W., Waxman, H. C., & Williams, S. E. (1994). *Impact of Calculators on Mathematics Instruction*. USA: University Press of America.
- Bruce, C., Chang, D., & Flynn, T. (2013). *Foundations to Learning and Teaching Fraction: Addition and Subtraction*. Trent University Shelley Yearley, Trillium Lakelands DSB.
- Campbell, P. F., & Stewart, E. L., (1993). *Calculators and Computers. Early Childhood Mathematics*. (Robert Jensen ed.). NCTM: Research Interpretation Project. NY: Macmillan Publishing Company, 251-268.
- Cangelosi, J. S. (2003). *Teaching mathematics in secondary and middle school: an interactive approach*. 3rd edition. New Jersey: Prentice Hall.
- Carpenter, T. P., Hiebert, J., & Moser, J. M. (1981). Problem Structure and First Grade Children's Initial Solution for Simple Addition and Subtraction Problems. *Journal for Research in Mathematics Education*, 12(1):27-39.
- CITed. (2007). *Beyond Getting the Answer, Calculators Help Learning Disabled Students Get the Concepts*. Retrieved from the Id Online website: <http://www.Idonline.org>.
- Coleman, D. (1996). *Emotional Intelligence*. London: Bloomsbury.

- Cobb, P., Yackel, E., & Wood, T. (1992). A constructivist alternative to the representational view of mind in mathematics education. *A Journal for Research in Mathematics Education*, 23 (1):2-33.
- Cobb, T. (1999). Applying constructivism: A test for the learner as scientist. *Educational Technology Research and Development*, 47(3):15-31.
- Cuoco, A. A., & Goldenberg, E. P. (1996). A role for technology in mathematics education. *Journal of Education*, 178 (20):15-31.
- Cox, B., Geary, D., Brogan, R., Singer, D., & Gauvain, M. (2009) Cognitive Development. Retrieved from Education.com website <http://www.education.com>
- Department of Education. (2011). *National Curriculum Statement (Curriculum Assessment Policy; Mathematics) (Grade 7-9)*. Pretoria: Seriti Printing Pty Ltd.
- Department of Education. 2011. *National Curriculum Statement: Curriculum and Assessment Policy (CAPS). Senior Phase Grade (7-9) Mathematics*. Pretoria: Department of Basic Education South Africa.
- Dessart, D. J., DeRidder, C. M., & Ellington, A. J. (1999). The research backs calculators. *Mathematics Education Dialogue*, 2(3), 6.
- Dunham, P. H. (1995). Does Using Calculators Work? The jury is almost in. *UME Trends*, 5(2):8-9.
- Dunham, P. H. (1995). Hand-held Calculators in Mathematics Education: A Research Perspective. Retrieved from Math Forum website <http://www.mathforum.org>.
- Ernest, P. (1991). *The philosophy of Mathematics Education*. Hampshire: The Falmer Press.
- Ellington, A.J. (2003). A Meta-Analysis of the effects of Calculators on Students' Achievement and Attitude Levels in Precollege Mathematics Classes. *A Journal for Research in Mathematics Education*, 34 (5):433-463.
- Ellington, A. J. (2006). The effects of non-CAS graphing calculators on student achievement and attitude levels in mathematics: A meta-analysis. *International Journal of Instructional Media*, 106, 16-26.

- Erickson, D. K. (1999). A problem-based approach to mathematics instruction. *The mathematics teacher*, 92(6):516-521.
- Freire, P. (1970). *Pedagogy of the Oppressed: What is a fraction?* New York: Herder and Herder George Mason University. Retrieved from George Mason University website: <http://www.cs.gmu.edu>.
- Greenwood, J. (1984). My anxieties about math anxiety. *Mathematics Teacher*.77 (662-663).
- Hausfather, S. (2001). Where is the content? The role of content in constructivist teacher. *Educational Horizons*, 80(1):15-19.
- Hiebert, J., Carpenter, T. P., Fennema, E., Fuson, K., Human, P. G., Murray, H., Olivier, I. A. & Wearne, D. (1996). Problem solving as a basis for reform in curriculum: The case for mathematics. *Educational Researcher*, May 1996:12-21.
- Hiebert, J., Carpenter, T. P., Fennema, E., Fuson, K., Human, P. G., Murray, H., Olivier, I. A. & Wearne, D. (1997). *Making Sense: Teaching and learning mathematics with understanding*. Portsmouth: NH Heinemann.
- Hiebert, J. & Grouws, D. (2009). Which teaching methods are most effective for maths? *Better: Evidence-Based Education*, 2, 10–11.
- Hembree, R., & Dessart, D. J. (1986). Effects of handheld calculators in precollege mathematics education: A meta-analysis. *Journal for Research in Mathematics Education*, 17:83-99.
- Howar, A. (1981). Addition of Fractions – the Unrecognised Problem. *Mathematics Teacher*, December 1991, 710-713.
- Jones. D. (1997). *A conceptual framework for studying the relevance of context to mathematics teacher's changes*. New Jersey: Lawrence Erlbaum Associates Publishers. (131-154).
- Jooste, Z. (1999). How Grade 3 & 4 learners deal with fraction problems in context. *Proceedings of the Fifth Annual Congress of the Association for Mathematics Education of South Africa*, 5-9 July 1999Port Elizabeth: Port Elizabeth Technikon. Vol. 1. (pp. 64-75).
- Kamii, C. (1994). *The young people continue to reinvent arithmetic: 3rd grade implications of Piaget's theory*. New York: Columbia University, Teachers College Press.
- Kamii, C. & Clark, F. B. (1995). Equivalent Fractions: Difficulty and Educational

- Implications. *Journal of Mathematical Behavior*, 14:365-378.
- Kendall, J. & Hart, D. (2012) *Spot On Mathematics Grade 7*. Pretoria Heinemann.
- Lambdin, D. & Lester, F. K. Jr. (2010). *Teaching and Learning Mathematics. Translating research for elementary school teachers*. Reston, VA: NCTM.
- Lukhele, R. B., Murray, H., & Olivier, A. (1999). Learners' understanding of the addition of fractions. *Proceedings of the Fifth Annual Congress of the Association for Mathematics Education of South Africa*, 5-9 July 1999. Port Elizabeth: Port Elizabeth Technikon. Vol. (1):87-97.
- Major, T. E. (2012). The Constructivist Theory in Mathematics: The Case of Botswana. Primary Schools. *International Review of Social Sciences and Humanities*, 3(2):139 - 147).
- Mayer, R. E. (2002). *The Promise of Educational Psychology, Volume 2: Teaching for meaningful learning*. Upper Saddle River: Prentice Hall.
- Maxwell, P., Devereaux, G., May, S., Ryan, S., Bridgeman., A, Gosse, P., Foss., S & King, W.(2004).*Calculators in Mathematics Instruction and Assessment*. A position Statement for Mathematics K-12 in the Province of Newfoundland and Labrador. Labrador. Government of Newfoundland and Labrador Department of Education.
- McAuliffe, E. (1995). *The Calculator in the Elementary Classroom: Making a Useful Tool out of an Ineffective Crutch*. Villanova University: USA.
- McMillan, J. H., & Schumacher, S. (2010). *Research in Education Evidence-Based Inquiry*. 7th Edition. New Jersey: Pearson Education Inc.
- McNamara, D. S. (1995). Effects of prior knowledge on the generation advantage: Calculators versus calculation to learn simple multiplication. *A journal of Educational Psychology*.87 (2).307-318.
- McLeod, R., & Newmarch, B. (2006). *Fractions* National Research and Development Centre for adult literacy and numeracy. London. University of London.
- Mbugua, Z. K., Muthoni, M. V., & Okere, M. O. (2011). *Attitude of secondary Students on use of Scientific Calculators in Learning Mathematics in Embu District in Kenya*. International Journal of Humanities and Social Science. USA. Vol .1.

(13).131-136.

Miles, B., Miles, H., & Miles. (2011). What is Conceptual Understanding? Retrieved from Site Builder Content website. www.mathleadership.co/sitebuildercontent/./conceptual.pdf
www.mathleadership.com/sitebuildercontent/./conceptualUnderstanding.pdf.

Murray, H., Olivier, & Human, P. (1993). Learning through Problem-Solving and Social Interaction. *Proceedings of the 17th International Conference for the psychology of mathematics education*, Tshukuba, Japan, July 1993. (193-203).

Murray, H., Olivier, A. & De Beer, T. (1999). Re teaching fractions for understanding. In O. Zaslavsky (Ed.). *Proceedings of the Twenty-third International Conference for the Psychology of Mathematics Education*, Haifa, Israel. (Vol. 3: 305-312).

National Council of Teachers of Mathematics (NCTM). 2000. *Principles and Standards for School Mathematics*. Reston: NCTM.

National Council of Teachers of Mathematics (NCTM). 2003. *The use of technology in the learning and teaching of mathematics (Position statements)*. Reston: NCTM.

National Curriculum Statement (NSC). (2011). *Curriculum and Assessment Policy Statement (CAPS)*: Department of Basic Education.

Newstead, K. (1998). Aspects of children's mathematics anxiety. *Educational Studies in Mathematics*, 36(1), 53-71.

Newstead, K. (1999). *Malati Materials: Fractions, Rational Numbers Grade 8 and Grade 9 teacher document*. South Africa: Malati and the Open Society Foundations for South Africa.

Newstead, K., & Murray, H. (1998). Young Students Constructions of Fractions in A. Olivier, & K. Newstead (Eds). *Conference of the International Group for the Psychology of Mathematics Education*, Stellenbosch. (Vol. 3: 295-302).

Newstead, K., & Olivier, A. (1999). *Addressing student's conceptions of common fractions*. In O. Zaslavsky (Ed.), *Proceedings of the Twenty-third International Conference for the Psychology of Mathematics Education*: Vol. 3. (329-337). Haifa, Israel.

Norman, & Hyland, T. (2003). *The role of confidence in lifelong learning*. University of Bolton.

Okoye, K. R. E. (2010). *Enhancing Quality in Educational Practice and Instructional*

Delivery by Teachers of Technology and Vocational Education in Nigeria. *African Research Review. An International Multi-Disciplinary Journal, Ethiopia. Vol. 4(2) April, 2010. Pp. 355-369.*

Ornstein, A. C. & Hunkins, F. P. (2004). *Curriculum, Foundations, Principles and Issues.* Washington: Allayn and Bacon Inc. University of Washington.

Ochanda, J. P., & Indoshi, F.C. (2011). *Challenges and benefits of using scientific calculators in teaching and learning of Mathematics in secondary education.* Journal of Media and Communication studies. Kenya. March 2011. Vol.3 (3).102-11.

Rittle-Johnson, B., & Schneider, M. (2012). *Developing Conceptual and Procedural Knowledge of Mathematics.* Retrieved from Johnson Scneider In Press website. <https://www.uni-trier.de>.

Ronau, R. N. (2011). *Educational Technology, Teacher Knowledge, and Classroom Impact: A research Handbook on Frameworks approaches.* USA. IGI Global.

Pomerantz, H. (1997). *The Role of Calculators in Math Education.* A Research prepared for the Urban Systematic Initiative/Comprehensive Partnership for Mathematics and Science Achievement (USI/CPMSA). Dallas, Texas.

Professional Development Service for Teachers (PDST). *Fractions Manual. A guide to teaching fractions in Irish Primary Schools.* Retrieved from PDST website <http://www.pdst.ie/fractions>.

Rakes, C. R., Ronau, R. N., Bush, S. B., Niess, M. L., Driskell, S, & Pugalee, D. (2011). *Using Calculators for Teaching and Learning Mathematics.* NCTM. Technology Research Brief. Karen D. Kings, Series Editor.

Reys, R. E., Suydan., M. N., Lindquist, M. M., & Smith, N. L. (1998). *Helping Learners Learn Mathematics* (5th ed.) Needham Heights: Allyn and Bacon.

Risser, H.S. (2011). What are We afraid of? Arguments against Teaching Mathematics with Technology in the Professional Publications of Organisations for US Mathematicians. *International Journal for Technology in Mathematics Education, 18(2), 97-101.*

Ruthven, A. (1992). "Personal Technology and Classroom Change: A British Perspective". In J.T. Fey (ED). *Calculators in Mathematics Education.* Reaston: The NCTM. (91-100).

- Schoenfield, A. H. (1985). *Mathematical Problem Solving*. Orlando FL: Academic Press
- Simon, M. (1995). Reconstructing mathematics pedagogy from a constructivist perspective, *Journal for Research in Mathematics Education*, 26(2), 114-145.
- Simon, M. A. (2006). Key developmental understandings in mathematics: A direction for investigating and establishing learning goals. *Mathematical Thinking and Learning*, 8:359–371.
- Skemp, R.R. (1986). *The Psychology of learning mathematics*. Hammondsport: Penguin.
- Skemp, R. R. (1976). Relational Understanding and Instrumental Understanding. *Mathematics Teaching*, 77:20-26.
- Smith, B. A. (1996). The Calculator Effect-Journal of Special Education Technology. A meta- analysis of outcomes from the use of calculators in mathematics education. Reston, VA: The NCTM. (33-45).
- Soderstrom, N. C., & Bjork, R. A. (2015). Learning Versus Performance. *Perspectives on Psychological Science*. vol. 10 (2):176-199. University of California, Los Angeles.
- Stein, M. K., Silver, E. A. & Smith, M. S. (1998). “Mathematics reform and teacher development from a community practice perspective”. In J. Greeno and S. Goldman (EDS). *Thinking Practices. A symposium on mathematics and science learning*. Hillsdale, NJ: Ellbaum. (17-52).
- Stirling, D. (2014). Motivation in Education. *Aichi Universities English Education Research Journal*. 29 (2013): 51-72. Trans. Mitsuo Kondo.
- Streefland, L. (1982). Subtracting Fractions with Different Denominators. *Educational Studies in Mathematics*, 13:233-255.
- Steffe, L. P. & Olive, J. 1991. The Problem Fractions. *The Elementary School Arithmetic Teacher* 389(4):12-17
- Suydam, M. N. (1982). *The Use of Calculators in Pre-College Education: Fifth Annual State- of-the-Art Review*. Columbus, OH: Calculator Information Centre. (ERIC Document

Reproduction Service No.220 273).

Suydam, M. N. (1985). *Research on Instructional Materials for Mathematics*. Columbus, OH; ERIC Clearinghouse for Science, Mathematics, and Environmental Education. (ERIC Document Reproduction Service No.276 569).

Suydam, M. N. (1987). *Research on instructional Materials for Mathematics; A letter to Teachers*. Columbus, OH: ERIC Clearinghouse for Science, Mathematics, and Environmental Education. (ERIC Document Reproduction Service No. ED 293 728).

Thijsse, L. J. (2002). *The effects of a structured teaching method on mathematics anxiety and achievement of Grade 8 learners*. Pretoria: University of South Africa.

Van Niekerk, T., Newstead, K., Murray, H. & Olivier, A. (1999). Successes and obstacles in the development of grade six learner's conceptions of fractions. *Fifth Annual Congress of the Association for Mathematics Education of South Africa, 5-9 July 1999: Port Elizabeth Technikon*. (Vol. 1: 221-232).

Verma, M. H. (2005). *Learner's Attitude and its Impact on Language Learning*. Invertis Institute of Engineering & Technology, Bareilly. India. Retrieved from Invertis Institute of Engineering and Technology website: <http://www.fe.hk>.

Wells, D. (1994). Anxiety, insight and appreciation. *Maths Teaching, 147*:(8-11).

Xin, M. (2009). *Learning and Teaching Mathematics*. Retrieved from Education .Com website <http://www.education.com>.

Appendix A
Principal Consent

Department of Education
College of Education
University of South Africa
6 January 2014

Dear Principal,

I would like to request for permission to use your school premises to carry out my study. I am a student at the University of South Africa. I wish to conduct my experimental research at Sandtonview Combined School as part of my research towards my Masters in Mathematics Education Degree.

The title of the study is:

THE INVESTIGATION OF THE EFFECTIVENESS OF USING HAND-HELD SCIENTIFIC CALCULATORS IN THE TEACHING AND LEARNING OF FRACTIONS. A CASE STUDY OF ONE SCHOOL IN GAUTENG PROVINCE.

The aim of the study is to investigate whether or not there is a significant difference in learners' performance when a calculator is used as a teaching and learning aid in the teaching and learning of fractions at Grade 8 level in Gauteng Province. Results of this study will be used to help teachers make an informed decision regarding the use of calculators in teaching fractions at Grade 8 level in the classroom to enhance learners' performance in the subject.

This study will take place after school from 14.30 to 15.30 for a month, that is, from the 1st of February 2014 to the 28th of February 2014, twice a week on Mondays and Thursdays. These lessons will be conducted by the learners' maths teachers. The learners will also be learning during the study, so homework, class work, and class tests will be given. Learners will also be asked to fill a questionnaire to rate the different teaching methods. A report of the final test will be given to you at the end of the study.

Please find the research proposal attached for further details about the study. If you have any questions, please contact

Mrs S.B Mthembu (Mutsvangwa) 073 641 1619

or Mr M Phoshoko

Faculty of Mathematics Education

University of South Africa

Tel 012 429 6993/082 408 6926

Email: phoshmm@unisa.ac.za

Consent

I _____, Principal of Sandtonview Combined School give permission/do not give permission for the school to participate in the study.

_____ Date _____

Signature of Principal

Appendix B
Parental Consent

Department of Education
College of Education
University of South Africa
6 January 2014

Dear Parent or Guardian,

R.E:

THE INVESTIGATION OF THE EFFECTIVENESS OF USING HAND-HELD SCIENTIFIC CALCULATORS IN THE TEACHING AND LEARNING OF FRACTIONS. A CASE STUDY OF ONE SCHOOL IN GAUTENG PROVINCE.

Your child _____ in Grade _____ has been selected to participate in the study to investigate the effectiveness of a calculator in the teaching and learning of fractions at Grade 8 level.

Due to learners' poor performance in mathematics, Mrs.S.B Mthembu (Mutsvangwa) under the auspices of the University of South Africa is conducting a study to investigate the effectiveness of teaching fractions with the aid of a calculator at Grade 8 level. This study is aimed to find out whether the use of a calculator helps learners performance of fractions. Results of this study will be used to help teachers make an informed decision regarding the use of calculators in the classroom to enhance learners' performance in the subject.

This study will help your child as he or she will have to attend extra classes after school on the subject after school from 14.30 to 15.30 for a month from the 1st of February 2014 to the 28th of February 2013 twice a week on Mondays and Thursdays. These lessons will be conducted by their maths teachers. The learners will also be learning during the study so homework, class work, and class tests will be given. Learners will also be asked to complete a questionnaire to rate the different teaching methods. A report of the final test will be also be given to you at the end of the study.

Although this study will be beneficial to your child's mathematics performance, you are not forced to consent to your child's participation. Your child can stop or withdraw at anytime without any penalty. If you have any questions about your child's participation in the study, please contact

Mrs S.B Mthembu (Mutsvangwa)

+27 73 641 1619

Consent

I _____ parent/guardian of _____ in
Grade 8 have read and understand the aims of the study. I therefore agree/disagree to my child
participating in the study.

_____ Date _____

Signature of Parent

Appendix C
Youth Assent Form

Department of Education
College of Education
University of South Africa

6 January 2014

Dear Learner,

R.E:

THE INVESTIGATION OF THE EFFECTIVENESS OF USING HANDHELD SCIENTIFIC CALCULATORS IN THE TEACHING AND LEARNING OF FRACTIONS. A CASE STUDY OF ONE SCHOOL IN GAUTENG PROVINCE.

This form may have some words that you do not understand. Please ask someone to explain any words that you do not understand. You may take a copy of this form home to think about and discuss with your parents before you decide whether or not you want to participate in the study.

I am here to ask you to participate in the study to investigate the effectiveness of a calculator in the teaching and learning fractions at Grade 8 level. Mrs S.B Mthembu (Mutsvangwa) under the auspices of the University of South Africa wishes to investigate whether or not the use of a calculator in the teaching of fractions at Grade 8 level enhances performance or affects learner's performance in fractions. This study is aimed to help teachers make an informed decision regarding the use of a calculator in teaching of fractions. The teachers' decisions are aimed to help learners perform better in mathematics.

This study will take place as extra lessons that will take place twice weekly on Mondays and Thursdays from 14.30 to 15.30, from the 1st of February 2014 to the 28th of February 2014. Homework and class work during the course of the study and class tests before and after study will be given to measure your performance. You will be asked to rate the lessons via a questionnaire that you will complete and hand to the teacher.

Although this study will be beneficial to your mathematics performance, you are not forced to participate. You can stop or withdraw at anytime without any penalty. No one will blame you or criticise you, or blame you for dropping out of the study. Do not sign this form if you have any questions; make sure someone answers your questions. If you have questions regarding the study contact

Mrs S.B Mthembu (Mutsvangwa)

CONSENT

I have _____ in grade _____ have read this form. I am willing/not willing to be in the study.

Date _____

Youth Signature

Teacher Consent

Department of Education

College of Education

University of South Africa

6 January 2014

R.E:

THE INVESTIGATION OF THE EFFECTIVENESS OF USING HAND-HELD SCIENTIFIC CALCULATORS IN THE TEACHING AND LEARNING OF FRACTIONS. A CASE STUDY OF ONE SCHOOL IN GAUTENG PROVINCE.

Dear Teacher,

I, the undersigned am conducting research on the above-mentioned topic through the College of Education, UNISA. This research forms part of my Masters in Mathematics Education studies.

I invite you to help me in conducting the lessons to be done during this study. You were approached to participate in this study because of your academic record and experience in the teaching mathematics to Grade 8 learners at the school. The aim of the study is to investigate whether or not there is a significant difference in learners' performance when a calculator is used as a teaching and learning aid in the teaching and learning of fractions at Grade 8 level in Gauteng Province. Results of this study will be used to help teachers make an informed decision regarding the use of calculators in teaching fractions at Grade 8 level in the classroom to enhance learners' performance in the subject.

This study will take place after school from 14.30 to 15.30 for a month, from the 1st of February 2014 to the 28th of February 2014, twice a week on Mondays and Thursdays. The learners will also be learning during the study, so homework, class work, and class tests will be given. Lesson plans and activities will be provided. Learners will also be asked to fill a questionnaire to rate the different teaching methods. A report of the final test will be given to you at the end of the study.

Please find the research proposal for further details regarding the study. If you have any questions, please contact

Mrs S.B Mthembu (Mutsvangwa)

or Mr M Phoshoko

Faculty of Mathematics Education

University of South Africa

Tel 012 429 6993/082 408 6926

Email: phoshmm@unisa.ac.za

Consent

I _____ a teacher at Sandtonview Combined School give agree/do not agree to participate in the study.

_____ Date _____

Signature of Teacher

ss work, and class tests will be given. Lesson plans and activities will be provided. Learners will also be asked to fill a questionnaire to rate the different teaching methods. A report of the final test will be be given to you at the end of the study.

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Tel 012 429 6993/082 408 6926

Email: phoshmm@unisa.ac.za

Consent

I _____ a teacher at Sandtonview Combined School give agree/do not agree to participate in the study.

_____ Date _____

Signature of Teacher

Appendix E

School Governing Board Consent

Department of Education

College of Education

University of South Africa

6 January 2014

Dear SGB Chairperson,

I would like to request permission to use Sandtonview Combined School's premises to carry out my study. I am a student at the University of South Africa. I wish to conduct my experimental research at your school as part of my research towards my Masters in Mathematics Education degree.

The title of the study is:

THE INVESTIGATION OF THE EFFECTIVENESS OF USING HAND-HELD SCIENTIFIC CALCULATORS IN THE TEACHING AND LEARNING OF FRACTIONS. A CASE STUDY OF ONE SCHOOL IN GAUTENG PROVINCE.

The aim of the study is to investigate whether or not there is a significant difference in learners' performance when a calculator is used as a teaching and learning aid in the teaching and learning of fractions at Grade 8 level in Gauteng Province. Results of this study will be used to help teachers make an informed decision regarding the use of calculators in teaching fractions at Grade 8 level in the classroom to enhance learners' performance in the subject.

This study will take place after school from 14.30 to 15.30 for a month, from the 1st of February 2014 to the 28th of February 2014, twice a week on Mondays and Thursdays. These lessons will be conducted by the learners' maths teachers. The learners will also be learning during the study so homework, class work, and class tests will be given. Learners will also be asked to complete a questionnaire to rate the different teaching methods. A report of the final test will be given to you at the end of the study.

Please find the research proposal attached for further details about the study. If you have any questions, contact

Mrs S.B Mthembu (Mutsvangwa) 073 641 1619

or Mr M Phoshoko

Faculty of Mathematics Education

University of South Africa

Tel 012 429 6993/082 408 6926

Email: phoshmm@unisa.ac.za

Consent

I _____ Chairman of the School Governing Body of Sandtonview Combined School give permission/do not give permission for the school to participate in the study.

_____ Date _____

Signature of the Chairman of the School Governing Body

Appendix F

Grade 8 Fractions Diagnostic Test

Duration: 2hrs

Total:100

Examiner: Mrs Mthembu

Moderators:

Mr Ncube, Mr Sinkala

Date:

Name and Surname _____

Class _____

Instructions

1. Write neatly and legibly.
2. Show all your working out.
3. Do not use a calculator.

Question 1

State whether the following fractions are improper fractions, proper fractions, or mixed numbers.

1.1) $\frac{14}{17}$ _____ (1)

1.2) $\frac{11}{9}$ _____ (1)

1.3) $3\frac{5}{4}$ _____ (1)

[4]

Question 2

Express the following fractions in their simplest forms.

2.1) $\frac{4}{16}$ _____ (1)

2.2) $\frac{12}{45}$ _____ (1)

[2]

Question 3

For each of the following write the equivalent fraction.

3.1) $\frac{1}{4}$ (2)

3.2) $1\frac{3}{5}$ (2)

3.3) $\frac{12}{36}$ (2)

[6]

Question 4

For each of the following find the missing value.

3.1) $\frac{3}{\quad} = \frac{15}{40}$ (2)

3.2) $\frac{\quad}{13} = \frac{24}{39}$ (2)

[4]

Question 5

Compare the following pairs of fractions and use signs $<$, $>$, or $=$, and show all working out.

5.1) $\frac{2}{3}$ and $\frac{3}{5}$ (2)

5.2) $\frac{6}{15}$ and $\frac{3}{7}$ (2)

5.3) $2\frac{2}{5}$ and $1\frac{3}{7}$ (2)

[6]

Question 6

Express the following fractions as mixed numbers in their lowest term.

5.1) $\frac{16}{5}$ (2)

5.2) $\frac{18}{6}$ (2)

5.3) $\frac{22}{4}$ (2)

[6]

Question 7

Convert the following fractions to improper fractions.

7.1) $2\frac{4}{5}$ (2)

7.2) $-11\frac{2}{5}$ (2)

[4]

Question 8

Calculate (all answers should be reduced to their lowest terms).

8.1) $\frac{1}{3} + \frac{5}{4}$ (4)

$$8.2) \frac{4}{9} - \frac{4}{11} \quad (4)$$

$$8.3) 6 - \frac{3}{4} \quad (4)$$

$$8.5) 4\frac{2}{5} + 2\frac{1}{5} \quad (5)$$

$$8.6) 1\frac{2}{x} - 2\frac{1}{4} \quad (5)$$

[23]

Question 9

Simplify.

$$9.1) -\frac{2}{5} \times \frac{10}{8} \quad (3)$$

$$9.2) 2\frac{1}{2} \times 3\frac{1}{3} \quad (4)$$

$$9.4) \frac{13\frac{1}{2}}{2\frac{3}{6}} \quad (5)$$

$$9.5) \frac{4}{9} \div \frac{108}{81} \div \frac{6}{7} \quad (5)$$

$$9.6) \frac{\frac{5}{2} + \frac{1}{4}}{12} \quad (5)$$

$$9.7) 9 \div 3\frac{3}{8} \quad (5)$$

[27]

Question 10

10) Peter and Eric bought a large pizza that has 12 slices. If Peter ate $\frac{7}{8}$ of the pizza,

10.1 How many slices did Peter eat? (3)

10.2 How many slices did Eric eat? (2)

10.3 What fraction of the pizza did Eric eat?

[2]

[7]

Question 11

Eunice was doing her homework and she came up with the following answers. Work through the same question in the space provided. State whether or not her answers are correct.

If not identify where she made mistakes.

11.1) $\frac{3}{4} \div \frac{2}{3} = \frac{4}{3} \times \frac{2}{3} = \frac{8}{9}$

(5)

11.2) $\frac{2}{3} + \frac{3}{5} - \frac{5}{6} = \frac{10}{14} = \frac{5}{7}$

(6)

[11]

Appendix G

Fractions Assignment Grade 8

Duration: 2 hours **Total:50**

Examiner : Mrs Mthembu **Moderator: Mr N Ncube**

Name _____ **Class** _____

Question 1

Arrange the following fractions in order, starting with the biggest $\frac{2}{5}, \frac{7}{10}, \frac{3}{4}, \frac{4}{7}$

(4)

Question 2

Use the correct symbol (< or >). In each case show all working out.

a) $\frac{2}{3}$ $\frac{3}{5}$ (2)

b) $\frac{6}{15}$ $\frac{3}{7}$ (2)

Question 3

Express the following fractions in their simplest forms.

a) $\frac{36}{64}$ (1)

b) $\frac{108}{117}$ (1)

Question 4

Convert the following fractions to improper fractions.

a) $2\frac{4}{5}$ (1)

b) $2\frac{13}{17}$ (1)

Question 5

Write the following as mixed numbers.

a) $\frac{16}{5}$ (1)

b) $\frac{19}{7}$ (1)

Question 6

Simplify the following.

a) $1\frac{2}{5} + 2\frac{2}{3} \div \frac{8}{9}$ (6)

b) $-5a - \frac{3a}{4}$ (4)

c) $\frac{-7ab}{2} + \frac{ab}{3} - \frac{2ab}{4}$ (5)

d) $7 - \frac{3}{5}$ (4)

e) $\frac{\frac{x}{10} + \frac{x}{5}}{\frac{2x}{5}}$ (5)

f) $4\frac{1}{2} \times 3\frac{2}{3}$

g) $\frac{4}{3} \times \frac{7}{9}$ (2)

h) $3\frac{3}{5} \div \frac{2}{10}$ (5)

Question 7

7.1) John and Maria had an orange that has $8\frac{2}{3}$ pieces. If John ate $\frac{2}{4}$ and Maria ate $\frac{3}{8}$, who ate more of the orange? (Show all working out). (3)

7.2 How many halves are there in two-fifths? (Show all working out). (2)

Appendix H

Grade 8 Fractions Post-test

Duration: 2hrs

Total:100

Examiner: Mrs Mthembu

Moderators:

Mr Ncube & Mr Sinkala

Date:

Name and Surname _____

Class _____

Instructions

1. Write neatly and legibly.
2. Show all your working out.
3. Do not use a calculator.

Question 1

State whether the following fractions are improper fractions, proper fractions, or mixed numbers.

1.1) $\frac{21}{7}$ (1)

1.2) $\frac{4}{9}$ (1)

1.3) $5\frac{6}{9}$ (1)

1.4) $\frac{5}{4}$ (1)

[4]

Question 2

Express the following fractions in their simplest form.

2.1) $\frac{28}{49}$ (1)

2.2) $\frac{64}{96}$ (1)

[2]

Question 3

For each of the following write the equivalent fraction.

3.1) $\frac{2}{5}$ (2)

3.2) $\frac{3}{5}$ (2)

3.3) $\frac{16}{48}$ (2)

[6]

Question 4

For each of the following find the missing value.

4.1) $\frac{6}{\quad} = \frac{18}{24}$ (2)

4.2) $\frac{\quad}{3} = \frac{48}{36}$ (2)

[4]

Question 5

Compare the following pairs of fractions and use signs $<$, $>$, $=$. Show all working out.

5.1) $\frac{3}{5}$ and $\frac{15}{25}$ (2)

5.2) $\frac{3}{8}$ and $\frac{9}{2}$ (2)

5.3) $2\frac{2}{3}$ and $1\frac{7}{8}$ (2)

[6]

Question 6

Express the following fractions as mixed numbers in their lowest terms.

6.1) $\frac{23}{7}$ (2)

6.2) $\frac{41}{8}$ (2)

6.3) $\frac{34}{6}$ (2)

[6]

Question 7

Convert the following fractions to improper fractions.

7.1) $5\frac{5}{6}$ (2)

7.2) $-13\frac{4}{5}$ (2)

[4]

Question 8

Calculate (all final answers should be reduced to their simplest form).

8.1) $\frac{7}{12} - \frac{4}{9}$ (4)

8.2) $3 - \frac{3}{7}$ (4)

8.3) $\frac{2}{3} - \frac{3}{4} + \frac{5}{6}$ (5)

8.4) $2\frac{1}{4} + 2 - 4\frac{5}{15}$ (5)

8.5) $3\frac{2}{3x} - 2\frac{3}{4}$ (5)

[23]

Question 9

Simplify (all final answers should be reduced to their simplest form).

9.1) $-\frac{2}{3} \times \frac{3}{10}$ (3)

9.2) $\frac{3}{4} \div \frac{15}{24}$ (4)

9.3) $\frac{15\frac{1}{2}}{5\frac{3}{6}}$ (5)

9.4) $\frac{4}{9} \div \frac{36}{48} \div \frac{3}{8}$ (5)

9.5) $\frac{\frac{2}{3} - \frac{1}{2}}{13}$ (5)

9.6) $3 \div 4\frac{3}{5}$ (5)

[27]

Question 10

10.) Mrs Khumalo had a cake with 36 pieces that she wished to share among her four children. Sam and Faith got more slices because they were older than Thabiso and Eddy. If Faith got $\frac{4}{9}$ of the cake and altogether Faith and Sam got $\frac{3}{4}$ of the cake, Eddy and Thabiso equally shared the remainder of the cake.

10.1) How many slices did Faith get? (1)

10.2) How many slices did Sam get? (2)

10.3) How many slices were left for Eddy and Thabiso to share? (2)

10.4) What fraction of the total piece of the cake did Sam and Eddy each get? (2)

[7]

Question 11

Rudo was answering the following question and the teacher said her final answer was wrong. Redo the questions again and explain where Rudo went wrong.

11.1) $2\frac{1}{2} \div 4\frac{2}{5} = \frac{5}{2} \div \frac{40}{5} = \frac{5}{2} \times \frac{40}{5} = 20$ (5)

11.2) $\frac{4}{13} + \frac{4}{11} = \frac{8}{24} = \frac{4}{12}$ (6)

[11]

Appendix I

Lesson Plans for the Research - Resource Worksheets and Classroom Mathematics

Lesson	Topic	Calculator-aided Group (A)	Non-calculator-aided Group (B)
1	<p>Definition of a fraction. Types of fractions. Converting of fractions. Reducing fractions to simplest form.</p>	<p>Teacher asks learners to define a fraction with an aid of an example. Teacher explains the concept of denominators and numerators. Learners give types of fractions, teacher ask for examples, class discussion. Teacher gives an activity on factors then explains how to find common factors of a given fraction, then moves on to explain how to reduce a fraction to its lowest term. Teacher explains converting fractions from improper to mixed numbers. Learners are given classwork on topics covered.</p>	<p>Same as group A.</p>
2	<p>Corrections on previous work. Equivalent fractions. Comparing fractions. Common multiples.</p>	<p>Teacher teaches learners how to use the calculator with particular attention to the fraction function. Teacher ask learners to punch the fractions from the activities from the previous exercise then punch the equal sign and see what they noticed. Teacher ask learners to do the same when converting fractions. Teacher give the learners a task and asks them to do the same and give their answers. Teacher moves to explain how to find equivalent fractions. Learners are given class work on equivalent fractions. Teacher ask learners to multiply each fraction by the same denominator and numerator and use their calculator to reduce it. Teacher ask learners to identify a multiple and factor then state the difference between the two. Learners find multiples of given numbers with the aid of a calculator by applying the equivalent fraction skill.</p>	<p>Teacher does corrections with learners, no calculators are used. Teacher explains how to find equivalent fractions using paper and pencil method. Class work given and answers done on the chalkboard. Teacher asks for examples of multiples. Learners identify factors and multiples of numbers without using a calculator then state difference. Task given on multiples, answers discussed in class.</p>
Lesson	Addition and		Teacher explains how to

3 &4	subtraction of fractions with same denominator. With Different denominators. Involving mixed numbers .	Teacher explains how to add and subtract fractions with the same denominator. Teacher explains how to add fractions and subtract fractions with different denominators. Teacher shows the learners how to use their calculator to first multiply the denominators, divide each denominator into product, and to write the numerator for each fraction. Then adding numerators with the same denominator, then using their calculator to reduce to lowest terms or as a mixed number. Learners are given task to do in pairs, then present answers on the chalkboard. Teacher show learners how to verify the answers. A task will be given.	add and subtract fractions with the same denominator. Teacher explains how to add fractions and subtract fractions with different denominators. Teacher shows learners how to divide each denominator into the common denominator, and to write the numerator for each fraction. Then adding numerators with the same denominator, then reduce to its lowest terms or as a mixed number. Learners are given a task to do in pairs, then present answers on the chalkboard. A task will be given.
Lesson6	Addition and subtraction with mixed numbers and with whole numbers and fractions.	Teacher explains the procedure step-by-step and asks learners to use their calculators to convert mixed numbers to improper fractions. Teacher asks learners to find denominators then complete the question. Learners are given questions to present for the whole class. Teacher explains the procedure of writing a whole number as a fraction with 1 as its denominator, and then use the approaches in Lessons 3 and 4 to complete tasks given all the way and learners verify answers with the calculator. Learners are given task that involves algebraic fractions.	Teacher explains the procedure step-by-step and asks learners to use paper and pencil to convert mixed numbers to improper fractions. Teacher asks learners to find denominators then complete the question. Learners are given questions to present for the whole class. Teacher explains the procedure of writing a whole number as a fraction with 1 as its denominator, and then use the approaches in lesson 3 and 4 to complete tasks given, and learners verify answers with the teacher. Learners are given tasks that involve algebraic

			fractions.
Lesson 7 and 8	<p>Multiplication of fractions.</p> <p>Reciprocals.</p> <p>Division of fractions.</p> <p>Bodimas.</p>	<p>Teacher explains the concept of multiplication of fractions and ask learners to use their calculators to find products then reduce them. Teacher also shows learners questions involving cross-cancelling. Tasks are given and learners verify answers with calculator.</p> <p>Teacher explains the concept of reciprocals and learners are given a task on reciprocals.</p> <p>Teacher explains the concept of division to learners.</p> <p>Learners will be given questions to work out in pairs, then present to the class.</p> <p>Learners will be given tasks on the concept, verify answers with the calculator.</p> <p>Teacher stresses learners to only use calculators to calculate denominators, products. and converting.</p> <p>Learners will do task that involves bodimas and the teacher explains how the order of operations works. All necessary working out should be shown and answers only will not be accepted, but a calculator will be used to do the calculations.</p> <p>Algebraic fractions will also be done. Tasks will be given.</p> <p>Learners verify answers with a calculator.</p>	<p>Teacher explains the concept of multiplication of fractions and asks learners to use paper and pencil to find products then reduce them. Teacher also shows learners questions involving cross-cancelling. Tasks will be given and learners verify answers with the teacher.</p> <p>Teacher explains the concept of reciprocals and learners are given a task on reciprocals.</p> <p>Teacher explains the concept of division to learners.</p> <p>Learners will be given questions to work out in pairs, then present in class.</p> <p>Learners will be given tasks on the concept, verify answers with the calculator.</p> <p>Teacher stresses learners to only use calculators to calculate denominators, products, and converting. Learners will do tasks that involve bodimas, and the teacher explains how the order of operations works. All necessary working out should be shown and answers only will not be accepted.</p> <p>Algebraic fractions will also be done. Tasks will be given.</p> <p>Learners verify answers with teacher.</p>

Appendix J

Questionnaire

Instructions:

- *Answer all questions.*
- *All answers will be treated in strictest confidence.*
- *Circle your choice from the given alternatives (indicate the extent to which you agree or disagree with the following statements).*

1. It is important to learn fractions using a calculator.

- a) Strongly disagree
- b) Disagree
- c) Agree
- d) Strongly disagree

2. A calculator enables you to find the common denominator easily.

- a) Strongly disagree
- b) Disagree
- c) Agree
- d) Strongly disagree

3. A calculator makes addition and subtraction of fractions easier.

- a) Strongly disagree
- b) Disagree
- c) Agree
- d) Strongly disagree

4. A calculator makes working with fractions more interesting.

- a) Strongly disagree
- b) Disagree
- c) Agree
- d) Strongly disagree

5. A calculator enables you to check whether or not your answer is correct.

- a) Strongly disagree
- b) Disagree
- c) Agree
- d) Strongly disagree

6. Working with a calculator enables you to work with big numbers.

- a) Strongly disagree
- b) Disagree

- c) Agree
- d) Strongly disagree

7. Calculators makes calculation much easier when dealing with large numbers.

- a) Strongly disagree
- b) Disagree
- c) Agree
- d) Strongly disagree

8. Calculators provide the answers for questions you do not understand.

- a) Strongly disagree
- b) Disagree
- c) Agree
- d) Strongly disagree

9. Doing fractions with a calculator is better than doing it with traditional paper and pencil.

- a) Strongly disagree
- b) Disagree
- c) Agree
- d) Strongly disagree

10. My understanding of fractions has improved since using a calculator.

- a) Strongly disagree
- b) Disagree
- c) Agree
- d) Strongly disagree

11. Calculators should be used in the teaching and learning of fractions.

- a) Strongly disagree
- b) Disagree
- c) Agree
- d) Strongly disagree

12. Working with a calculator enables me to finish my tasks faster than paper and pencil.

- a) Strongly disagree
- b) Disagree
- c) Agree
- d) Strongly disagree

13. Working with a calculator enables you to work with real-life problems.

- a) Strongly disagree
- b) Disagree
- c) Agree
- d) Strongly disagree

14. Fractions is now a very simple topic for me.

- a) Strongly disagree
- b) Disagree
- c) Agree
- d) Strongly disagree

15. Working with a calculator makes me confident when doing fractions.

- a) Strongly disagree
- b) Disagree
- c) Agree
- d) Strongly disagree

Appendix K: Gauteng Research Approval Letter



GAUTENG PROVINCE
Department: Education
REPUBLIC OF SOUTH AFRICA

For administrative use: Reference no: D2014/330
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GDE RESEARCH APPROVAL LETTER

Date:	23 January 2014
Validity of Research Approval:	10 February to 3 October 2014
Name of Researcher:	Mutsvangwa S.B.
Address of Researcher:	685 Letaba Street Klipfontein View Midrand 1685
Telephone Number:	011 056 9931 / 073 641 1619
Email address:	sekesaimthembu@gmail.com
Research Topic:	The investigation of the effectiveness of using hand held scientific calculators in teaching and learning of fractions. A case study of one school in Gauteng Province
Number and type of schools:	ONE Secondary School
District/s/HO	Johannesburg East

Re: Approval in Respect of Request to Conduct Research

This letter serves to indicate that approval is hereby granted to the above-mentioned researcher to proceed with research in respect of the study indicated above. The onus rests with the researcher to negotiate appropriate and relevant time schedules with the school/s and/or offices involved to conduct the research. A separate copy of this letter must be presented to both the School (both Principal and SGB) and the District/Head Office Senior Manager confirming that permission has been granted for the research to be conducted.

The following conditions apply to GDE research. The researcher may proceed with the above study subject to the conditions listed below being met. Approval may be withdrawn should any of the conditions listed below be flouted:

2014/01/24
Making education a societal priority

Office of the Director: Knowledge Management and Research
9th Floor, 111 Commissioner Street, Johannesburg, 2001
P.O. Box 7710, Johannesburg, 2000 Tel: (011) 355 0606
Email: David.Makhado@gauteng.gov.za
Website: www.education.gpg.gov.za

1. The District/Head Office Senior Manager/s concerned must be presented with a copy of this letter that would indicate that the said researcher/s has/have been granted permission from the Gauteng Department of Education to conduct the research study.
2. The District/Head Office Senior Manager/s must be approached separately, and in writing, for permission to involve District/Head Office Officials in the project.
3. A copy of this letter must be forwarded to the school principal and the chairperson of the School Governing Body (SGB) that would indicate that the researcher/s have been granted permission from the Gauteng Department of Education to conduct the research study.
4. A letter / document that outlines the purpose of the research and the anticipated outcomes of such research must be made available to the principals, SGBs and District/Head Office Senior Managers of the schools and districts/offices concerned, respectively.
5. The Researcher will make every effort obtain the goodwill and co-operation of all the GDE officials, principals, and chairpersons of the SGBs, teachers and learners involved. Persons who offer their co-operation will not receive additional remuneration from the Department while those that opt not to participate will not be penalised in any way.
6. Research may only be conducted after school hours so that the normal school programme is not interrupted. The Principal (if at a school) and/or Director (if at a district/head office) must be consulted about an appropriate time when the researcher/s may carry out their research at the sites that they manage.
7. Research may only commence from the second week of February and must be concluded before the beginning of the last quarter of the academic year. If incomplete, an amended Research Approval letter may be requested to conduct research in the following year.
8. Items 6 and 7 will not apply to any research effort being undertaken on behalf of the GDE. Such research will have been commissioned and be paid for by the Gauteng Department of Education.
9. It is the researcher's responsibility to obtain written parental consent of all learners that are expected to participate in the study.
10. The researcher is responsible for supplying and utilising his/her own research resources, such as stationery, photocopies, transport, faxes and telephones and should not depend on the goodwill of the institutions and/or the offices visited for supplying such resources.
11. The names of the GDE officials, schools, principals, parents, teachers and learners that participate in the study may not appear in the research report without the written consent of each of these individuals and/or organisations.
12. On completion of the study the researcher/s must supply the Director: Knowledge Management & Research with one Hard Cover bound and an electronic copy of the research.
13. The researcher may be expected to provide short presentations on the purpose, findings and recommendations of his/her research to both GDE officials and the schools concerned.
14. Should the researcher have been involved with research at a school and/or a district/head office level, the Director concerned must also be supplied with a brief summary of the purpose, findings and recommendations of the research study.

The Gauteng Department of Education wishes you well in this important undertaking and looks forward to examining the findings of your research study.

Kind regards


.....

Dr David Makhado
Director: Education Research and Knowledge Management

DATE: 2014/01/24
.....

Making education a societal priority

2

Office of the Director: Knowledge Management and Research

9th Floor, 111 Commissioner Street, Johannesburg, 2001
P.O. Box 7710, Johannesburg, 2000 Tel: (011) 355 0506
Email: David.Makhado@gauteng.gov.za
Website: www.education.gpg.gov.za

Appendix L: Ethical Clearance Certificate



Research Ethics Clearance Certificate

This is to certify that the application for ethical clearance submitted by

SB Mthembu [411695146]

for a M Ed study entitled

**The influence of using a scientific calculator in learning fractions: a case study of
one school in Gauteng province**

has met the ethical requirements as specified by the University of South Africa
College of Education Research Ethics Committee. This certificate is valid for two
years from the date of issue.

A handwritten signature in black ink, appearing to read 'KP Dzimbo'.

Prof KP Dzimbo
Executive Dean : CEDU

A handwritten signature in black ink, appearing to read 'M Claassens'.

Dr M Claassens
CEDU REC (Chairperson)
mdc1c@netactive.co.za

Reference number: 2014 MAY /411695146/MC

19 MAY 2014

Appendix M: Assignment Memorandum

Memorandum

Appendix G

Fractions Assignment Grade 8

<u>Duration</u>	<u>Total</u>
<u>Examiner :Mrs Mthembu</u>	<u>Moderator:Mr N Ncube</u>
<u>Name</u>	<u>Class</u>

Question 1

Arrange the following fractions in order starting with the biggest $\frac{2}{5}, \frac{7}{10}, \frac{3}{4}, \frac{4}{7}$

$$\text{L.C.M} = 140$$

$$\Rightarrow \frac{2}{5} = \frac{56}{140}, \frac{7}{10} = \frac{98}{140}, \frac{3}{4} = \frac{105}{140}, \frac{4}{7} = \frac{80}{140}$$

$$\Rightarrow \frac{3}{4} > \frac{7}{10} > \frac{4}{7} > \frac{2}{5} \text{ (in correct order)}$$

(4)

Question 2

Use the correct symbol (< or >) in each case show all working

a) $\frac{2}{3} > \frac{3}{5}$ (2)

$$\text{L.C.M} = 15$$

$$\frac{2}{3} = \frac{10}{15}, \frac{3}{5} = \frac{9}{15} \Rightarrow \frac{2}{3} > \frac{3}{5}$$

b) $\frac{6}{15} < \frac{3}{7}$ (2)

$$\text{L.C.M} = 105 \Rightarrow \frac{6}{15} \times \frac{7}{7} = \frac{42}{105}, \frac{3}{7} \times \frac{15}{15} = \frac{45}{105} \Rightarrow \frac{6}{15} < \frac{3}{7}$$

Question 3

Express the following fractions in simplest form

a) $\frac{36}{64} = \frac{9}{16}$ i.e. $\frac{36 \div 4}{64 \div 4} = \frac{9}{16}$ ✓ (1)

b) $\frac{108}{117} = \frac{12}{13}$ ✓ (1)

Memorandum

Appendix G

Fractions Assignment Grade 8

<u>Duration</u>	<u>Total</u>
<u>Examiner :Mrs Mthembu</u>	<u>Moderator:Mr N Ncube</u>
<u>Name</u>	<u>Class</u>

Question 1

Arrange the following fractions in order starting with the biggest $\frac{2}{5}, \frac{7}{10}, \frac{3}{4}, \frac{4}{7}$

$$\text{L.C.M} = 140$$

$$\Rightarrow \frac{2}{5} = \frac{56}{140}, \frac{7}{10} = \frac{98}{140}, \frac{3}{4} = \frac{105}{140}, \frac{4}{7} = \frac{80}{140}$$

$$\Rightarrow \frac{3}{4} > \frac{7}{10} > \frac{2}{5} > \frac{4}{7} \text{ (in correct order)}$$

(4)

Question 2

Use the correct symbol (< or >) in each case show all working

a) $\frac{2}{3} > \frac{3}{5}$ (2)

$$\text{L.C.M} = 15$$

$$\frac{2}{3} = \frac{10}{15}, \frac{3}{5} = \frac{9}{15} \Rightarrow \frac{2}{3} > \frac{3}{5}$$

b) $\frac{6}{15} < \frac{3}{7}$ (2)

$$\text{L.C.M} = 105 \Rightarrow \frac{6}{15} \times \frac{7}{7} = \frac{42}{105}, \frac{3}{7} \times \frac{15}{15} = \frac{45}{105} \Rightarrow \frac{6}{15} < \frac{3}{7}$$

Question 3

Express the following fractions in simplest form

a) $\frac{36}{64} = \frac{9}{16}$ i.e. $\frac{36 \div 4}{64 \div 4} = \frac{9}{16}$ (1)

b) $\frac{108}{117} = \frac{12}{13}$ (1)

Rudo was answering the following question and the teacher said her final answer was wrong. Re do the questions again and explain where Rudo went wrong

$$11.1) 2\frac{1}{2} \div 4\frac{2}{5} = \frac{5}{2} \div \frac{40}{5} = \frac{5}{2} \times \frac{40}{5} = 20 \quad (5)$$

$$\frac{5}{2} \times \frac{5}{22} = \frac{25}{44}$$

Problems: a) wrong multiplied by number ✓
 b) did not change order of fraction ✓

$$11.2) \frac{4}{13} + \frac{4}{11} = \frac{8}{24} = \frac{4}{12} \quad (6)$$

$$\text{L.C.D} = 143$$

$$\frac{44}{143} + \frac{52}{143} = \frac{96}{143}$$

Errors: Did not find Common Denominator ✓

[11]

: added denominators ✓

Rudo was answering the following question and the teacher said her final answer was wrong. Re do the questions again and explain where Rudo went wrong

$$11.1) 2\frac{1}{2} \div 4\frac{2}{5} = \frac{5}{2} \div \frac{40}{5} = \frac{5}{2} \times \frac{40}{5} = 20 \quad (5)$$

$$\frac{5}{2} \times \frac{5}{22} = \frac{25}{44}$$

Problems: a) wrong multiplied by number ✓
 b) did not change order of fraction. ✓

$$11.2) \frac{4}{13} + \frac{4}{11} = \frac{8}{24} = \frac{4}{12} \quad (6)$$

$$\text{L.C.D} = 143$$

$$\frac{44}{143} + \frac{52}{143} = \frac{96}{143}$$

Errors: Did not find Common Denominator ✓ [11]
 : added denominators ✓

Q10

$$\frac{4}{9} + x = \frac{3}{4}$$

$$\Rightarrow x = \frac{3}{4} - \frac{4}{9} = \frac{27-16}{36} = \frac{11}{36}$$

a) Eate got $\frac{4}{9} \times 36 = 16$ slices ✓

b) Same got $\frac{17}{36} \times 36 = 17$ slices ✓

c) $1 - \frac{3}{4} = \frac{4}{4} - \frac{3}{4} = \frac{1}{4}$ ✓

d) $\frac{4}{4} \times \frac{1}{4} \text{ Sam} = \frac{17}{36}$

$$\text{edd } y = \left(\frac{1}{4} \div 2\right) = \frac{1}{4} \times \frac{1}{2} = \frac{1}{8}$$

$$\Rightarrow \frac{17}{36} + \frac{1}{8} = \frac{34+9}{72} = \frac{43}{72}$$

$$\text{or } \frac{1}{8} \times \frac{36}{1} = \frac{36}{8} = 4\frac{4}{8} = 4\frac{1}{2}$$

$$\Rightarrow 17 + 4\frac{1}{2} = \frac{21.5}{36}$$

Q 10

$$\frac{4}{9} + x = \frac{3}{4}$$

$$\Rightarrow x = \frac{3}{4} - \frac{4}{9} = \frac{27-16}{36} = \frac{11}{36}$$

a) Fute got $\frac{4}{9} \times 36 = 16$ slices ✓

b) Same got $\frac{17}{36} \times 36 = 17$ slices ✓

c) $1 - \frac{3}{4} = \frac{4}{4} - \frac{3}{4} = \frac{1}{4}$ ✓

d) $\frac{4}{9}$ same = $\frac{17}{36}$

$$\text{Add } y = \left(\frac{1}{4} \div 2\right) = \frac{1}{4} \times \frac{1}{2} = \frac{1}{8}$$

$$\Rightarrow \frac{17}{36} + \frac{1}{8} = \frac{34+9}{72} = \frac{43}{72}$$

$$\text{Or } \frac{1}{8} \times \frac{36}{1} = \frac{36}{8} = 4\frac{4}{8} = 4\frac{1}{2}$$

$$\Rightarrow 17 + 4\frac{1}{2} = \frac{21.5}{36}$$

$$9.3) \frac{15\frac{1}{2}}{5\frac{3}{6}} \quad (5)$$

$$\frac{31\frac{1}{2} \checkmark}{3\frac{3}{6} \checkmark} = \frac{31 \checkmark \times 6^3}{21 \times 33}$$

$$= \frac{93 \checkmark}{33} = \frac{31 \checkmark}{11 \checkmark}$$

$$9.4) \frac{4}{9} \div \frac{36}{48} \div \frac{3}{8} \quad (5)$$

$$\frac{4 \checkmark \times 48 \times 8 \checkmark}{9 \times 36 \times 3} = \frac{128 \checkmark}{81 \checkmark}$$

$$9.5) \frac{\frac{2}{3} - \frac{1}{2}}{13} \quad \text{L.C.D} = 6 \checkmark \quad (5)$$

$$\frac{4-3 \checkmark}{13} = \frac{1}{13} \times \frac{1}{6} = \frac{1}{78} \checkmark$$

$$9.6) 3 \div 4\frac{3}{5} \quad (5)$$

$$\frac{3}{1} \times \frac{5}{23} = \frac{15}{23} \checkmark$$

[27]

Question 10

10.) Mrs Khumalo had a cake with 36 pieces she wished to share among her four children. Sam and Faith got more slices because they were older than Thabiso and Eddy. If Faith got $\frac{4}{9}$ of the cake and altogether Faith and Sam got $\frac{3}{4}$ of the cake. Eddy and Thabiso shared equally the remainder of the cake.

10.1) How many slices did Faith get (1)

10.2) How many slices did Sam get (2)

10.3) How many slices were left for Eddy and Thabiso to share (2)

10.4) what fraction of the total pieces of the cake did Sam and Eddy each get (2)

[7]

9.3) $\frac{15\frac{1}{2}}{5\frac{3}{6}}$ (5)

$$\frac{3\frac{1}{2} \checkmark}{3\frac{3}{6} \checkmark} = \frac{31 \checkmark \times 6^3 \checkmark}{21 \checkmark \times 33 \checkmark}$$

$$= \frac{93 \checkmark}{33 \checkmark} = \frac{31 \checkmark}{11 \checkmark}$$

9.4) $\frac{4}{9} \div \frac{36}{48} \div \frac{3}{8}$ (5)

$$\frac{4}{9} \times \frac{48}{36} \times \frac{8}{3} = \frac{128 \checkmark}{81 \checkmark}$$

9.5) $\frac{\frac{2}{3} - \frac{1}{2}}{13}$ L.C.D = 6 (5)

$$\frac{4-3 \checkmark}{13} = \frac{1}{13} \times \frac{1}{13} = \frac{1}{169} \checkmark$$

9.6) $3 \div 4\frac{3}{5}$ (5)

$$3/1 \times 5/23 = 15/23 \checkmark$$

[27]

Question 10

10.) Mrs Khumalo had a cake with 36 pieces she wished to share among her four children. Sam and Faith got more slices because they were older than Thabiso and Eddy. If Faith got $\frac{4}{9}$ of the cake and altogether Faith and Sam got $\frac{3}{4}$ of the cake. Eddy and Thabiso shared equally the remainder of the cake.

10.1) How many slices did Faith get (1)

10.2) How many slices did Sam get (2)

10.3) How many slices were left for Eddy and Thabiso to share (2)

10.4) what fraction of the total pieces of the cake did Sam and Eddy each get (2)

[7]

$$3 - \frac{3}{7} = \frac{3}{1} - \frac{3}{7} \Rightarrow \text{L.C.D} = 7 \checkmark$$

$$\frac{21 - 3 \checkmark}{7} = \frac{18}{7} = 2 \frac{4}{7} \checkmark$$

$$8.3) \frac{2}{3} - \frac{3}{4} + \frac{5}{6} \quad (5)$$

$$\frac{8 - 9 + 10}{12} = \frac{8 - 9 + 10}{12} = \frac{9}{12} = \frac{3}{4}$$

$$8.4) 2\frac{1}{4} + 2 - 4\frac{5}{15} = \frac{9}{4} + \frac{2}{1} - \frac{65}{15} \quad (5)$$

$$= \frac{135 + 120 - 260}{60} = \frac{-5}{60} = -\frac{1}{12} \checkmark$$

$$8.5) 3\frac{2}{3x} - 2\frac{3}{4} = \frac{9x+2}{3x} - \frac{11}{4} = \frac{4(9x+2) - 33x}{12x} \quad (5)$$

$$= \frac{36x + 8 - 33x}{12x} = \frac{3x + 8}{12x} \checkmark$$

[23]

Question 9

Simplify (all final answers should be reduced to its simplest form)

$$9.1) -\frac{2}{3} \times \frac{3}{10} \quad (3)$$

$$-\frac{2}{3} \times \frac{3}{10} = -\frac{1}{5} \checkmark$$

$$9.2) \frac{3}{4} \div \frac{15}{24} \quad (4)$$

$$\frac{3}{4} \times \frac{24}{15} \checkmark$$

$$= \frac{6}{5} = 1\frac{1}{5} \checkmark$$

$$9.3) \frac{15\frac{1}{2}}{5\frac{3}{6}} \quad (5)$$

$$3 - \frac{3}{7} = \frac{3}{1} - \frac{3}{7} \Rightarrow \text{L.C.D} = 7 \checkmark$$

$$\frac{21 - 3}{7} = \frac{18}{7}$$

$$= 2 \frac{4}{7} \checkmark$$

8.3) $\frac{2}{3} - \frac{3}{4} + \frac{5}{6}$ (5)

$$\frac{8 - 9 + 10}{12} = \frac{8 - 9 + 10}{12}$$

$$= \frac{9}{12} = \frac{3}{4}$$

8.4) $2\frac{1}{4} + 2 - 4\frac{5}{15}$ (5)

$$= \frac{9}{4} + \frac{2}{1} - \frac{65}{15}$$

$$= \frac{135 + 120 - 260}{60} = \frac{-5}{60} = -\frac{1}{12} \checkmark$$

8.5) $3\frac{2}{3x} - 2\frac{3}{4}$ (5)

$$= \frac{9x + 2}{3x} - \frac{11}{4} = \frac{4(9x + 2) - 33x}{12x}$$

$$= \frac{36x + 8 - 33x}{12x} = \frac{3x + 8}{12x} \checkmark$$

[23]

Question 9

Simplify (all final answers should be reduced to its simplest form)

9.1) $-\frac{2}{3} \times \frac{3}{10}$ (3)

$$\frac{-2}{3} \times \frac{3}{10} = -\frac{1}{5} \checkmark$$

9.2) $\frac{3}{4} \div \frac{15}{24}$ (4)

$$\frac{3}{4} \times \frac{24}{15} \checkmark$$

$$= \frac{6}{5} = 1\frac{1}{5} \checkmark$$

9.3) $\frac{15\frac{1}{2}}{5\frac{3}{6}}$ (5)

$$5.3) 2\frac{2}{3} \text{ and } 1\frac{7}{8} \Rightarrow \text{L.C.M} = 24 \checkmark$$

$$\rightarrow 2\frac{2}{3} = \frac{8}{3} = \frac{64}{24} \text{ and } 1\frac{7}{8}$$

$$= \frac{15}{8} = \frac{45}{24} \therefore 2\frac{2}{3} > 1\frac{7}{8}$$

Question 6

Express the following fractions as mixed numbers to their lowest terms

$$6.1) \frac{23}{7} = 3\frac{2}{7} \checkmark$$

$$6.2) \frac{41}{8} = 5\frac{1}{8} \checkmark$$

$$6.3) \frac{34}{6} = 5\frac{4}{6} = 5\frac{2}{3} \checkmark$$

Question 7

Convert the following fractions to improper fractions

$$7.1) 5\frac{5}{6} = \frac{35}{6} \checkmark$$

$$7.2) -13\frac{4}{5} = -\frac{69}{5} \checkmark$$

Question 8

Calculate (all final answers should be reduced to simplest forms)

$$8.1) \frac{7}{12} - \frac{4}{9} \quad \text{L.C.D} = 108 \checkmark$$

$$\Rightarrow \frac{63 - 48}{108} = \frac{15}{108} = \frac{5}{36} \checkmark$$

$$5.3) 2\frac{2}{3} \text{ and } 1\frac{7}{8} \Rightarrow \text{L.C.M} = 24 \checkmark \quad (2)$$

$$\rightarrow 2\frac{2}{3} = \frac{8}{3} = \frac{64}{24} \text{ and } \frac{17}{8}$$

$$= \frac{15}{8} = \frac{15}{24} \therefore 2\frac{2}{3} \} \frac{17}{8}$$

[6]

Question 6

Express the following fractions as mixed numbers to their lowest terms

$$6.1) \frac{23}{7} = 3\frac{2}{7} \checkmark \quad (2)$$

$$6.2) \frac{41}{8} = 5\frac{1}{8} \checkmark \quad (2)$$

$$6.3) \frac{34}{6} = 5\frac{4}{6} = 5\frac{2}{3} \checkmark \quad (2)$$

[6]

Question 7

Convert the following fractions to improper fractions

$$7.1) 5\frac{5}{6} = \frac{35}{6} \checkmark \quad (2)$$

$$7.2) -13\frac{4}{5} = -\frac{69}{5} \checkmark \quad (2)$$

[4]

Question 8

Calculate (all final answers should be reduced to simplest forms)

$$8.1) \frac{7}{12} - \frac{4}{9} \quad \text{L.C.D} = 108 \checkmark \quad (4)$$

$$\Rightarrow \frac{63 - 48}{108} = \frac{15}{108} = \frac{5}{36} \checkmark$$

Appendix N: Post –Test Memorandum

Memorandum.

Appendix F

Grade 8 Fractions Post-test

Duration: 2hrs

Total:100

Examiner:Mrs Mthembu

Moderator:Mrs Nair

Date:

Name and Surname _____

Class _____

Instructions

1. Write neatly and legibly
2. Show all your working out
3. Do not use a calculator

Question 1

State whether the following fractions its improper,proper fraction or mixed number

1.1) $\frac{21}{7}$

Improper ✓ ①

(1)

1.2) $\frac{4}{9}$

Proper ✓ ①

(1)

1.3) $5\frac{6}{9}$

Mixed Fraction/number ✓ ①

(1)

1.4) $\frac{5}{4}$

Improper ✓ ①

(1)

[4]

Question 2

Express the following fractions in simplest form:

2.1) $\frac{28}{49}$

$\frac{28 \div 7}{49 \div 7} = \frac{4}{7}$ ✓

(1)

2.2) $\frac{64}{96}$

$= \frac{64 \div 32}{96 \div 32} = \frac{2}{3}$ ✓

(1)

[2]

Memorandum.

Appendix F

Grade 8 Fractions Post-test

Duration: 2hrs

Total:100

Examiner:Mrs Mthembu

Moderator:Mrs Nair

Date:

Name and Surname _____

Class _____

Instructions

1. Write neatly and legibly
2. Show all your working out
3. Do not use a calculator

Question 1

State whether the following fractions its improper, proper fraction or mixed number

1.1) $\frac{21}{7}$

Improper ✓ ①

(1)

1.2) $\frac{4}{9}$

Proper ✓ ①

(1)

1.3) $5\frac{6}{9}$

Mixed Fraction/number ✓ ①

(1)

1.4) $\frac{5}{4}$

Improper ✓ ①

(1)

[4]

Question 2

Express the following fractions in simplest form:

2.1) $\frac{28}{49}$

$\frac{28 \div 7}{49 \div 7} = \frac{4}{7}$ ✓

(1)

2.2) $\frac{64}{96}$

$\frac{64 \div 32}{96 \div 32} = \frac{2}{3}$ ✓

(1)

[2]

Assignment memo

$$= \frac{2}{6 \frac{2}{5}} \checkmark$$

e) $\frac{\frac{x}{10} + \frac{x}{5}}{\frac{2x}{5}}$ L.C.M of numerator = 20 \checkmark (5)

$$\Rightarrow \frac{(2x + 4x)}{20} \times \frac{5}{2x} \checkmark$$

$$= \frac{6x \checkmark}{20} \times \frac{5}{2x} = \frac{6x}{20} \times \frac{5}{2x} \checkmark$$

$$= \frac{3}{4} \checkmark$$

f) $4 \frac{1}{2} \times 3 \frac{2}{3}$

$\frac{1}{2} \times 3 \frac{2}{3}$

$$= \frac{9}{2} \times \frac{11}{3} \checkmark$$

$$= \frac{33}{2} \checkmark$$

g) $\frac{4}{3} \times \frac{7}{9}$

(2)

$$= \frac{4 \times 7}{3 \times 9}$$

$$= \frac{28}{27} \checkmark$$

h) $3 \frac{3}{5} \div \frac{2}{10}$

$$= \frac{18}{5} \times \frac{10}{2} \checkmark$$

$$= \frac{18 \times 2}{8} \times \frac{10}{2} \checkmark$$

$$= 18 \checkmark$$

(4)

Question 7

7.1) John and Maria had an orange that has $8 \frac{2}{3}$ pieces. if John ate $\frac{2}{4}$ and Maria ate $\frac{3}{8}$, who ate more oranges? (show all working) (3)

$$\frac{2}{4} > \frac{3}{8}$$

$$\text{L.C.M} = 8 \checkmark$$

$$\Rightarrow \frac{2}{4} = \frac{4}{8} \quad \& \quad \frac{3}{8} = \frac{3}{8}$$

\therefore it was John \checkmark

7.2 How many halves are there in two-fifths (show all working) (2)

$$\frac{2}{5} \div \frac{1}{2} \checkmark = \frac{2}{5} \times \frac{2}{1} = \frac{4}{5} \checkmark$$

Assignment memo

$$= 6\frac{2}{5} \checkmark$$

e) $\frac{\frac{x}{10} + \frac{x}{5}}{\frac{2x}{5}}$ L.C.M of numerator = 20 \checkmark (5)

$$\Rightarrow \left(\frac{2x+4x}{20}\right) \times \frac{5}{2x} \checkmark$$

$$= \frac{6x \checkmark}{20} \times \frac{5}{2x} = \frac{6x}{20} \times \frac{5}{2x} \checkmark$$

$$= \frac{30x}{40x} \checkmark$$

$$= \frac{3}{4} \checkmark$$

f) $4\frac{1}{2} \times 3\frac{2}{3}$ $\frac{1}{2} \times 3\frac{2}{3}$

$$= 9/2 \times 11/3 \checkmark$$

$$= \frac{33}{2} \checkmark$$

g) $\frac{4}{3} \times \frac{7}{9}$ (2)

$$= 4/3 \times 7/9$$

$$= \frac{28}{27} \checkmark$$

$$= \frac{28}{27} \checkmark$$

h) $3\frac{3}{5} \div \frac{2}{10}$ $= 18/5 \times 10/2 \checkmark$

$$= \frac{18 \cancel{9} \times \cancel{10}^2}{5 \times 2} \checkmark$$

$$= 18 \checkmark$$

(4)

Question 7

7.1) John and Maria had an orange that has $8\frac{2}{3}$ pieces. if John ate $\frac{2}{4}$ and Maria ate $\frac{3}{8}$, who ate more oranges? (show all working) (3)

$$\frac{2}{4} > \frac{3}{8} \checkmark$$

$$\text{L.C.M} = 8 \checkmark$$

$$\Rightarrow \frac{2}{4} = \frac{4}{8} \quad \frac{3}{8} = \frac{3}{8}$$

\therefore it was John \checkmark

7.2 How many halves are there in two-fifths (show all working) (2)

$$\frac{2}{5} \div \frac{1}{2} \checkmark = \frac{2}{5} \times \frac{2}{1} = \frac{4}{5} \checkmark$$

Assignment Memo

Convert the following fractions to improper fractions

a) $2\frac{4}{5} = \frac{14}{5} \checkmark$ (1)

b) $2\frac{13}{17} = \frac{47}{17} \checkmark$ (1)

Question 5

Write the following as mixed numbers

a) $\frac{16}{5} = 3\frac{1}{5} \checkmark$ (1)

b) $\frac{19}{7} = 2\frac{5}{7} \checkmark$ (1)

Question 6

Simplify the following

a) $1\frac{2}{5} + 2\frac{2}{3} \div \frac{8}{9}$ (5)

$$= \frac{7}{5} + \frac{8}{3} \div \frac{8}{9} \checkmark$$

$$= \frac{7}{5} + \frac{8}{3} \times \frac{9}{8} = \frac{7}{5} + \frac{8}{\cancel{3}} + \frac{9}{\cancel{8}} = \frac{7}{5} + \frac{3}{1} \checkmark$$

$$\text{L.C.D} = 5 \Rightarrow \frac{7+15}{5} = \frac{22}{5} \checkmark$$

b) $5a - \frac{3a}{4} = \frac{-5a}{1} - \frac{3a}{4} \Rightarrow \text{L.C.D} = 4 \checkmark$ (4)

$$\Rightarrow \frac{20a - 3a}{4} = \frac{17a}{4} \checkmark$$

c) $\frac{-7ab}{2} + \frac{ab}{3} - \frac{2ab}{4} \Rightarrow \text{L.C.D} = 12 \checkmark$ (5)

$$\frac{-42ab + 4ab - 6ab}{12} \checkmark$$

$$= \frac{-44ab}{12} \checkmark$$

d) $7 - \frac{3}{5} \Rightarrow \text{L.C.D} = 5 \checkmark$ (4)

$$\Rightarrow \frac{7}{1} - \frac{3}{5} = \frac{35 - 3}{5} = \frac{32}{5}$$

Assignment Memo

Convert the following fractions to improper fractions

a) $2\frac{4}{5} = \frac{14}{5} \checkmark$ (1)

b) $2\frac{13}{17} = \frac{47}{17} \checkmark$ (1)

Question 5

Write the following as mixed numbers

a) $\frac{16}{5} = 3\frac{1}{5} \checkmark$ (1)

b) $\frac{19}{7} = 2\frac{5}{7} \checkmark$ (1)

Question 6

Simplify the following

a) $1\frac{2}{5} + 2\frac{2}{3} \div \frac{8}{9}$ (6)

$$= \frac{7}{5} + \frac{8}{3} \div \frac{8}{9} \checkmark$$

$$= \frac{7}{5} + \frac{8}{3} \times \frac{9}{8} = \frac{7}{5} + \frac{6}{1} + \frac{9}{1} = \frac{7}{5} + \frac{15}{1} \checkmark$$

$$\text{L.C.D} = 5 \Rightarrow \frac{7+15}{5} = \frac{22}{5} \checkmark$$

b) $-5a - \frac{3a}{4} = \frac{-5a}{1} - \frac{3a}{4} \Rightarrow \text{L.C.D} = 4 \checkmark$ (4)

$$\Rightarrow \frac{20a - 3a}{4} = \frac{17a}{4} \checkmark$$

c) $\frac{-7ab}{2} + \frac{ab}{3} - \frac{2ab}{4} \Rightarrow \text{L.C.D} = 12 \checkmark$ (5)

$$\frac{-42ab + 4ab - 6ab}{12} \checkmark$$

$$= \frac{-44ab}{12} \checkmark$$

d) $7 - \frac{3}{5} \Rightarrow \text{L.C.D} = 5 \checkmark$ (4)

$$\Rightarrow \frac{7}{1} - \frac{3}{5} = \frac{35 - 3}{5} = \frac{32}{5} \checkmark$$

Appendix O: Editing Certificate

Alan Gray
Editor

078 -35 1361

18 August 2016

TO WHOM IT MAY CONCERN

Dear Sir/Madam,

CERTIFICATE OF EDITING – SEKESAI BRIDGET MUTSVANGWA

I hereby confirm that Sekesai Bridget Mutsvangwa dissertation entitled “**THE INFLUENCE OF USING A SCIENTIFIC CALCULATOR IN LEARNING FRACTIONS: A CASE STUDY OF ONE SCHOOL IN GAUTENG PROVINCE. A DIAGNOSTIC MODEL FOR THE PREDICTION OF MATHEMATICAL ACHIEVEMENT FOR UNIVERSITY STUDENTS**” for the University of South Africa, was edited by in August 2016. Additionally, I confirm that the technical aspects of the document were effected by me.

Sincerely

Alan Gray
Professional Editor